An Investigation of Older Driver Freeway Needs and Capabilities

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Research and Development
Turner-Fairbank Highway Research Center
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FOREWORD

The proportion of the North American population over age 65 is increasing and will continue to increase dramatically. The research documented in this report identified the specific problems that older drivers experience on freeways. A series of six problem identification activities are described. These include a task analysis, focus groups, computerized accident data analysis, hard-copy accident analysis, a survey of older drivers, and a travel diary. The activities identified a number of problems that older drivers experience on freeways. Recommendations for additional research to address those problems are presented.

The information contained in this report should be of interest to design engineers, transportation planners, and transportation engineers involved in the design, construction, and/or reconstruction of freeway and limited-access highways within the highway system.

Sufficient copies of this report are being distributed to provide a minimum of one copy to each Region and two copies to each Division office and State Transportation Agency. Additional copies for the public are available from the National Technical Information Service (NTIS), Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161. A small charge will be imposed by NTIS.

A. George Ostensen, Director
Office of Safety and Traffic
Operations Research and Development

NOTICE

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16. Abstract

The objectives of the study were to: (1) identify the characteristics of older drivers that affect their ability to drive on freeways; (2) identify the characteristics of freeway driving that cause the greatest difficulties for older drivers; (3) conduct problem identification research to define the problems experienced by older drivers on freeways; and (4) recommend further research to develop guidelines for countermeasures to accommodate the needs and capabilities of older drivers.

To achieve these objectives, six problem identification activities were conducted: (1) a task analysis was performed to identify the relationship between the freeway driving tasks and age-diminished capabilities; (2) a series of eight focus groups were conducted to identify older driver freeway driving problems; (3) computerized accident data analyses were done to compare the freeway accident involvement of younger and older drivers; (4) more than 900 hard-copy accident records were reviewed and coded to identify causative and descriptive factors associated with older driver freeway accidents; (5) about 1,500 members of the American Association of Retired Persons (AARP) from 39 States were surveyed to identify specific problems or difficulties experienced by older drivers on freeways; and (6) a 2-week travel diary study representing almost 8,000 trips by older drivers in 29 States was conducted to document route selection criterion, freeway avoidance behavior, and problems encountered.

The preceding project activities identified a wide range of different problems that older drivers have on freeways. Recommendations were made for additional research to address these problems.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3

NOTE: Volumes greater than 1000 l shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

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1. INTRODUCTION

This report summarizes the activities performed under a Federal Highway Administration (FHWA) contract, Investigation of Older Driver Freeway Needs and Capabilities. The objectives of the contract were to:

- Identify characteristics of older drivers that affect their needs and capabilities with regard to freeway driving.
- Identify specific elements in the freeway driving environment that cause the greatest difficulty for older drivers. Elements to be identified shall include, but are not limited to, those related to three major categories: freeway design, freeway operations, and traffic control device design and implementation.
- Conduct problem identification research to more closely define the problems that confront the older driver on freeways in terms of the identified factors.
- Recommend further research to develop guidelines for freeway countermeasures designed to address the problems identified above and thereby accommodate the needs and capabilities of older drivers.

In order to achieve these objectives, seven discrete activities were undertaken:

1. **Task Analysis/Literature Review**. A detailed analysis of the freeway driving tasks was performed to identify specific behaviors, the performance of which may be affected by aging. In addition, a review of the literature was conducted to identify age-related characteristics that may influence freeway driving. This work was done by A. James McKnight and A. Scott McKnight of the National Public Services Research Institute, 8201 Corporate Drive, Suite 220, Landover, MD 20785.

2. **Focus Group Discussions**. A series of eight focus group discussions involving older drivers in four cities was conducted. The purpose of these focus groups was to identify the kinds of problems that older drivers experience when driving on freeways. Dr. Michael Cosgrove of Nancy Low and Associates, Inc., The Barlow Building, Suite 1300, 5454 Wisconsin Avenue, Chevy Chase, MD 20815 served as the focus group moderator.

3. **Computerized Accident Analysis**. An analysis of computerized State and national databases was performed to quantify the specific safety problems experienced by older drivers on freeways. This work was done by David L. Harkey, Herman Huang, and Charles V. Zegeer of the University of North Carolina Highway Safety Research Center, 134-1/2 East Franklin Street, Chapel Hill, NC 27599.

4. **Hard-Copy Accident Analysis**. The accident narrative and collision diagram of hard-copy accident reports contain qualitative and subjective information that is not typically available in computerized accident databases. Over 900 hard-copy accident reports from 4 States were reviewed to identify the accident situations/locations/scenarios that are hazardous to older drivers on freeways.

5. **AARP Survey**. A survey of 1,400 members of the American Association of Retired Persons (AARP) in 39 States was conducted. The members completed an eight-page survey form in order to identify some of the specific problems or difficulties experienced by older drivers on freeways.

6. **Travel Diary Study**. The problems experienced by older drivers on freeways are a function of the degree of driving that older drivers do on freeways. It could be hypothesized that some older drivers don't experience problems on freeways because they avoid using freeways. To determine the freeway usage and avoidance behavior of older drivers, a travel diary study was conducted. A subset of 178 older drivers from the AARP Survey completed a 2-week travel diary. Data from nearly 8,000 trips were analyzed.

7. **Research Recommendations**. The ultimate objective of this contract was to recommend additional research to identify countermeasures to address the older driver freeway problems identified in the earlier project activities. This recommended research is intended to develop and evaluate countermeasures to address the problems experienced by older drivers on freeways. Project consultants Dr. Martin Pietrucha and Dr. Robert Dewar assisted in the development of the research recommendations.

These seven project activities are described in the remaining sections of this report.

2. TASK ANALYSIS/LITERATURE REVIEW

This section identifies and classifies the age-related characteristics of older drivers that adversely affect their abilities to operate automobiles safely and efficiently on freeways. Known behavioral requirements of freeway operation were matched with deficiencies known to occur in elderly populations in order to identify the specific aspects of freeway driving in which the older drivers present a risk to themselves and others.

The lack of empirical data led to the formal analytic approach used here. Empirical data on age-diminished capabilities related to freeway driving were incorporated into the analysis wherever they were available. However, such data are meager. The older drivers are underrepresented in freeway accidents, presumably due to reduced exposure, i.e., they do not drive as much on freeways as do younger drivers, and the characteristics of freeways tend to minimize the consequences of their limitations. Because of this, previous studies of older driver errors and analyses of accidents involving the older drivers have concentrated on urban and suburban driving. We know, for example, that older drivers are heavily overrepresented in left-turn accidents, which obviously do not occur on freeways.

Because the process is analytic rather than empirical, the results must be treated as *hypotheses* as to which aspects of freeway driving are particularly vulnerable to age-diminished capabilities. The objective of the process is not so much to provide answers, rather it is to be sure we are asking the right questions.

The section is divided into three parts:

- *Summary of Age and Freeway Driving Tasks* — A summary of age-related deficiencies in relation to specific freeway driving tasks.
- *Age-Affected Freeway Driving Tasks* — A detailed analysis of freeway driving tasks, identifying specific behaviors that involve characteristics affected by age.
- *Age-Related Characteristics* — Identification of age-related characteristics that can influence freeway driving, as determined from a review of scientific and technical literature.

SUMMARY OF AGE AND FREEWAY DRIVING TASKS

This section summarizes the detailed analysis of freeway tasks and age-diminished capabilities. It lacks direct one-to-one relationships between the two sets of study variables. Each age-diminished capability can affect a range of tasks, while each task can be affected by a range of capabilities. This summary is organized in terms of freeway driving tasks. For each freeway driving task, the effect of diminished capabilities is described. The description does not detail the diminished capabilities themselves, nor does it include tasks that are common to all driving, except where effects are particularly severe.

1 BASIC DRIVING TASKS

- ***Control.*** Tasks required in controlling the direction and motion of the vehicle without regard to specific characteristics of the highway traffic environment.

  Directional Control—Reduced visual acuity, visual field, and eye height limit perception of direction from surface streaming and ability to judge lateral clearance. Along with reduced tracking ability, the result may be wandering within lane. While these diminished capabilities affect all lane keeping, their effect in freeway operation is aggravated by the high speed of freeway travel.

  Speed Control—Reduced motor coordination and endurance lead to speed fluctuations. Compensating use of cruise control may lead to the inclination to change lanes rather than adjusting speed when overtaking vehicles ahead, exposing the driver to the risk involved in lane changing.

- ***Speed Selection.*** Self-recognized loss of sensory and perceptual ability, along with diminished directional control, can result in slow travel and being passed more frequently.

- ***Position Selection***

  Lane Selection—Difficulty in judging clearance to the right encourages use of left lane for through travel, creating an obstruction to overtaking traffic. Vehicles are forced to pass on the right where they are less easily seen and would be vulnerable to right, blind-side lane changes without adequate visual search.

  Following Distance—Limitations in attention and detection of motion reduces responsiveness to headway changes, necessitating a larger following distance for older drivers. The need is particularly great during conditions of poor visibility, given limitations in contrast sensitivity, low contrast acuity, and low illumination acuity. Greater following distance also allows more time to respond to traffic interruptions, helping to offset limitations in choice reaction time, information processing, and attention sharing.

  Lateral Clearance—Because of difficulties in judging clearance to the right, older drivers tend to use vehicles to the left as a guide in establishing lane position, particularly when the lane is narrowed by construction or vehicles.

  Clearance Behind—Characteristically slow driving exposes older drivers to rapid overtaking and tailgating. This vulnerability can be minimized by driving in the right-most available lane and changing to the right lane when overtaken or tailgated, as well as signaling intention to change lanes well in advance.

- ***Visual Search.*** While the diminished visual capabilities of older drivers increases the importance of visual search, they also serve to limit many forms of visual search itself.

Visual Search Ahead—While older drivers can compensate for their slow response by concentrating their gaze well down the road, the extent to which they sense and perceive distant highway and traffic conditions, as well as nearby signs or signals, is degraded by limitations in general attention, visual acuity, attention sharing, and possibly field dependency. As drivers age, their sphere of attention becomes more constricted, with the result being that they are less likely to perceive hazardous conditions outside of the fovea. And, when such conditions are detected, they tend to become the focus of attention.

Visual Search to the Side—Limited freedom of head rotation, coupled with restriction in visual field tend to limit visual search to the side. During lane changes, these limitations can result in failure to detect other vehicles in the right- and left-rear quarters of the driver's vehicle. Detection can be improved with interior and exterior mirrors that provide a wider view to the rear without the distortion inherent in certain parabolic mirrors.

Visual Search Behind—The characteristically slow driving of older drivers encourage greater dependence upon side and rear-view mirrors, use that is somewhat restricted by limitations in attention sharing and, at night, limited glare resistance and glare recovery.

Interior—Limitations in parafoveal attention, attention sharing, visual acuity, and visual accommodation interfere with use of instrument displays that are of particular value to older drivers in monitoring speed, steering wheel/engine status, and distance to the next exit.

Attentional limitations of older drivers encourage minimizing distraction from passengers, or from manipulating secondary controls, or they encourage the use of the passenger as a navigator.

- ***Communication***. There is no evidence that older drivers are deficient in communicating their intentions to others. One element of communication is making one's presence known by keeping the vehicle where it is visible to other drivers. Older drivers may be less knowledgeable than others as to the hazards of driving in someone else's blind spot for a lengthy period.

2 MANEUVERING

- ***Passing***. While the passing of vehicles on freeways is relatively infrequent among older drivers, the risk is elevated by limitations in visual search before lane changing that result from diminished attention sharing and restricted head rotation.

- ***Entering Freeways***

Entering from a Ramp—Freeway entrances by older drivers are characterized by failure to yield right-of-way, improper lane use, indecisive merges, and lane straddling. Because of limited attention sharing, older drivers are particularly prone to rear-end collisions with vehicles ahead while looking upstream. One risk can be reduced by waiting until a vehicle ahead has entered the freeway before entering. Also, limitations in attention sharing, accompanied by lack of knowledge, result in a tendency by older drivers to drive down to the end of an entrance lap and wait for a gap rather than merging at speed. Finally, the difference between the direction of a destination and the direction of an entrance ramp (i.e., the ramp goes north, yet the driver wants to go south) can lead to confusion.

Entering from Roadside—Lacking knowledge of proper procedure, older drivers frequently pull onto a freeway from a dead stop rather than accelerating to speed along the roadside before entering.

- ***Leaving Freeways***

  Leaving at an Exit—Limitations in sign information processing, visual acuity, and lack of knowledge as to common exit configurations may lead older drivers to slow down excessively while still on a freeway, while indecision can even result in a stop at a freeway exit.

  Exit to the Roadside—Lacking knowledge of proper procedure, older drivers tend to reduce speed excessively while still on the freeway, give inadequate warning, and choose inappropriate places to stop. Lack of visual acuity may also contribute to selecting inappropriate places to stop (obstructions, degraded surfaces).

- ***Toll Plazas.*** While there is no evidence that toll plazas are particularly hazardous for older drivers, the presence of merging vehicles, traffic interruptions, signs indicating special lanes and toll charges, and searching for toll cards or money overburden the attention-sharing and information-processing abilities of older drivers. Lane changing at toll plazas is risky for reasons not reported earlier. Depositing money or tickets can be difficult for some drivers with limited range of motion.

3 ABNORMAL CONDITIONS

- ***Reduced Visibility.*** The limited visual acuity of older drivers makes their driving at high speed under rain, fog, snow, or darkness particularly hazardous, and it encourages high beams except when following, and pulling off the road completely under extreme visibility limitations (e.g., patch fog). Older drivers can overcome some of these effects by using sunglasses to reduce eyestrain and fatigue, operating in far-right lanes at night to minimize glare, and minimizing interior lighting.

- ***Reduced Surface Friction.*** Diminished visual acuity may reduce ability to detect slippery surfaces, while diminished motor coordination may reduce the ability of older drivers to control acceleration, braking, and small steering corrections on slippery surfaces.

- ***Wind.*** Older drivers of oversized vehicles (motor homes and trailers) may be unprepared for the effect of steady-state and varying wind on lane keeping.

- ***Temperature*** — N/A

- ***Emergency Vehicles*** — N/A

- ***Vehicle***

  Oversized Vehicle (See Wind)—Since they frequently use motor homes and pull trailers, older drivers are particularly vulnerable to the difficulty in handling oversized vehicles, especially on windy days when the vehicles are exposed to strong crosswinds.

  Loads on Vehicle—Large loads carried on roof racks lead to risks similar to those for oversized vehicles.

  Breakdown—Because of their frailty, many older drivers gain particular benefit from having cellular phones that will allow them to summon help quickly and without publicizing their vulnerability, and to remain in the vehicle with the doors locked while awaiting help.

- ***Other Road Users.*** Other vehicles, particularly tractor trailers, have a special effect on older drivers. Beyond the general apprehensiveness they cause, heavy vehicles cause air turbulence when passing that drivers may not anticipate and which may tax their coordination.

- ***Construction Zones.*** In construction areas, the older driver's limitations and visual acuity, selective attention, attention sharing, and information processing lead to confusion and slow driving, particularly in the presence of construction personnel and vehicles.

4 EMERGENCIES

Because of the separation of opposing lanes of traffic on freeways, situations requiring unusually rapid or precise responses from drivers are less frequently encountered on freeways. While diminished motor coordination may limit the ease with which older drivers respond to emergency situations, it is not primarily a freeway problem.

5 DRIVER READINESS

- ***Travel Planning.*** With an abundance of free time, older drivers use freeways extensively for long trips. Diminished capabilities and vulnerability to fatigue give rise to special requirements for freeway travel, including:

  - Timing travel so as not to encounter heavy traffic.

- Avoiding travel under adverse weather conditions.

- Modifying travel schedule for short daily trips, frequent rest stops, and to avoid conflicts with sleep/wake cycle.

- Planning route in advance and using simplified maps to avoid navigational errors.

• ***General Health***. Because of diminished capabilities and susceptibility to fatigue, older drivers may consider having a general physical exam and checks of vision and hearing before embarking on extended freeway travel.

• ***Fatigue Prevention***. Because of heightened susceptibility to fatigue, fatigue prevention is particularly important for older drivers while driving on freeways. Precautions include frequent rest breaks; relief drivers; use of sunglasses (when appropriate); modified driving techniques, including longer following distances and lower speeds; attentiveness to signs of fatigue; and complete termination of travel (temporary remedies successful for younger drivers are not appropriate for the older drivers).

• ***Medication***. The combination of multiple medications and diminished capabilities presents a particular hazard in high-speed, lengthy freeway travel. Safety requires avoiding drugs that further diminish capabilities, avoiding travel when affected by drugs, and not mixing drugs with alcohol.

6 VEHICLE READINESS

The vehicle being driven by older drivers in freeway travel influences the extent to which diminished capabilities affect driving safety and mobility.

• ***Vehicle Purchase***. Vehicle characteristics that influence their safety and mobility in freeway operation include:

- Size, weight, and construction that will maximize survivability, without making the vehicle difficult to handle.

- Safety features including airbags, panoramic mirrors, and automated braking.

- Mobility features, including power steering, cruise control, and in-vehicle navigation aids.

- Comfort features, including adjustable contoured seats and climate control.

• ***Maintenance***. Prolonged high-speed operation and infrequent service facilities call for high-level maintenance, including frequent inspection, routine servicing, and sufficient fuel supplies.

AGE-AFFECTED FREEWAY DRIVING TASKS

This section presents an inventory of tasks required in operating automobiles on freeways. Those specific elements of freeway operating tasks that are potentially vulnerable to the effects of age-diminished capabilities are identified, along with the specific capabilities that: (1) are judged to be involved in carrying out the particular task element and (2) are among the capabilities identified as declining with age.

Task Analysis

The term "analysis" refers to "separation of a whole into its component parts." *Task analysis* involves the separation of a task into component behaviors. It was developed in the 1950's as a means of predicting the behavioral requirements that would be created by complex hardware systems (weapons, communication, transportation, etc.) while they were still on the drawing board, thus making it possible to select and train operation and maintenance personnel to use the hardware system.

The purpose of a task analysis is not to discover new things about a task, but rather to create a framework that allows discovery to take place. Only when *all* of the tasks that are required in driving on freeways are known can the demands that are placed upon drivers and the effects of age upon the ability to meet those demands be identified. Task analysis is a process, not a product; documentation of a task analysis comes in the form of "Task Descriptions." It should not be confused with empirical methods of studying actual task performance, such as time and motion study. Since the process is one of formal analysis, its results must be treated as *hypotheses* as to the effects of age-diminished capabilities upon freeway driving.

This analysis of freeway driving tasks borrows from a set of task descriptions representing the full array of driving tasks, resulting from a task analysis conducted over 20 years ago (McKnight and Adams, 1970). Specific excerpts for the freeway driving analysis include both task elements that are fundamental to all aspects of driving, and task elements that are specific to freeway driving. Excluded are all tasks that do not arise in connection with freeway driving, such as traversing intersections and passing in the presence of oncoming traffic.

Information Provided

As noted, the task analysis merely provides a framework. The true content of this section lies in the identification of those task elements involving capabilities that have been found to diminish with age. The specific capabilities affected are listed in italics beneath the element involved. The breadth in which the capabilities are identified corresponds to the breadth of the age effect. For example, the term "visual acuity" means that the particular behavior demands visual acuity in all its aspects and would be adversely affected by diminished acuity in any form. In contrast "low illumination acuity" means that the behavior is particularly demanding of low illumination acuity and the age effect would be limited to loss of the specific capability.

For most of the behaviors, the relationship between diminished capability and the behavior involved is rather obvious. For example, it is not difficult to recognize the effect of reduced visual acuity upon being able to read destination signs at a sufficient distance to permit comprehension of the entire message before passing the sign. However, where a relationship is not obvious, additional information is provided. For example, the importance of peripheral vision to maintaining lane position might not be appreciated if one were not aware of research on the role that stimulus "streaming" toward the periphery plays in the perception of position on the road. Wherever such additional information is needed to clarify relationships, it is provided.

Age-Induced Task Elements

Certain task elements that have been identified are not inherently a part of the task to be carried out, but have been prescribed specifically to neutralize the effect of diminished capability upon performance of the task. For example, when drivers do not have the correct change or ticket at a toll both, performance of the task calls for coming to a stop at the toll booth before searching. While this is a good practice for everyone, it is especially appropriate for older drivers in order to circumvent the difficulties that older drivers would have in sharing attention between driving up to the toll booth and finding change. In those instances where the particular age-diminished capability gives rise to a task element, the task element appears in brackets, e.g., *[attention sharing]*.

Structure of the Analysis

The task descriptions follow a hierarchical structure. The first set of *basic driving* tasks includes all the tasks involved in operating a motor vehicle without any constraints. The second set of tasks involves the requirements imposed on basic driving by specified freeway *maneuvers*. The third layer of tasks superimposes upon basic driving and maneuvering tasks the additional requirements involved in accommodating *abnormal conditions*, including reduced visibility, reduced traction, extreme temperature, wind, driver states, and vehicle characteristics. The next level in the hierarchy involves responses to *emergencies* arising in the course of the preceding tasks, where the term "emergency" refers to situations requiring extremely rapid or precise responses, not simply unplanned events such as vehicle breakdowns. The final level in the hierarchy involves *non-driving* tasks that predetermine the safety of driving, including making one's self and one's vehicle ready to drive.

1 BASIC DRIVING—This category involves the tasks that constitute the basic elements of driving, regardless of the maneuver being performed. They include control, speed determination, position determination, visual search, and communication.

- Control—Tasks in this category are those required for control of vehicle direction and speed, without regard to specific characteristics of the highway traffic environment.
  - Directional Control.
    - Maintains grip on wheel.
      - Uses both hands at all times—*The prevalence of hemiplegia (stroke) with age can result in the inability to use one arm. While steering control knobs permit one-handed steering, the long trips that frequently characterize freeway driving among older drivers can hasten fatigue.*
      - Maintains firm grip—*A loss of strength at advanced ages, coupled with increased susceptibility to fatigue, can hamper ability to maintain a firm grip on the steering wheel over long periods of time.*
    - Steers as necessary to maintain position in center of lane.
      - Static acuity, field—*Drivers perceive direction from the streaming of surface stimuli (pavement texture, lane delineators) within the central visual field; they use peripheral stimuli (lane delineators) to maintain center position. Deterioration in visual functions of static visual acuity, contrast sensitivity, and peripheral vision may limit the ability to maintain a desired, appropriate lane position.*
      - Static acuity, height—*Combination of short stature and visual limitations makes it difficult for some older drivers to judge clearance to the right of the vehicle and, therefore, they rely upon the left-lane delineator for lane position. The result is a tendency to shade the left side of the lane, which can, in turn, encourage selecting the left-most travel (passing) lane.*
      - Tracking—*The high speed of freeway travel magnifies the effect of the above limitations.*
    - Steers as necessary to track curves. *Tracking.*
    - Steers as necessary to avoid potholes and other road irregularities. *Tracking.*
    - Maintains control under circumstances in which factors (e.g., wind, potholes, grooves in road) tend to redirect vehicle. *Diminished strength and increased susceptibility to fatigue limit the responsiveness of older drivers to these disruptions.*
  - Speed Control.
    - Maintains speed with as few fluctuations as possible. *Motor Coordination.*
    - Makes speed changes gradually.
    - Activates cruise control when traffic permits. *[Fatigue.]*
    - Use of cruise control may increase lane changing.
    - Checks speed against speedometer periodically. *After prolonged periods of travel at high speed, drivers tend to adapt to the visual, kinesthetic, and auditory velocity cues with the result that they may underestimate their speed. The result may be gradually increasing speeds.*
    - Keeps car in gear at all times (does not coast down long declines).
    - If necessary to reduce speed, initiates change well in advance.
  - Deceleration.
    - Applies brakes evenly with amount of pressure appropriate to the situation.
    - Avoids skidding by anticipating and avoiding conditions that might reduce surface friction. These include excessive deceleration, areas of decreased friction, excessive speeds in turns and curves.

- Speed Selection—Deciding what speed is appropriate to prevailing conditions.
  - Legal Limits.
    - Does not exceed the maximum limit. *While exceeding the speed limit is not a characteristic of older drivers, some may feel pressured into doing so in order to avoid interfering with and incurring the displeasure of others.*
    - Does not fall below the minimum legal speed. *Sensory, Perceptual — Inability to see clearly and to process visual information quickly often leads to slower driving in order to lengthen available response time.*
  - Visibility. Speed must not exceed that which allows the vehicle to be stopped quickly enough to avoid anything that appears in the driver's path, i.e., stopping distance must not exceed sight distance.

    Visual acuity — Reductions in static, dynamic, and low contrast acuity with age reduce sight distance and, therefore, maximum safe speed.
  - Friction.
    - Must adjust speed to reduction in pavement surface friction. *Reduced friction lengthens stopping distance, necessitating a reduction in speed to keep stopping distance within available sight distance.*
  - Traffic. Increased traffic volume generally reduces vehicle headways and escape paths, necessitating reduced speed.
  - Hazards. Decreases speed in response to hazards ahead that could enter path. Includes vehicles, pedestrians, animals on the roadside.
- Position Selection—Deciding what position on the freeway is appropriate to prevailing conditions.
  - Lane.
    - Travels in right-most lane when operating at below legal speed limit.
    - When more than two lanes are available, utilizes center lanes for through traffic when operating close to the speed limit.
    - Where practical, uses left lane to pass.
    - Changes lanes as little as possible.
    - Avoids left lane except when passing. *Difficulty in judging clearance to the right encourages older drivers to use the left lane for through travel, creating an obstruction to overtaking vehicles. The overtaking driver is forced to change lanes and to pass on the right, where the older driver is less likely to see them, particularly given characteristically reduced visual search prior to changing lanes.*
  - Vehicles Ahead.
    - Maintains greater than 2-s following distance behind vehicles ahead. *[General Attention, Motion in Depth - Reduced responsiveness to headway changes necessitates a larger following distance for older drivers.]*
    - Responds quickly to changes in headway to reduce the need for abrupt speed changes and risk of collision with vehicles ahead or behind. *General Attention, Motion in Depth. Reduced responsiveness to headway changes, if not accompanied by increased following distance, may increase the chances of rear-end collisions.*
    - Increases following distance behind: (1) large vehicles that obscure view ahead, (2) motorcycles, which have high injury potential, and (3) vehicles carrying protruding loads.
    - Increases following distance in conditions of reduced visibility, including fog, rain, snow, other weather-related conditions, and darkness. *[Reduced Contrast Sensitivity, Low Contrast Acuity, Low Illumination Acuity.]*

Increases following distances in conditions of reduced surface friction, including rain, snow, ice, gravel, and other rough road surfaces.

Allows more space ahead, by adjusting speed or changing lanes, when encountering traffic interruptions, including:

Drivers who are indecisive at exit ramps.

Drivers making last-moment lane changes to get to exits.

Drivers entering at ramps.

Drivers ahead who may be changing lanes to pass slower traffic.

Distracted or impaired drivers.

Vehicles, pedestrians, animals on the roadside that could enter path. *[Choice Reaction Time, Information Processing, Attention Sharing.]*

- Vehicles to the Sides.

Drives in the center of the lane to maximize distance from vehicles on both sides. *Difficulty in judging clearance to the right may result in a tendency to drive closer to the left side of the lane.*

When construction or vehicles intruding on the lane narrow lateral clearance, minimizes clearance on left side, where visibility is greater. *[Height.]*

- Vehicles Behind.

When followed closely:

Changes lanes to increase headway. *[Slow Travel Vulnerability - The vulnerability of older drivers to physical injury, including whiplash from rear-end collisions, warrants maneuvering to reduce the likelihood of collision.]*

Leaves more room ahead to reduce risk of rear-end collision if it is necessary to decelerate quickly. *Knowledge.*

Continues to monitor situation behind without losing track of what's going on ahead. *Attention Sharing.*

Avoids sudden decelerations. *Knowledge. Older drivers may flash the brakes to "scare them into backing off." Something that only serves to provoke tailgaters into unsafe actions.*

Signals intention to change speed or direction. *Drivers should do this anyway, but it is more critical when being closely followed.*

When changing lanes, does not pull in front of other vehicles so close as to leave insufficient space between driver's vehicle and vehicles behind. *Head Rotation.*

Avoids backing up on the freeway. *Knowledge.*

- Visual Search. *The diminished visual abilities of many older drivers increases the importance of search behavior. In addition, the shorter stature of some older drivers impacts their ability to see, especially those vehicles immediately in front of the vehicle.*

- Visual Search Ahead.

Straight ahead.

Focuses attention well down the road (greater than 12 s) to allow ample time for anticipating speed/direction changes. Avoids fixating attention just in front of the car. *Visual Acuity.*

Attends to roadway/traffic conditions ahead, including turns, curves, signs, other road users, pavement condition. *Visual Acuity, General Attention.*

Examines trajectory of hills and curves. *Field Dependency: There is no evidence that field dependency is in any way related to the ability to judge the horizontal and vertical curvature of the roadway; its relationship to accidents is uncertain and could be mediated by other variables entirely.*

However, if it has any influence upon driving, this is one task in which figure-ground relationships may be involved.

Examines road signs, including signs identifying upcoming exits and "exit only" lanes. *Visual Acuity, Attention Sharing, Field Dependency.*

Identify cues (brake lights, closure) that vehicle or vehicles ahead are slowing. *Contrast Sensitivity, Visual Acuity, Motion Detection.*

Ahead to the sides. Visually sweeps the road from side to side to detect path threats, including vehicles ahead signaling lane changes and conditions encouraging lane changes. *Parafoveal Attention.*

Avoids fixating on potential hazards. *Attention Sharing.*

- Visual Search to the Side.

  Observes areas in the rear quarters to either side of the vehicle, prior to lane change. *Visual Field; Head Rotation.*

  Views right- and left-side mirrors. Observes condition of the shoulder in case it becomes necessary to leave the road.

- Visual Search Behind.

  Uses rearview and side mirrors frequently to monitor following traffic, especially when traveling slower than other traffic or on downgrades. *[Slow Travel, Increased Vulnerability]; Use of Mirrors.*

  Avoids overlong glances in mirrors. *[Attention Sharing, Information Processing.]*

  Avoids glare from mirrors at night by using two-position mirrors, if available, and by avoiding mirrors if followed by vehicle with high beams on. *[Glare Resistance, Glare Recovery.]*

- Interior.

  Monitors gauges to detect/avoid vehicle-related problems such as overheating, running out of gas. *Visual Acuity, Accommodation, Attention Sharing.*

  Monitors speedometer to avoid exceeding, or driving too far below, speed limits.

  Avoids unnecessary distraction from passengers, operating radio and secondary controls, etc. *[Attention Sharing.]*

  Uses navigator or memorizes directions to avoid having to consult maps when driving. *[Information Processing.]*

  Monitors odometer to aid in determining location and predicting distance to exits. *[Information Processing.]*

- Auditory Search.

  Identifies and interprets sounds indicating possible hazards or vehicle malfunctions. *Hearing; Knowledge.*

  Doesn't compromise ability to hear, e.g., by playing radio or not using hearing aid properly. *[Auditory Acuity.]*

- Olfactory Search—Identifies and interprets important odors indicating possible vehicle malfunctions. *Olfaction; Knowledge.*

• Communication.

- Presence.

  Avoids remaining in the blind spot of other drivers. *Knowledge.*

  Sounds horn when appropriate to warn other drivers.

  Short blast for warning.

  Long blast for emergency.

  Not to express displeasure or to greet.

- Intention.

  Uses turn signals to communicate intention to change lanes.

When forced to decelerate suddenly, flashes brakes to warn following drivers, gives hand signal where appropriate or necessary.

2 MANEUVERING—This section addresses the effect of superimposing upon basic driving the special requirements of fundamental freeway maneuvers.

- Passing and Lane Changing.
  - Deciding.
    - Operates in lane that minimizes the need to pass other vehicles. *Elevated chance of, and vulnerability to, lane change collisions are offset by slow driving and limited lane changes among older drivers.*
    - Notes lane markings or signs requiring vehicles to remain in lane.
    - Notes signs that drivers ahead in adjacent lanes may change position and become hazards.
  - Speed.
    - Accelerates quickly past vehicle to minimize time spent alongside.
  - Position.
    - Passes to the left of other vehicle to maximize visibility to driver being passed.
    - Initiates lane change gradually to permit time for unseen vehicles to accommodate the maneuver.
    - Returns to the travel lane after completing pass. Does not remain in passing lane.
  - Search.
    - Checks rearview and side mirrors before initiating lane change. *Attention Sharing.*
    - Looks over shoulder to check the blind spot before initiating lane change. *Attention Sharing; Head Rotation.*
    - Observes vehicles in far lanes for indication of change into the same lane to which the driver is preparing to enter. *Attention Sharing; Head Rotation.*
  - Communication.
    - Activates turn signal sufficiently in advance of lane change to allow other drivers to observe it and accommodate maneuver.
    - Deactivates signal after completing lane change.
- Entering Freeway.
  - Entrance from Access Road (entrance ramp, acceleration lane, including roadside service areas with access lanes). *Research discloses common performance deficiencies of older drivers in entering freeways, including failure to yield, improper lane use, indecisive merges, and lane straddling.*
    - Speed.
      - Regulates speed on entrance to await suitable gap in traffic.
      - Accelerates to match as closely as possible the speed of traffic on the highway before attempting to enter.
    - Position.
      - Enters highway in first acceptable gap. *Knowledge.*
      - Avoids reaching the end of access lane if at all possible.
      - If forced to stop:
        - Allows vehicle ahead to vacate access lane before moving in order to minimize attention sharing. *[Attention Sharing.]*
        - Awaits gap of sufficient size before attempting to enter highway.
        - Maintains normal following distance from any vehicle ahead, but does not cut too close in front of vehicle on freeway to do so.
        - Avoids leaving access lane and/or entering main roadway prematurely.

Makes lane change as quickly and safely as possible, i.e., does not delay transition between lanes.

Search.

Observes signs indicating destination rather than relying on sense of direction since direction of freeway may not be apparent from location or direction of the ramp. *The relation of the direction/location of a ramp to the ultimate direction often conflicts with the experience of older drivers.*

Looks specifically for "wrong way" and "do not enter" signs. *Attention Sharing.*

Looks well ahead to determine:

Whether ramp joins freeway on right or left.

The length of acceleration ramp, if any.

Whether other ramps cross or join the selected entrance ramp.

Driver glances over shoulder as necessary to select appropriate gap in traffic. *Attention Sharing; Head Rotation.*

Uses mirror to monitor gap.

To the extent possible, aligns car with highway to afford mirror view of overtaking traffic.

Compares direct and mirror view of selected gap, uses side mirror to survey overtaking traffic.

Shifts attention rapidly between mirror and path ahead.

Does not shift glance from path ahead for more than an instant.

Looks well ahead through intended path when glancing forward to gather as much pertinent information as possible.

Communication.

Activates turn signal upon entering ramp.

Uses correct hand signals, if necessary or appropriate.

Deactivates signal, if necessary, after entering freeway.

- Entering from Roadside (i.e., shoulder area).

Speed. If surface is paved, accelerates to the speed of traffic before initiating entry. *Knowledge.*

Position. Accepts gap suitable to speed of traffic and ability to accelerate.

Search.

While stationary, looks over shoulder for gap in overtaking traffic. *Head Rotation.*

When moving, uses mirrors to monitor the approach of the selected gap.

Communication.

Activates turn signal upon entering ramp.

Deactivates turn signal after entering freeway.

Control.

If entering from dirt, gravel, or misaligned pavement.

Steers back onto road sharply (rather than gradually) to avoid losing control as tires enter roadway. *Knowledge; Coordination; Strength.*

Steers quickly back down the road to avoid overshooting after tires have entered roadway. *Knowledge; Coordination; Strength.*

- Leaving.

- Leaving at Exit.

Speed.

Maintains a speed as close to the maximum limit as possible while still on the highway to prevent conflict with following vehicles. *Visual Acuity; Information Processing; Knowledge.*

Upon exiting, operates at posted speed or below the maximum permitted by rate of curvature and degree of superelevation.
If part of the exit is shared with drivers entering the freeway, adjusts speed to share roadway space with those drivers.
Avoids stopping upon exiting. *Information Processing.*
Avoids shifting gears in a curve by shifting, if necessary, before the turn.
If turn is missed, avoids backing up on highway or along roadside. *Knowledge.*

Position.
Enters lane closest to exit lane well before reaching it. (Avoids crossing lane to reach exit.)
Enters deceleration lane at first opportunity.
Steers into deceleration lane smoothly.
Moves into deceleration lane as quickly and safely as possible.

Search.
Checks mirrors before slowing down on freeway.
Observes signs showing speed limits on ramp.
Glances at speedometer to ensure that vehicle is traveling at the right speed prior to entering and while on exit ramp. *Attention Sharing.*
Looks well ahead along intended path of travel. *Visual Acuity.*
Observes shape and length of deceleration lane and ramp as early as possible to determine the appropriate vehicle speed and trajectory.
Determines whether other ramps cross or join the selected exit ramp.
Where branches in the ramp lead to different destinations, looks for signs indicating which branch goes where.
Observes the end of ramp to determine the need to stop or modify speed based on presence of stop signs, traffic lights, stopped or slow vehicles.

Communication.
Activates turn signal well in advance of leaving freeway.
Deactivates turn signal, if necessary, after exiting.

- Exit to Roadside.

Speed.
If followed, maintains posted speed while on freeway. *Knowledge.*
If not followed, reduces speed before entering roadside.
Checks speedometer to make sure not to underestimate the speed at which the vehicle leaves the road.

Position.
Avoids exiting to median area except in emergency.
Exits to the right from right lane only.
Gradually enters roadside.
Does not stop until as far off the road as safely possible. *Knowledge.*
Looks for overtaking traffic before attempting to open door/exit vehicle.

Search.
Looks well ahead along roadside for parked vehicles, obstructions, degrades surfaces. *Visual Acuity.*
Checks mirrors for following vehicles before slowing down on highway.
In stalled traffic, uses mirrors and looks over shoulder for vehicles driving along roadside, before attempting to exit. *Knowledge; Head Rotation.*

Communication.
Activates signal before leaving freeway.
If followed, flashes brake lights before slowing on roadway. *Knowledge.*

If possible, selects roadside area that is visible to overtaking traffic from at least 200 ft (61 m) away. *Knowledge.*

Once stopped, uses flashers, flares, triangles to communicate presence.

Control.

Maintains maximum control of vehicle by selecting best available area at which to exit, e.g., paved rather than gravel, dry rather than wet, hard rather than soft, firm rather than slippery (snow, ice). *Visual Acuity.*

Brakes as gently as possible on surfaces offering poor traction, e.g., dirt, gravel, loose pavement, ice, snow. *Coordination.*

- Toll Plazas.
  - Observes signs and other warnings of toll plaza ahead. *General Attention.*
  - Decelerates as appropriate:

    Not so soon as to be a hazard to other traffic.

    Soon enough to comply with posted speed signs or to avoid approaching plaza at a speed that requires hard braking to stop in time.

    Observes signs warning of need to decelerate.
  - Observes toll booths ahead to select a booth based on:

    Presence or height of overhead structure in relation to vehicle height.

    Whether booth is open.

    Whether booth requires exact change and whether driver has exact change.

    Whether a given lane is intended for passenger car traffic.

    Which lanes are closest to the driver's lane, so that the driver does not need to cross lanes of shifting traffic to get to the selected booth.

    Any applicable restrictions on vehicle size for certain lanes. *Attention Sharing; Information Processing.*
  - Enters appropriate lane.

    Changes lateral position as necessary to get into line for toll booth.

    Checks for traffic in adjacent lanes and approaching from the rear.
  - Gets money/toll card ready without diverting attention from the driving task.

    If possible, has passenger get money/toll card ready.

    If no passenger, has money/toll card ready in an accessible place in the car.

    If necessary, waits until stopping in line at the toll booth to get money/toll card ready, rather than diverting attention from driving. *[Attention Sharing.]*
  - Pulls vehicle into booth area properly. *Height.*

    Parallel to the lane.

    Close enough to basket or attendant to be able to exchange money/toll card without difficulty.

    Not so close as to risk colliding with the booth or associated equipment.
  - Deposits money/ticket — If money/toll card is dropped or misses change basket, does not exit vehicle to get it, but adds more change or summons help from toll plaza personnel. *Reach, Knowledge.*
  - Waits for green signal or gate arm to lift before starting away from toll booth.
  - Reenters freeway.

    Selects lane on freeway to enter while in merge area after toll plaza.

    Accelerates to freeway speed quickly to avoid obstructing traffic behind, but not so quickly as to overtake vehicles ahead.

    Changes lateral position as needed to get into selected lane, checking for traffic in adjacent lanes and approaching from the rear. *Head Rotation.*
- Construction Areas. Adjusts speed and position appropriately to avoid hazards due to restricted travel areas associated with construction zones (e.g., barriers, unpaved areas).

Visual Acuity, Height: The directional control requirements are intensified by the narrowing of lanes and frequent lack of shoulders in construction zones.
Information Processing: The directions for navigating through some construction areas can be difficult for older drivers to decipher.
Attention Sharing.

3 ABNORMAL CONDITIONS—This section addresses the effect of superimposing upon the previously enumerated freeway tasks the special requirements imposed by unusual characteristics of the environment, driver, or vehicle. Because of the difficulty in coping with the conditions described, older drivers tend to avoid driving altogether.

- Reduced Visibility (rain, fog, darkness).
  - Adjusts speed and following distance to compensate for lack of visibility along path ahead. *Knowledge; Low Contrast Acuity; Low Illumination Acuity.*
  - Pulls to the roadside before reaching patch fog; waits for fog to lift. *Knowledge.*
  - Uses headlights when appropriate, e.g., darkness, inclement weather, in tunnels. *Knowledge.*
  - At night, uses high beams except when following another vehicle. *[Low Illumination Acuity]; Knowledge.*
  - Does not operate vehicle with parking lights alone.
  - If forced to stop at roadside, activates emergency flashers.
  - Operates in lane farthest to the right to minimize glare from oncoming vehicles. *[Glare Resistance, Glare Recovery.]*
  - Uses sunglasses, visor, when necessary to reduce eyestrain; removes sunglasses when necessary if lighting conditions change, e.g., going through tunnels. *[Visual Fatigue.]*
  - Uses windshield washer/wipers to clean windshield when necessary. Adjusts wiper speed to intensity of rain.
  - Uses defroster and/or air conditioner to clear windshield of ice, moisture. Uses clean cloth if above method is insufficient.
  - Under very dark conditions, constantly shifts gaze to compensate for reduced sensitivity of central vision. *[Low Illumination Acuity.]*
  - Avoids using bright lights in the vehicle (e.g., matches, dome lights) that cause eyes to adapt to the brighter light. *[Low Illumination Acuity]; [Glare Recovery.]*
  - Adjusts intensity of panel lights as necessary to see instruments without reducing overall visibility. *[Low Illumination Acuity.]*
- Reduced Surface Friction.
  - Reduces speed proportionally to reduced traction in order to maintain normal stopping distance.
  - Observes signs of reduced traction.
    - Hydroplaning (absence of treadmarks, altered steering characteristics).
    - Puddles in road after or during heavy rain.
    - Mixture of water and oil on the roadway, especially just after start of rain.
    - On bridges and overpasses when temperatures are below freezing.
    - Black areas indicating possibility of glare ice.
    - Areas where road surface is abnormal due to damage or grooving of pavement. *Knowledge; Acuity.*
  - Adjusts speed and/or lane position accordingly.
    - Uses smaller steering corrections. *Fine Motor Coordination.*
    - Reduces acceleration before braking.

If possible, avoids speed adjustment, steering adjustment while under temporary conditions of low traction (e.g., while crossing small patch of ice). *Knowledge.*

Follows in tracks of vehicles ahead.

Remains aware of other vehicles around that may be impacted by change of speed or position.

- Tests brakes periodically to test for/reduce effects of wet brake components.
- Installs tire chains when appropriate.
- If roadway is covered with snow, uses proper techniques for putting vehicle into motion (e.g., rocking), and keeping vehicle in motion (e.g., avoiding stopping, gathering momentum for hills). *Knowledge.*
- If stuck in snow, does not run engine with windows up to keep warm (risk of carbon monoxide poisoning).

• Wind—When conditions of high wind affect vehicle handling, driver should:
- Hold steering wheel firmly.
- Slow down.
- Be prepared to steer against wind to keep vehicle in lane position.
- Avoid overcompensating by steering too hard or continuing to steer when the wind stops. Overcompensation would lead to the vehicle getting out of lane position in the direction of the wind.
- Anticipate the temporary effects of objects that may block the wind (e.g., large vehicles, hills) and be prepared for resurgence of wind when those objects no longer protect vehicle from the wind.
- Keep windows closed to reduce wind noise and to prevent objects from being blown into the vehicle.

• Temperature.
- Adjusts heating/air conditioning to maintain comfortable temperature.
- Monitors gauges for signs of overheating.
- If below freezing, watches for slippery surfaces (wet spots, shaded areas).

• Emergency Vehicles.
- When being approached from behind by an emergency vehicle, pulls over to the farthest right-hand lane possible without disrupting traffic and slows down as much as is safely possible without disrupting traffic.
- Remains aware that more than one emergency vehicle may be near and does not pull back left and resume speed until all emergency vehicles have passed.
- When traveling behind a moving emergency vehicle, does not follow closer than 500 ft (152 m) behind.
- When approaching a stopped emergency vehicle, slows and looks for direction from police or other officials. Watches for more emergency vehicles possibly approaching from behind.

• Driving in Unfamiliar Surroundings.
- Uses navigator when possible to avoid visual and cognitive distraction.
- If lost or disoriented, leaves the freeway and stops in safe place to determine location, ask for directions.
- Adjusts search techniques; uses mirrors to compensate for lack of rearward visibility.
- Adjusts to maneuver limitations, remains in right lane.

• Vehicle.
- Oversized Vehicle (mobile home, trailer).

  Adjusts speed to requirements of vehicle.

  Anticipates effects of increased weight on handling, stopping distance.

Adjusts maneuvering to effects of trailer.
Avoids hard, quick lane changes.
Allows more room behind when changing lanes.
Observes overhead clearance limitations at toll booths and roadside. facilities.
Adjusts to increased effects of wind on the handling of large vehicles.
Distributes loads evenly.
Stops periodically to check the security of trailer and trailed loads.

- Loads within, and on top of, the vehicle.
  Secures all cargo to prevent it from becoming a hazard either within the vehicle or in the roadway.
  Adjusts speed to, and anticipates effects of, increased weight on handling, stopping distance.
  Where possible, loads vehicle so as not to reduce visibility through windows, mirrors, etc. (e.g., does not obscure rearview mirror view by placing objects on rear deck).
  Distributes loads evenly.
  Is attentive to, and compensates for, increased effects of wind and speed on vehicle handling when objects are carried securely on top of the vehicle. *Knowledge.*
  Is attentive to, and compensates for, increased effects of wind and speed on security of cargo on top of the vehicle.
  Stops periodically to check the security of loads.
- Breakdowns.
  Stops as far from travel lanes as possible.
  Uses cellular phone, radio, raised hood to summon assistance. *Use of cellular phones expedites response and is preferred in order to avoid publicizing vulnerability.*
  Remains in vehicle with doors locked. *The vulnerability of older drivers to fatigue, the elements, and the criminal element makes this practice particularly important.*

• Other Road Users.
- Maintains control of vehicle when experiencing turbulence due to passing or being passed by large vehicles, e.g., tractor-trailers. *Knowledge; Coordination.*
- Adjusts speed and position in response to actual and potential pedestrian and slow-moving traffic near construction areas. *Selective Attention, Attention Sharing, Information Processing, Visual Acuity.*

4 EMERGENCIES—Here, the term "emergency" refers only to those conditions requiring unusually rapid and/or precise responses to prevent collision or injury. It specifically excludes tasks arising after breakdowns or accidents. *All of the procedures described in this section require a high degree of perceptual motor skill. Deficiencies among older drivers might result from: (1) cohort effect—less likely to have had specific instruction or experience or (2) deficiencies in basic perceptual motor ability. However, because the emergencies involved are far less likely to occur on freeways than elsewhere, the deficiencies of drivers in handling them are not a true freeway problem and, thus, will not be treated.*

• Skid Recovery.
- Detects skid.
- Attempts to arrest skid.
  Stays off brake.

Oversteers to arrest vehicle rotation.
- Countersteers to damp out rotary motion.
- Steers to prevent overshooting. Continues corrections as necessary. May need to correct in each direction several times before vehicle is under control in desired direction.

• Collision Avoidance. *The design of freeways greatly reduces the likelihood of vehicles for being on a collision course, all but eliminating the prospect of intersecting and head-on collisions.*
- Overtaking (vehicle is slowing or stopping).
  - Slows—Stops in lane, if possible, by modulated braking to maintain directional control.
  - Swerves.
    - Steers into adjacent clear lane if stopping distance is insufficient.
    - Roadside lanes (left and right) least likely to produce conflict with another vehicle.
  - Sounds horn to communicate danger to other road users if possible.
- Converging (adjacent vehicle entering freeway or changing lanes).
  - Slows or stops in lane if behind trailing, converging vehicle and not closely followed.
  - Uses modulated braking to maintain directional control.
  - Otherwise, gives way to the adjacent lane.
  - Sounds horn to communicate danger to other road users if possible.
- Being overtaken. Accelerates and/or changes lanes as necessary to avoid being struck by vehicles from behind.
- Objects in roadway.
  - Decides whether size of object allows vehicle to pass over top of the object.
  - If so, straddles object properly to avoid hitting it with tires.
  - If not:
    - Checks for traffic around the vehicle before attempting to change lanes/slow down.
    - Changes speed and position quickly, but not so quickly as to risk losing control of vehicle.
    - If possible, communicates presence of object to other road users by flashing brake lights and getting out of the way quickly to allow drivers behind to see the object.
- Minimizing Collision Severity. If it is impossible to prevent a collision, steps can be taken to minimize the severity of the collision.
  - Avoid frontal impact in favor of glancing blows by steering away.
  - Prepares to steer to avoid secondary collision.

• Off-Road Recovery. If the vehicle leaves the road, either inadvertently or to avoid collision, the driver follows the correct procedures for re-entering the roadway.
- Grasps steering wheel firmly to keep vehicle headed straight.
- Reduces speed gradually, avoids braking, pumps brakes to maintain steering control if braking is necessary.
- Checks for traffic on the roadway, in all directions, before attempting to pull back onto the road.
- Slows down as much as possible before turning back onto the road.
- If the shoulder is of a different material and/or different height than the roadway:
  - Turns wheels sharply back onto the pavement.
  - Prepares to compensate for tendency of vehicle to shoot across roadway as wheels are directed onto the pavement.

- Vehicle Malfunctions.
  - Tire Failure.
  - Brake Failure.
    - If brakes are obviously beginning to fail, get off the road at a safe place and get assistance.
    - If it is necessary to stop immediately and the brakes are not working normally:
      - Push harder on the brakes. If that doesn't work,
      - Pump the brakes to rebuild pressure in systems. If that doesn't work,
      - Use emergency brakes. Keep the release handle pulled out or
        - the release button pushed in to keep emergency brakes from staying on.
      - Transmission braking.
      - Scrubbing tires, using other objects to slow vehicle.
  - Accelerator Sticks.
  - Hood Latch Failure.
  - Steering Failure.
  - Headlight Failure.
  - Overheating.

5 DRIVER READINESS.

- Travel Planning. Safety is often best achieved by advanced planning to ensure that travel takes place under the most favorable conditions.
  - Travel Decision.
    - Timing freeway travel so as not to coincide with commuter rush hours or heavy holiday and weekend traffic. *[Attention Sharing, Information Processing, Fatigue.]*
    - Avoiding travel under weather, roadway, or traffic conditions that engender risk. *[All Diminished Capabilities.]*
  - On long-distance travel, takes steps to prevent fatigue: *[Fatigue.]*
    - Scheduled stopping points do not involve travel beyond 6 hours.
    - Arranges accommodations in advance to avoid the temptation to push on.
    - Notifies others of destination and keeps them apprised of progress.
    - Plans frequent rest stops.
    - Avoids travel schedule that conflicts with normal sleep/wake cycle.
    - *[Attention Sharing, Information Processing.]*
      - Studies route in advance to minimize navigational errors.
    - Obtains simplified strip maps to consult while driving (as opposed to fully detailed road maps) if there is no passenger to act as navigator.
  - On unfamiliar routes, simplifies navigation.
- General Health.
  - Has physical exam before long trips to avoid potential problems due to poor health. *[General Health.]*
  - Takes steps to avoid potential hazards due to impaired vision and hearing. *[All Sensory Capabilities.]*
    - Has vision, hearing checks and other medical checkups.
    - Wears glasses if necessary.
    - Uses hearing aid if necessary.
    - Modifies driving to allow for impaired senses, e.g., allows greater following distance when depth perception is impaired, increases visual scanning when hearing is impaired.

Does not drive when visual or auditory impairment is too great (e.g., doesn't drive at night if night vision is too poor, does not drive at all if overall vision is too poor).

- Fatigue Prevention. *[Fatigue.]*
  - Takes steps while driving to avoid fatigue.
    - Doesn't plan on driving for periods longer than driver can drive comfortably.
    - Takes breaks to avoid muscle fatigue and/or stiffness.
    - Uses relief drivers when appropriate.
    - Wears sunglasses, when appropriate, to avoid eye strain.
  - Modifies driving to allow for effects of fatigue.
    - Leaves longer following distance.
    - Reduces speed.
    - Allows for longer stopping distance.
  - After prolonged driving, is attentive to signs of fatigue, including muscle fatigue, eye strain, yawning, nodding off.
    - Immediate response — Fresh air, radio, hot liquids, etc.
    - Ultimate response — Terminate travel.
      - Temporary remedies, such as pulling off for a short nap, would not be appropriate for older drivers.
- Medication. *[All Capabilities.]* The use of multiple drugs by older drivers exposes them to the risk of side effects in extended freeway travel.
  - Avoids drugs that affect capabilities involved in driving.
  - If drug use has already taken place, avoids driving.
  - Avoids mixing drugs and alcohol.

6 VEHICLE READINESS.

- Vehicle Characteristics. Paradoxically, the population most deficient in the physical and psychomotor abilities needed to maneuver vehicles tends to purchase vehicles that are the least maneuverable to begin with.
  - Vehicle Construction (size, weight).
    - Should offer high crash protection to increase survivability for population with a high accident severity rate. *[Fragility.]*
    - Within the above constraint, vehicles should be small enough to be easily maneuverable. *[Strength, Fatigue.]*
  - Vehicle Safety Features. *[Vulnerability.]*
    - Occupant protection—airbags.
    - Visibility enhancements—panoramic and other additional mirrors.
    - Collision avoidance—automated brake system, collision warning devices.
  - Mobility Features. *[Strength, Fatigue.]*
    - Power steering.
    - Cruise control.
    - In-vehicle navigation systems.
  - Comfort Features. *[Fatigue.]*
    - Adjustable contour seats.
    - Climate control.
- Maintenance.
  - Prolonged high-speed operation, coupled with the difficulty in obtaining road service on freeways, places a premium on vehicle maintenance, including:
  - Frequent inspection and maintenance.
  - Routine servicing, particularly coolant.
  - Sufficient fuel to reach the next exit.

AGE-RELATED CHARACTERISTICS

This section describes those characteristics of drivers that affect vehicle operation and that may change with advanced years, as well as the effect of those changes on safety. The majority of the discussion is dedicated to age-diminished characteristics such as vision and information processing. There will also be some discussion of other characteristics of older drivers, such as attitudes, knowledge, and exposure, that are related to driver safety.

Very little in the scientific literature relates diminished capabilities of older individuals directly to motor vehicle operation. What we have is a body of research that charts declines in various human capabilities over the upper end of the age distribution and another body of research literature that relates variations in the same capabilities to accidents over the entire age range.

Priority — Of these two bodies of research, that which relates capabilities with age is the more important in that it both represents evidence that is necessary and provides sufficient to identify age-related freeway risks. It is "necessary" because unless the capability involved has been shown to decline with age, it is outside the scope of this inquiry. The only source of valid information as to age-diminished capabilities is research. It is also "sufficient" because if we know how capabilities decline with age, we can make reasonable inferences as to what effect those diminished capabilities will have upon driving. For example, knowing that low illumination acuity decreases markedly with age, we can be reasonably certain that older drivers, as a group, represent a risk when driving at night on freeways. On the other hand, data relating various capabilities to accidents play only a supporting role. As we have just seen, it isn't necessary in establishing risk, nor is it really sufficient to establish risk since almost all of the empirical evidence relating diminished capabilities to accidents comes from survey research and establishes only association, not causation. For example, if limitations in peripheral vision are related to accidents, we do not know for certain whether the true cause lies in peripheral vision itself, or other health conditions correlated with these limitations. For the reasons given, only those capabilities evidencing an age-related decline in empirical study appear in this section. However, they appear even though research relating diminished capabilities to accidents is unavailable.

Magnitude of Effect—The information presented in this section merely cites relevant literature showing an effect (or no effect, where stated). It does not describe actual study outcomes; specifically, it does not quantify magnitudes of decline, e.g., 20 percent. To do so would be very misleading, since the magnitude of decline in any one study is far more dependent upon characteristics of the population studied, the measures used to assess decline, and controls on the effects of extraneous variables than on the strength of any causal relationship. The literature cited also includes studies in which no effect was observed at all. These citations represent a small minority of the research studies dealing with any variables, and were frequently characterized by low statistical power and/or lack of adequate statistical control. The reason for citing these studies with contradictory outcomes is to show that they were not overlooked. Where the preponderance of evidence failed to show a decline with age, that variable does not even appear. One such variable is simple reaction time, probably the first aspect of human performance that is frequently associated with aging, but one that has failed to show a sufficient decline with age.

Diminished Capabilities

Evidence that older drivers represent a safety problem comes from studies of age and crash involvement that show accidents per vehicle mile traveled beginning to climb at age 65 and rising sharply — by a factor of 5 — beyond age 75 (Cerrelli, 1989). In addition to being more vulnerable to having accidents, older drivers are also more vulnerable to their consequences, suffering a much higher rate of injury than their younger counterparts. For that reason, where the involvement rate increases by a factor of 5, the fatality rate increases by a factor of 10.

Causes of Diminished Capabilities

Why should drivers who represent the highest degree of experience also represent the highest per mile rate of accident and injury? While experience increases, the capabilities required in driving diminish. Although the mere passage of time does not bring about a loss of ability, the two are related in the following ways:

Age-Related Processes—Almost all human mental and physical processes show a decline with age. There are enormous individual differences; some people at age 70 are able to outperform others at age 25. However, across the population at large, there exists a decline in capability that parallels the rate of accident involvement, beginning slowly in middle age and becoming more sharp in really advanced ages. The affected processes may be involved in accidents.

Age-Related Diseases—Many diseases that could occur at any age arise more frequently among people in their advanced years. These diseases can affect driving by causing loss of consciousness (e.g., cardiac arrest), sensory capability (e.g., glaucoma), cognitive processes (e.g., Alzheimer's), or motor capabilities (e.g., stroke).

Cumulative Effects—Many sources of diminished capability are not themselves related to age, but are more prevalent among older drivers simply because they are permanent when they occur and are, therefore, cumulative, i.e., each age level includes deficiencies acquired at earlier ages.

Age-diminished capabilities assume increasing importance with the gradual aging of the American public. As a larger and larger proportion of the motoring public enters the advanced age range, the magnitude of the problem caused by age-related decline increases. The problem is further aggravated by the increased geographical dispersion of the older population—a larger and larger share of older drivers are found in suburban areas, where public transportation is lacking and many destinations are inaccessible by foot. It also appears that we have an increasingly active older population, one that maintains a high degree of mobility for longer periods of time.

Abilities Affected

Driver abilities that tend to diminish with age can be divided into three categories—visual, perceptual-cognitive, and motor abilities.

Visual Abilities

Most aspects of vision are affected by age. Since most of the information drivers use is attained through vision, the loss of visual abilities has serious consequences. Both age-related processes and diseases contribute to reduced visual performance in older drivers. The following visual abilities are known to be affected by aging.

Visual Acuity—Older drivers are likely to experience a loss of visual acuity under a range of conditions, e.g., static acuity, dynamic acuity, accommodation (Weale, 1963; Reading, 1968), acuity under normal illumination (Hartmann, 1981; Staplin, Breton, Haimo, Farber, and Byrnes, 1986; Flint, Smith, and Rossi, 1988), in low light (Kline, Taub, and Sturr, 1989; McFarland, Domey, Warren, and Ward, 1960; Sivak, Olson, and Pastalan, 1981), and in the presence of glare (Staplin et al., 1986; Wolf, 1960; LeClaire, Nadler, Weiss, and Miller, 1982). Factors generally identified as influencing this loss of acuity include:

- Yellowing of the lens, a normal age-related phenomenon that causes less light to be allowed into the eye.
- Clouding of the lens that leads to the scattering, rather than focusing, of light.
- Loss of the ability to focus.
- Reduced pupil size, which allows less light into the eye (Kornzweig, 1954).
- Cataracts.
- Diseases such as glaucoma.

The literature is replete with studies that find very low, but significant, correlations between accident involvement and visual acuity (see Shinar, 1977 for review). The minimal requirement of at least 20/40 vision in the better eye leads to use of corrective lenses, which restricts the range of acuities in the driving population. In the absence of such a restriction, the correlation would probably be higher.

Dynamic Acuity is a measure of acuity for a moving target and, as such, it is considered a more valid measure for driver visual requirements than static acuity. Burg (1964), Henderson and Burg (1974), and Shinar (1975, 1977) all obtained significant correlations between performance on this task and accident involvement.

Although the correlations were low, they were consistently higher than those obtained for static visual acuity.

Visual Field—Loss of visual field includes both a narrowing of the visual field, i.e., loss of peripheral vision (Flint, Smith, and Rossi, 1988; Johnson and Keltner, 1983) and loss of areas of vision within the foveal and parafoveal regions (Scialfa, Kline, Lyman, and Kosnik, 1987; Ball and Sekuler, 1986). Visual field is affected by retinal detachments and diseases such as retinitis pigmentosa as well as by normal aging processes.

Since many visual cues related to accident avoidance responses first appear in the peripheral field (e.g., child stepping off a curb) and much of the driving-related visual information is obtained from the peripheral field (e.g., speed and position in lane), visual field—especially in the horizontal meridian—has been argued to be essential for safe driving.

Early large-scale studies that attempted to relate visual field to accident involvement obtained either very weak relationships (Burg, 1968; Shinar, 1977), none at all (Henderson and Burg, 1974), or even weak relationships in the opposite direction than was expected (Smeed, 1953). North (1985) argued that the measuring of vehicle field in these earlier studies was inaccurate due to the imprecise techniques and incomplete testing of the horizontal meridian. Also, most of the subjects used had little or no visual field loss, therefore, any relationship between field loss and accidents has been artificially minimized by the large group of subjects who had negligible variability in field loss.

Two studies have, however, demonstrated the relevance of visual field to safe driving. Council and Allen (1974), in a study of 52,000 North Carolina drivers, found that although overall, field-deficient drivers did not have more accidents than the rest of the drivers, more of the accidents of field-deficient drivers came from the deficient side than from the non-deficient side. Keltner and Johnson (1980), in a study of the visual field of nearly 10,000 drivers, found that drivers with visual field loss in both eyes had twice the number of accidents and three times the number of convictions as "normal" drivers matched for age and sex.

Szlyk, Severing, and Fishman (1991) used a driving simulator to measure driving performance of subjects with known visual field loss compared to control subjects. They also compared performance and field loss data with both officially reported and self-reported accidents. Visually impaired and control groups were matched for age, sex, driving experience, and miles driven per year. They found that visual function factors accounted for 26 percent and 6 percent of real-world and simulator accidents, respectively. The inclusion of simulator performance indices (e.g., lane keeping and braking performance) with visual factors in a multiple regression analysis accounted for 71 percent and 80 percent of real-world and simulator accidents, respectively.

Fishman, Anderson, Stinson, and Haque (1981) studied drivers with extensive field loss due to retinitis pigmentosa and found that they had significantly more accidents than an age- and sex-matched control group.

Night Vision—The aspects of vision that are affected by age and that also affect the ability to see at night include:

- Acuity, especially acuity under low illumination and acuity in the presence of glare.
- The ability to adapt to the dark (Pitts, 1982; McFarland et al., 1960) and recover from glare.

Since driving is done under conditions of reduced illumination, it has been argued that acuity should be tested under conditions of low illumination (i.e., less than 30 cd/m^2). This measure may be particularly relevant to older drivers since their acuity under low mesopic levels tends to deteriorate independently of sustained adequate acuity under photopic illumination levels (Kline, Taub, and Sturr, 1989). This measure has been found to be weakly related to nighttime accident involvement (Shinar, 1975, 1977).

Resistance to the effects of glare has two dimensions: (1) acuity in the presence of glare and (2) recovery following the cessation of glare.

Acuity in the Presence of Glare—The empirical data to date do not indicate a significant relationship between acuity in the presence of a glare source and accident involvement. Burg (1968, 1974), Henderson and Burg (1974), and Shinar (1976) did not find any significant relationships, while Shinar (1977) obtained some weak, though significant, relationships, but mostly for the younger (17 years old) rather than the older drivers who are typically more susceptible to glare (Owsley and Sloane, 1989). However, using a more specific sign detecting test, Strickland, Ward, and Allen (1968) showed how simulated glare reduced by half the detection distance.

Glare Recovery Time—The glare from opposing traffic is usually short-lived, lasting less than a minute. However, because of the asymmetry between the time courses of light and dark adaptation, even brief glare can disrupt vision for up to a few minutes after its termination. No empirical data could be found relating glare recovery time to driving-related measures.

Contrast Sensitivity and Low-Contrast Acuity— These abilities are important because of the low-contrast nature of the visual scene at night.

Contrast sensitivity typically refers to the minimum contrast under which a person can detect a target. Studies that have found loss of contrast sensitivity with age include Scialfa, Garvey, Goebel, Gish, Deering, and Liebowitz, 1989; Staplin et al., 1986; Owsley, Sekuler, and Siemsen, 1983; and Scialfa, Guzy, Liebowitz, Garvey and Tyrell, 1991. It has been argued that this capability is more relevant to driving performance than acuity, since most driving-related visual tasks involve the detection of targets of supra-threshold size, but with low contrast (as in glare, haze-reduced illumination conditions, or objects that have low contrasts with their background) rather than detecting small targets under maximal (near 100 percent) contrast. Arden (1978), Comerford (1983), and Kleiner, Enger, Alexander, and Fine (1988) studied the relationship between contrast sensitivity and various visual deficiencies (e.g., visual acuity, visual field, color discrimination, age-related macular degeneration) and showed that contrast sensitivity can be a good measure for detecting a host of other visual impairments. Ginsburg, Evans, Sekuler, and Harp (1982); Ginsburg (1984); Shinar and Gilead (1987); Shinar, Gilead, and Conforty (1989); and Owsley and Sloane (1987) all obtained strong and significant relationships between contrast sensitivity and the detection of differing real-world targets embedded in complex backgrounds, including the detection of partially obscured traffic signs. In all of the above cases, visual acuity was controlled either statistically or through the experimental design.

Regan and Neima (1983) developed Snellen-type letter charts with various levels of contrast. These charts provide measures of visual acuity for different levels of contrast, rather than measures of contrast sensitivity for different-size targets. In general, these charts yield similar data to that obtained by other such tests, including a computerized version and a fixed-size variable-contrast letter chart (Sturr, Schultz, Taub, and Hoeppner, 1989). Correlations between the Regan charts and Ginsburg's charts of contrast sensitivity are low, but significant (Owsley and Sloane, 1989). No studies were identified that correlated low-contrast acuity with accidents. However, given the similarity between low-contrast acuity and both contrast sensitivity and acuity under low illumination, it is possible that there is also a similarity in the way that these abilities relate to accident risk.

Color Vision—Color vision or gross discrimination of colors is reduced with age (Verriest, 1963; Knoblauch, Podgor, Kusada, Saunders, Hynes, Higgins, and DeMonasterio, 1986; Verriest, Van Laetham, and Uvijls,1982). Though included in many driver licensing tests, color vision is not considered relevant to the driving task requirements, nor is it empirically related to accident involvement or performance on driving-related tasks (Henderson and Burg, 1974; Shinar, 1978).

<u>Other Sensory Abilities</u>

Hearing—The ability to hear and to understand what is heard (auditory acuity) deteriorates with age (Winter, 1984; Botwinick, 1978; Colavita, 1978; Kalish, 1982). Well-controlled studies by Coppin and Peck (1964) show deaf male drivers to have higher accident rates than comparable drivers with normal hearing. On the other hand, Roydhouse (1967), Henderson and Burg (1973), and Schein (1968) found no differences among the accident records of drivers with and without hearing impairments.

At the present time, no States disqualify drivers on the basis of hearing except for transit operations, where the reasons are not related to public safety or mobility. Some States have required deaf drivers to have outside mirrors to improve visual detection. However, in this day and age, when many cars come equipped with outside mirrors on both sides, this requirement does not impose much of a burden. Moreover, it is not known whether the deaf are any more dangerous than hearing drivers with the radio volume turned up, air conditioning on, and windows rolled up.

Olfaction—The ability to smell deteriorates with age and age-related diseases (Doty, 1989; Cain and Stevens, 1989). No studies were identified that found any link between a driver's ability to smell and safe driving. The subject is mentioned here primarily because it is known that a driver's sense of smell deteriorates with age and because one of the driving tasks listed in the task analysis requires a sense of smell.

Perceptual-Cognitive Abilities

The ability to perceive and understand what is going on around the vehicle has an obvious relationship to safe driving. A number of perceptual and cognitive abilities also have been shown to diminish over time.

General Attention—The ability to maintain attention over sustained periods of time was found to decline with advanced age (Hoyer and Plude, 1980; Quilter, Giambra, and Benson, 1983). Studies finding a relationship between general attention and accidents include Kahneman (1973) and Treat, Tumbas, McDonald, Shinar, Hume, Mayer, Stansifer, and Castellan (1977).

Selective Attention—The ability to separate important from unimportant information has also been shown to decline with age (Clay, 1956; Layton, 1975; Rabbitt, 1980; Temple, 1989; McDowd and Filion, 1992). Barrett, Alexander, and Forbes (1977) found that an information-processing model of accident prediction, based in part on measures of selective attention, was predictive of motor vehicle accident rates. Auditory tests of selective attention were shown to correlate with accident involvement by Gopher and Kahneman (1971); Barrett, Mihal, Panek, Sterns, and Alexander (1977); Kanneman, Ben-Ishae, and Lotan (1973); and Mihal and Barrett (1976). Avolio, Droeck, and Panek (1985) studied correlations between performance on audio- and visual-based selective attention tests and accident rates. On both audio- and visual-based measures, subjects were scored on the basis of errors made by not responding to relevant stimuli (omission errors), errors made by responding to irrelevant stimuli (intrusion errors), and errors made immediately after instructions were switched (switching errors). This last type of error, it was theorized, was due to the confusion caused by the switched instructions. The authors found that, based on means of scores for all aspects of all tests, the subjects without accidents performed better than those with accidents.

Attention Sharing—The ability to share attention among tasks is as important as the ability to selectively attend to various individual highway traffic situations. Attention sharing refers to the ability to pay attention and respond appropriately to two or more events that are occurring simultaneously. Since it is not really possible to attend to two things simultaneously, this attention "sharing" usually involves effective switching of attention and responding to one situation and then the other (e.g., monitoring vehicles ahead on an entrance ramp and adjusting speed as necessary to avoid colliding with them, and monitoring vehicles on the freeway and adjusting speed to merge safely into the traffic stream).

Attention sharing is particularly critical when traveling in unfamiliar areas, where attention must be shared between destination finding and safe operation of the vehicle. Decline in the ability to share attention has been related to age (Craik, 1973; Parkinson, Lindholm, and Urell, 1980; Temple, 1989; Ranney and Pulling, 1990; Crossley and Hiscock, 1992). In two studies of attention sharing and driving behavior, McKnight and McKnight (1991, 1992) found that older drivers were more likely than younger drivers to respond to potential hazards during simulated driving when not sharing attention, but less likely to react when sharing attention between driving and conversation. They also found that older drivers required more time to look at (simulated intelligent vehicle-highway systems [IVHS]) navigational aids than younger drivers. Other studies that found a relationship between attention-sharing abilities and accidents include Mihal and Barrett (1976), Kahneman (1973), and Harris, Howlett, and Ridgeway (1979).

Information Processing—The overrepresentation of older drivers in intersection accidents (Partyka, 1983; Maleck and Hummer, 1986) has been attributed, in part, to a decline in the ability to process the wide array of information presented at intersections, particularly those that are unfamiliar. The speed and accuracy with which information is processed have been found to decline significantly with age (Braune, Wickens, Strayer, and Stokes, 1985; Welford, 1981; Rackoff, 1974; Temple, 1989; Ranney and Pulling, 1990). Studies that found a relationship between information-processing abilities and accidents include Partyka (1983) and Maleck and Hummer (1986). Ranney and Pulling found that older driver performance on an information-processing measure correlated with overall performance on an off-road driving performance measure, as well as with errors in judging whether the vehicle would fit through a narrow path. McPherson, Michael, Ostrow, and Shaffron (1988) found a correlation between information-processing times and age, and performance on a road test.

Choice Reaction Time—This refers to the time it takes to react to a stimulus when there is some amount of cognitive processing involved in recognizing the appropriate response from among a choice of possible responses. Studies that have found significantly longer response times for older drivers include Temple (1989) and Flint, Smith, and Rossi (1988). Lerner (1995) found no age-related differences in reaction times.

By and large, studies of motor skills and accidents have not found highly significant correlations between any sort of reaction time and accidents (Lerner, 1995; Knoblauch, Nitzburg, Reinfurt, Council, Zegeer, and Popkin, 1994). However, a study by Hakkinen (1979) that found no significant differences in choice reaction time between "safe" and "accident" groups of professional drivers did find significant differences in errors on choice reaction time measures.

Problem Solving—While most aspects of driving involve rote behaviors and are not mentally challenging with novel stimulus components, some situations, such as navigating through a construction zone, may involve problem solving. Research by Case, Hulbert, and Beers (1970) and Arenburg (1982) have found that problem-solving ability declines with age.

No studies could be found regarding deficits in problem-solving abilities and accidents. However, in those cases where a driver might encounter a problem requiring some degree of problem-solving ability—be it a driving-related problem or a potentially distracting, non-driving problem—it certainly would be of benefit to be able to solve it quickly and accurately.

Short-Term Memory—While short-term memory has not been studied in relation to accidents, the ability to recall directions and signs is certainly related to mobility and is an element in avoiding the confusion that could lead to accidents. The loss of short-term memory is one of the most common complaints of older people, complaints that are proven to be valid through research (Miller, 1979; Welford, 1981; Temple, 1989; Kausler, Wiley, and Lieberwitz, 1992; Uttl and Graf, 1993).

While no studies could be found linking deficits in memory to accident involvement, it seems likely that those drivers with memory problems are going to be more likely to become lost and/or confused on the freeway, which, in turn, could lead to dangerous situations. Furthermore, many types of information processing rely on memory. For example, attention sharing between vehicles ahead on an entrance ramp and vehicles approaching from behind on the freeway requires the driver to remember the presence and location of vehicles in one area while looking in another. Appropriate responses to emergencies ahead could be greatly aided by an accurate memory of the presence and location of vehicles behind, based on the last look in the rearview mirror.

Spatial Perception—The ability to understand and make decisions based on spatial relationships is necessary for maneuvering a vehicle through traffic, both in a broader sense (e.g., understanding where one is and how to get where one wants to go) and in a smaller, more immediate sense (e.g., judging how close one's vehicle is to others when parking). Older people have demonstrated a reduced ability to perceive spatial relationships (Herman and Bruce, 1983; Jacewicz and Hartley, 1979; Herman and Coyne, 1979; Ohta, Walsh, and Krauss, 1981; Bruce and Herman, 1983; Craik and Dirkx, 1992; Hoyer and Rybash, 1992). Older drivers are more likely to attempt to drive through a gap that is too small for their vehicle and more likely to strike gap boundaries when driving through a gap of sufficient size (Ranney and Pulling, 1990).

No studies have been identified that relate spatial perception to accident rates. Ranney and Pulling (1989) measured drivers' abilities in judging whether their vehicle would fit between two stationary barrels as part of a study that also included a number of other laboratory and driving measures. They found that for older drivers, poor performance on the gap judgment measure correlated with poor performance on a measure of information processing and errors on a measure of selective attention.

Field Dependence—Field dependence, also referred to as perceptual or cognitive style, refers to the ability to interpret information in the presence of other potentially distracting or interfering information. Studies have found that older drivers are more field dependent (Conalli, 1965; Shinar, McDowell, Rackoff, and Rockwell, 1978; Axelrod and Cohen, 1961).

A number of studies have been done to determine the effects of field dependence on driving safety. Some have found no significant correlation, others have found relations between field dependence and other perceptual cognitive disabilities, driving, and accidents. Studies that have found correlations between field dependence and other perceptual cognitive abilities include Thornton, Barrett, and Davis (1968); Ton (1972); Shinar et al. (1978); and Goodenough (1976). Studies relating field dependency to driving behaviors (such as visual search and the ability to detect road signs) include Mihal and Barrett (1976); Loo (1978); Barrett and Thornton (1968); Barrett, Thornton, and Cabe (1969); Olson (1974); and Shinar et al. (1978). Studies of field dependency and accidents include Williams (1971); Harano (1970); Harano, Peck, and McBride (1976); Jameson (1971); Avolio, Droeck, and Panek (1985); Barrett, Alexander, and Forbes (1977); and Barrett, Mihal, Panek, Sterns, and Alexander (1977).

Of the studies mentioned above, some identified the older drivers in the sample as being responsible for the correlation between field dependence and accidents (Mihal and Barrett, 1971; Jameson, 1971).

Motion Detection—Studies have found that older drivers have greater difficulty detecting both angular motion, i.e., motion across the field of view (Shinar, 1977; Hills, 1975), and motion in depth, i.e., motion toward or away from the viewer (Flint, Smith, and Rossi, 1988; Kline, 1986; Schiff, Oldak, and Shah, 1992; Gilmore, Wenk, Naylor, and Stuve, 1992).

Because most of the time much of the visual scene is moving relative to the driver, it has been hypothesized that thresholds for angular movement and movement in depth (which is represented on the retina by the target growing larger or smaller) are critical for many safety-related responses to changes in traffic flow. In a test designed specifically to measure the relationship between threshold to angular movement and accident involvement, Henderson and Burg (1974); Shinar, Mayer, and Treat (1975); and Shinar (1977) found, in three independent studies, that the threshold for angular movement in the central visual field was significantly related to accident involvement.

The monocular or retinal representation of an object moving toward or away from an observer is represented by changes in size. Such changes provide drivers with cues to changes in the relative speed of a vehicle ahead. In a test designed specifically for an evaluation of the relationship between movement in depth and accident involvement, Henderson and Burg (1973, 1974) obtained conflicting results, while Shinar (1975, 1977) obtained marginal support for such a relationship, especially for older drivers.

Parafoveal Attention—This refers to the ability to detect targets outside of central vision while attention is focused upon a stimulus in central vision. Owsley, Sloane, Roenker, and Bruni (1991) found a high correlation between age and performance on a measure of parafoveal attention (useful field of view). This study examined responses to targets that were relatively far outside subjects' central vision. Temple (1989) measured responses to targets in the parafoveal visual region, i.e., just outside of central vision. Older drivers took longer both to make a simple response to the appearance of a target and to make the appropriate response to one of two randomly alternating targets.

The negligible or lower-than-expected correlations obtained between visual field and accidents in some studies have recently been attributed to the fact that the standard tests of visual field measure a passive capability where the observer has no central task to perform and no need to divide attention between the central and peripheral parts of the visual field. Owsley and Sloane (1989) have demonstrated that the passive measure is a gross underestimate of the functional visual field when divided attention is required. Owsley et al. (1991) found a correlation between parafoveal attention and accidents.

Motor Abilities

A number of diseases that become more frequent with age can also affect motor performance. These diseases, described more fully by Waller (1974), include arthritis, hemiplegia, and Parkinson's disease. However, Brainin, Bloom, Breedlove, and Edwards (1977) reviewed a number of studies and found no significant relationship between such disabilities and accidents.

Because of their obvious involvement in driving, perceptual-motor abilities were among the first studied in relation to the operation of motor vehicles. Among the earliest studies was that of Viteles (1925), who attempted to relate a variety of perceptual-motor tasks to the job success of transit drivers. Research concerned with specific perceptual-motor abilities involved studies of reaction time (Bransford, 1939; Lauer et al., 1952), coordination (Goldstein, Van Steenberg, and Birnbaum, 1962; Lauer et al., 1952), and manipulative speed (Ghiselli and Brown, 1949).

None of these variables proved to be related to driving performance as noted by Miller and Dimling (1969) in their exhaustive review of driving-related factors: "Thus, in summary, studies of the relationship between isolated measures of psychomotor abilities and driving performance have not proved fruitful in the past. In addition, the available evidence indicates strongly that further studies of this sort are not likely to prove fruitful in the future." This advice seems to have been largely heeded since the literature discloses very few attempts over the last 20 years to relate measures of basic perceptual-motor performance to driving. Instead, in the 1960s, attention shifted to specific driving abilities, such as those involved in car-following behavior (Perchonok and Hurst, 1965), judgment of following distance (Wright and Sleight, 1962; Gantzer and Rockwell, 1966), or judgment of oncoming vehicle gap (Forbes, Silver, and Landis, 1968).

While reaction times have not been found to correlate with accidents, increased errors on choice reaction time measures have shown correlations to accidents (Hakkinen, 1979). The same study also found significant differences in a measure of eye-hand coordination between accident and no-accident groups of professional drivers. Barrett, Alexander, and Forbes (1977) identified "perceptual-motor reaction time" as being one of three elements of an information-processing model of accident prediction (the other two elements being perceptual style and selective attention).

Simple Response Time—Contrary to popular opinion, simple reaction time is not among those capabilities that have been consistently found to be related to either accidents or age. Olson and Sivak (1986) found that older drivers respond just as quickly to obvious road hazards as younger drivers, while Quimby and Watts (1981) made the same observation with respect to filmed hazards. One study that did find a connection between simple response time, age, and driver performance was Ranney and Pulling (1989). This study found that for older drivers, simple response time correlated with driving measures of speed selection and consistency. Simple and complex response time measures correlated with intersection clearance time (the time between exiting a signalized intersection and onset of the red light) and striking the boundaries of a narrow pathway that drivers elected whether or not to attempt to pass through.

Choice Reaction Time, that is, the time required to carry out different responses to various stimuli, involves speed of information processing; it has more often been linked to the effects of age and to accidents. Because choice reaction time involves more cognitive abilities than motor abilities, it is discussed under Perceptual-Cognitive Abilities, above.

Motor Coordination—Some aspects of motor coordination do decline with age. Brainin et al. (1977) found older drivers to be deficient with respect to the coordination involved in backing, lane keeping, maintaining speed, coming to a smooth stop, handling curves, and negotiating left turns. However, these deficiencies have never been specifically related to accidents.

Tracking—Tracking tasks have been used to measure the ability of subjects to react to changing conditions through motor inputs. A driving-related example of a tracking task is keeping the vehicle centered in its lane by means of steering inputs as the lane curves. Staplin et al. (1986) found that older drivers have difficulty accomplishing a tracking task.

Physical Abilities

Range of Motion—As people age, their range of motion tends to decrease (Smith and Raynor, cited in McPherson et al., 1988). This explains the well-documented tendency for older drivers not to turn their bodies sufficiently to see behind them while backing (Yee, 1985; Brainin et al., 1977; McKnight and Green, 1977). McPherson et al. (1988) found that older drivers were less flexible in neck, shoulder, and torso rotation, and that this lack of flexibility correlated with poor driving performance.

Physical Fitness—There are a number of aspects of physical fitness that tend to deteriorate with age. These include strength, endurance/susceptibility to fatigue, and aerobic fitness. No studies were found that expressed the tendency for strength and endurance to diminish with age. It may be that this phenomenon is considered an accepted fact and unnecessary to reference. There were no studies that reported a correlation between physical strength and driving safety. It does not seem likely that physical strength, in itself, would affect safety unless it dropped to a very low level. Studies relating fatigue to driving safety include studies finding correlations between fatigue and accidents in professional drivers (Kaneko and Jovanis, 1992; National Transportation Safety Board, 1990; Mackie and Miller, 1978) and studies of the effects of fatigue on abilities that have been shown to relate to driving, e.g., attention (Miller and Dimling, 1969).

McPherson et al. (1988) found correlations between cardiorespiratory fitness; perceptual, cognitive, and motor skills; and driving performance. McPherson et al. refer to a number of studies that seem to find that aerobic exercise increases the amount of oxygen in the blood, which, in turn, facilitates mental processing and decreases reaction times.

Driver Eye Height—It is generally agreed that as people age, they tend to become shorter in stature. Decreased height in the upper torso results in decreased eye height; drivers have greater difficulty seeing out of the vehicle. In addition, older drivers have a tendency to purchase larger vehicles. This combination of reduced eye height, and higher doors and dashboards over which to see, results in sight lines that provide less relevant visual information to the driver. Studies that have examined the effect on safety of vehicles that were too large for smaller drivers include Burger, Smith, Queen, and Slack, 1977 and McFarland and Moseley, 1954.

Driving-Specific Characteristics

There are aspects of driving that affect all drivers' safety (e.g., knowledge of stopping distances at freeway speeds), and there may be characteristics of older drivers that affect those aspects of driving (e.g., older drivers may not be as knowledgeable of stopping distances at high speeds).

These aspects of driving that affect safety include:

- Performance.
- Knowledge.
- Skill.
- Attitude.

Each of these aspects, and its relationship to older drivers, is described below.

Performance

Driving performance is what drivers do. It is influenced by all the things that drivers know and are capable of doing, and influenced by drivers' motivations to perform these tasks either safely or unsafely. The performance of older drivers is affected both by factors out of their control (e.g., diminished capabilities) and factors under their control (e.g., exposure and vehicle choice).

Not much research has been done regarding specific differences in performance between younger and older drivers. The research that exists is primarily concerned with older drivers in the urban environment, not on freeways. Research findings regarding older driver performance summarized here will involve both freeway and non-freeway environments.

Information as to the performance of older drivers comes from observational studies, traffic records, and self-reports.

Observational Studies — Brainin et al. (1977) conducted a study in which they took drivers from three age groups (25-44, 60-69, and 70+) on a test route. They found that older drivers did not perform as well on the following maneuvers:

- *Backing, both straight line and in a curve.* The differences were greater for backing on a curve. Much of the problem stemmed from older drivers not turning their head sufficiently to see behind. Interestingly, when asked if they were having problems turning, most said they were not. Some older subjects "backed by feel," e.g., backed until they hit something. The two older groups had the same types of backing problems, but the oldest drivers had more of them.

- *Negotiating curves.* Older drivers tended to lose points on a curve for going too slowly for conditions and for improper lane position.

- *Maintaining proper speed on the freeway.* Older drivers tended to be inconsistent in speed selection and to drive too slowly for the conditions.

- *Lane tracking and positioning.* Older drivers had problems on the freeway.

- *Improper turning.* On certain turns, older drivers (primarily the oldest) tended to not be cautious, to use improper lane positioning during the turn, and to not signal prior to the turn.

Schiff and Oldak (1993) compared performances of older and younger drivers using computer video scenarios, and found no significant differences in responses to highway traffic situations, except for a small practice effect that appeared among the older subjects.

Traffic Records — Evidence of drivers' performance deficiencies can be found in traffic records. Certain types of accidents and violations have been associated with older drivers. Most of these seem to be related to older drivers' difficulties with certain cognitive tasks, such as information processing and attention sharing. For example, older drivers tend to be overrepresented in accidents that take place at intersections or other places where the paths of vehicles cross, e.g., freeway access ramps.

Older drivers are more likely to be killed in accidents in which they are struck from the side (Viano, Culver, Evans, and Frick, 1990); to be involved in accidents involving right-of-way violations of the older driver (Huston and Janke, 1986; Garber and Srinivasan, 1991); and to receive tickets involving right-of-way violations, such as turning left in front of traffic (Harrington and McBride, 1970; Brainin et al., 1977; Huston and Janke, 1986) and for disregarding signs and signals (Brainin et al., 1977; Garber and Srinivasan, 1991). Younger drivers tend to be involved in accidents involving high speeds, are more likely to be killed in rollover accidents (Evans, 1991), and are more likely to be cited for speeding (Harrington and McBride, 1970).

Staplin and Lyles (1991) examined the performance of older drivers in the following accident types:

- *Merging and lane changing at freeway access ramps*—Older drivers were more likely to be guilty of failure to yield and improper lane use than younger drivers. Drivers in the age 56-75 group were considered underrepresented for their level of exposure for this type of accident. Drivers over age 75 were considered to be overrepresented for their level of exposure.

- *Lane changing on freeways (not at ramps)*—Older drivers were more likely to be guilty of failure-to-yield and lane-use violations. Older drivers from ages 56-75 and over age 75 were considered overrepresented. Fewer older drivers were considered guilty of causing such accidents and it was suggested that this was because older drivers were driving slower and passing less.

- *Left turn across traffic*—Older drivers from ages 56-75 and over age 75 were considered very overrepresented in this type of accident. Older drivers were more likely to turn left and collide with other drivers, but no more likely to be going straight and collide with left-turning traffic.

- *Gap acceptance crossing non-limited-access highways*—Older drivers were overrepresented in this type of accident also, but not to the extent that they were in left turn across traffic. The authors theorize that this is because it is easier for older drivers to detect the movement of vehicles across their vision than the motion in depth involved in judging gaps before oncoming vehicles.

Younger drivers in this study tended to be guilty of speeding and following too closely. Analysis revealed that the overrepresentation of older drivers in certain types of violations (e.g., right-of-way and improper turn violations) was not due simply to their underrepresentation in committing other types of violations (e.g., speeding and tailgating).

In a separate analysis within the same study, Staplin and Lyles found that older drivers ages 56-75 were not overrepresented in accidents as a whole, but were overrepresented in accidents in which, prior to the accident, they had been changing lanes to the left, turning to the left, or turning right. Drivers over age 75 were overrepresented in all accidents, with accidents in which they had been changing lanes to the left or turning left being the most endemic. Drivers in the age 56-75 range were overinvolved in accidents involving "making an improper exit from a roadway onto a driveway or ramp," "improper turning," "careless lane change," or "making an improper entrance to a roadway or driveway to ramp." The greatest ratio of overinvolvement for these drivers was for improper turning. Drivers over age 75 were overrepresented for all of the same behaviors, only to a much greater extent, and were also slightly overinvolved in accidents in which they had been following too closely.

Studies that compare freeway accidents of older drivers with those of their younger counterparts point to deficiencies that are at least, to some degree, specific to older drivers. However, they are not necessarily specific to *older drivers on freeways*. In preparing this report, fatal accident records for the year 1988 were examined to compare freeway accidents involving drivers over age 65 with accidents involving two younger age groups (<30, 30-64), and to *other* road categories (major arterials, collectors). This classification established a 3 x 3 matrix. A variety of accident characteristics were then analyzed through analysis of variance (ANOVA) as to the extent to which they varied as a function of age and road category (more specifically, the interaction between these two variables). Those showing a significant interaction and a difference from chance expectation greater than 5 percent are provided below:

Drinking — Only about 10 percent of older driver accidents involved drinking, in contrast with 40 percent and 30 percent for the <30 and 30-64 age groups. However, older drivers had 11 percent more accidents involving alcohol on freeways than would have been expected from their involvement in similar accidents on other categories of roads.

Driving Alone — Older drivers were 9.2 percent less likely to be driving alone on freeways (i.e., without a passenger) than would be expected by chance.

Occupants Killed — The number of occupants killed in vehicles in which an older driver died is 5.3 percent greater than that of vehicles with younger drivers. This could result from a combination of having more occupants in the vehicle and the greater vulnerability of the occupants.

Number of Vehicles — The number of vehicles in fatal accidents involving older drivers is 11.7 percent less than expected, a possible indication of the traffic volumes at times older drivers operate on freeways.

Number Killed — While the number killed in all fatal accidents involving older drivers is less than that characterizing younger drivers, the number killed in freeway accidents involving older drivers is relatively higher—by 8.2 percent. Since the result is apparently not due to greater numbers of vehicles, it would appear to be the result of the greater number of passengers.

Truck Fatalities — While older drivers are much less likely to be fatally injured while driving a truck than their younger counterparts (28 percent vs 16 percent, respectively), it is even less likely — about 5 percent — to occur on freeways. This is possibly due to less exposure.

Striking Vehicle — While older drivers are more likely to be in the striking vehicle rather than the struck vehicle in a fatal accident, their likelihood of being the striking vehicle in a freeway accident is 22 percent greater than expected.

Non-Collision Accidents — Accidents that don't involve a collision (e.g., rollovers) comprise only about 10 percent of the accidents involving drivers under age 65 and about 4 percent of the older drivers. However, older drivers sustain 44 percent more non-collision accidents on freeways than expected from the ratio of non-freeway-to-freeway accidents within the general population.

The findings of the studies of driver records, described above, tend to indicate that older drivers are not guilty of deliberately risky behavior, but are, rather, simply making serious mistakes while driving. Other studies that have found that older drivers are more likely to be involved in accidents due to errors in judgment or perception include Cooper, 1989; Scialfa et al., 1987; Schultz, 1991. To what extent these mistakes are due to any of the factors discussed below (e.g., ability, habit, knowledge) that contribute to performance is not clear from the accident and violation data.

Another aspect of driver performance that affects safety is the amount and type of exposure, that is, when, where, and how often they will drive. While it is unusual to think of drivers' exposure as an aspect of performance, drivers normally make active decisions regarding when, where, and how often they will drive. Traffic records show that while older drivers have higher rates of accidents per mile, they have lower accident totals (Cerrelli, 1989). Surveys indicate a marked decline in annual mileage as age increases beyond age 60 (McKnight, Simone, and Weidman, 1982). In addition to compiling lower mileage, older drivers tend to shy away from conditions that present high accident exposure. Sjögren, Bjornstig, and Eriksson (1993) found that Swedish drivers over 70 years old were less likely to be involved in crashes involving ice, snow, and other environmental factors than any age group except the youngest (ages 18 to 24).

An issue to consider when examing older drivers' exposure and accident rates is that accident rates do not increase in a linear fashion with respect to exposure. Accident rates tend to decrease for high-mileage drivers (Elander, West, and French, 1993). This may be due, in part, to greater practice, leading to greater skill, among those who drive frequently. It is also likely that high-mileage drivers operate more on limited-access freeways (which tend to be safer in terms of accidents per mile). Therefore, the higher accident rate of older drivers may be explained to some extent by the amount and nature of their exposure.

A sign that older drivers may be safer in some respects than younger drivers, due to their voluntary limiting of exposure, is their underrepresentation in accidents under conditions when older drivers might be more likely to decide not to drive. Schultz (1991) found that nighttime accidents for older drivers in Alabama represented only 5 percent of total accidents and suggested that this was evidence of older drivers' avoidance of nighttime driving.

Self-Reports — One way to identify elements of poor driving performance is through the use of self-reports. Yee (1985) reported that the six problems most frequently mentioned by older drivers are:

- Reading traffic signs.
- Seeing while driving at night.
- Turning the head while backing.
- Reading the instrument panel.
- Reaching the seatbelt.
- Merging and exiting in high-speed traffic.

In a study of motion-detection abilities as measured in a driving environment, Hills (1975) found that older drivers need either more time or greater speed of stimulus to detect the motion of an approaching car.

<u>Knowledge</u>

Because some older drivers may not have had any formal education in proper procedures for dealing with freeways, knowledge in this area may be deficient. McKnight and Green (1977) identified certain types of information with which older drivers were unfamiliar. It is likely that in the 16 years since that study, the characteristic knowledge of older drivers has changed somewhat. However, it is also likely that drivers 16 years apart in age are still somewhat similar with respect to familiarity with specific knowledge. For example, the fact that older drivers in 1977 were unaware of effective collision avoidance techniques points to the possibility that older drivers of today are equally unaware of them. It is likely, too, that the broader knowledge areas identified by McKnight and Green represent areas in which older drivers are deficient, no matter what the year. For example, McKnight and Green found that older drivers in 1977 were unfamiliar with some road signs that were relatively new in 1977. Older drivers of 1993 may not be unfamiliar with signs that were new in 1977, but it is not unreasonable to expect that they are unfamiliar with signs that are new in 1993.

The areas identified by McKnight and Green in which older drivers were knowledge-deficient included:

- *Signs*—Older drivers had more difficulty in identifying signs by shape and in interpreting some of the less frequently encountered signs.

- *Laws*—Older drivers seemed to have more problems with the letter of the law than with its spirit.

- *Defensive Driving*—Older drivers were less familiar with techniques of protecting themselves against unsafe acts of others (e.g., visual scanning procedures) and against the elements (e.g., driving on slippery surfaces).

- *Emergencies*—Older drivers were less familiar with emergency procedures such as skid control and emergency braking.

- *Textbook Information*—Older drivers were less familiar than the general population with information such as stopping distances.

- *Characteristic Older Driver Behaviors*—Older drivers' responses to some questions reflected behaviors that are common among older drivers, e.g., using mirrors rather than turning around to see behind while backing.

As part of their study on the correlation between driver knowledge and accidents, Treat et al. (1977) found a relationship between age and the ability to answer certain items correctly. Items showing a significant age decrement included those dealing with:

- Maximum legal speed in a business district.

- Steering to avoid a collision and pumping brakes to facilitate steering for collision avoidance.

- Proper visual search prior to turning.

- Maintaining space behind when changing lanes in front of another vehicle.

Items showing a marginally significant age decrement included:

- Lane use on a road with no painted center line.

- Communicating presence by using headlights during the day.

- Protecting space behind when turning into a driveway.

- Effect on brakes of continued use on long downgrades.
- Proper steering for skid control.
- When to check tire pressure.
- Braking techniques as part of collision avoidance.
- Avoiding "overdriving the headlights"; i.e., driving so that the distance illuminated by the headlights does not allow sufficient time to see and react.

Skill

The term "skill" refers to an aspect of performance in which an acceptable performance level can be achieved only through practice. For example, the ability to keep the vehicle tracking a straight line while temporarily diverting attention to the rearview mirror or heater controls represents a driving-specific skill that is learned through practice. The skills most important to safe driving are believed to be the psychomotor skills involved in vehicle handling and the perceptual skills involved in identification of hazards.

Studies of driver skill require a precision in measurement of driver performance only achievable through instrumented measurement, simulation, or off-street range testing. Ranney and Pulling (1989) studied the relationship between driving performance on laboratory measures of visual, perceptual, and cognitive abilities and driving performance on an off-road driving range. The authors found age differences both between performance on individual measures and the relationship between laboratory measures and driving measures. For younger drivers, none of the laboratory measures correlated with overall driving performance. For older drivers, however, measures of information processing and response time correlated with overall driving performance and individual driving measures, especially measures related to control of the vehicle. This was especially true for drivers over age 74.

Hills and Johnson (1980) found that older drivers have difficulty in motion detection that seems to translate into a tendency to judge safe gaps for crossing traffic on the basis of distance alone, without regard to closing speed of the approaching vehicle.

Attitude

Driver's attitudes about safety issues, specifically their beliefs and opinions, are known to play a role in their motivational pattern. This is particularly true for issues involving differences of opinion, such as safety belts or speed. Attitudes are strongly influenced by knowledge, and the effort to affect driver motivation by means of knowledge is primarily directed at modifying attitudes.

Several older studies of age and attitudes focused on the tendency for the youngest drivers to have attitudes that are not conducive to safe driving (Beamish and Malfetti, 1962; Levonian, 1968). No more recent studies were found that examined the relationship of attitudes of large numbers of older drivers to safe driving.

Lonero (1994) conducted a study that included holding a focus group discussion of older drivers who expressed certain attitudes about older drivers' abilities to drive safely. The results of Lonero's study indicate that older drivers sometimes recognize the reduction of certain of their abilities and sometimes they do not. Sometimes those drivers take sufficient steps to compensate for those diminished abilities and sometimes they do not. The majority of older drivers in the focus group felt, however, that they had experienced no loss of abilities that was beyond their ability to compensate. These drivers felt that they were among the safest drivers on the road and that the problems they experienced on the road were the result of other drivers' unsafe and discourteous driving. It seems likely, then, that older drivers attitudes may contribute to unsafe driving when they stand in the way of recognizing the extent to which their abilities have diminished and the extent to which they contribute to dangerous driving situations.

SUMMARY

This section identified the age-related characteristics of older drivers that may adversely affect the ability of these individuals to safely and efficiently drive on freeways. Because of the lack of empirical information on age-diminished capabilities related to freeway driving, the task analysis was necessarily analytical as opposed to empirical. The results of the analysis were therefore in the form of hypotheses concerning specific aspects of freeway driving that may be vulnerable to age-diminished capabilities. Three specific topics were addressed:

- Summary of Age and Freeway Driving Tasks.
- Age -Affected Freeway Driving Tasks.
- Age-Related Characteristics.

Summary of Age and Freeway Driving Tasks. The first section summarized the analysis of the freeway driving task and age-diminished capabilities. Obviously, each age-diminished capability may affect a number of capabilities. The section is organized in terms of the following topics:

1. Basic Driving Tasks
    - Control
    - Speed Selection
    - Position Selection
    - Visual Search
    - Communication

2. Maneuvering
    - Passing
    - Entering Freeways
    - Leaving Freeways

3. Abnormal Conditions
    - Reduced Visibility
    - Reduced Surface Friction
    - Wind
    - Temperature
    - Emergency Vehicles
    - Vehicle Characteristics
    - Other Road Users
    - Construction Zones

4. Emergencies

5. Driver Readiness
    - Travel Planning
    - General Health
    - Fatigue Prevention
    - Medication

6. Vehicle Readiness
    - Vehicle Purchase
    - Maintenance

Age-Affected Freeway Driving Tasks. The second section includes an inventory of the various tasks involved in driving on freeways and identifies those specific tasks that are potentially vulnerable to the effects of age-diminished capabilities. Through the process of formal analysis, potential effects of age-related changes in driving ability on freeway driving are hypothesized. The task analysis thus provides a framework for identifying potential problems. The task inventory has the same hierarchical structure as the previous section, i.e., basic driving tasks, maneuvering, etc. Potential interactions between age-diminished capabilities and various aspects of the driving task are described.

Age-Related Characteristics. The last section describes relevant research that has addressed the characteristics of drivers that influence vehicle operations and that may change with increased age. General abilities discussed include visual aspects (acuity, dynamic acuity, visual field, night vision, contrast sensitivity); other sensory abilities (hearing, olfaction); perceptual-cognitive abilities (attention sharing, information processing, choice reaction time, problem solving, short-term memory, spatial perception, field dependence, motion detection, parafoveal attention); motor abilities; and physical abilities. Driving-specific characteristics discussed include: performance, knowledge, skill, and attitude.

3. FOCUS GROUP DISCUSSIONS

INTRODUCTION AND BACKGROUND

A focus group is a carefully planned discussion among a group of 10 to 12 prescreened participants. A professional moderator guides the discussion through a set of issues while maintaining a permissive nonthreatening environment for respondents. The moderator may also probe certain responses for more detail. This approach is cost-effective because few individuals need to be queried to provide the data that planners and engineers need. Furthermore, the comments of one participant can elicit remarks from another that might have been lost in a structured interview. And finally, a focus group discussion is broad ranging, yet it collects details on specific critical issues.

This section addresses the following:

- Methodology.
- Written questionnaire results.
- Focus group discussion results:
  - General comments.
  - Extent of overall and freeway driving.
  - Route planning.
  - Night driving.
  - Unfavorable aspects of freeway driving.
  - Signage.
  - Freeway design.
  - Trucks.
  - Rest areas.
  - Recommendations.

METHODOLOGY

Two focus groups each were conducted in Washington, DC; San Diego, California; Tampa, Florida; and Phoenix, Arizona, for a total of eight sessions. Candidates were selected if they were age 65 or older and were still actively driving. A brief telephone interview was conducted with each candidate to explain the FHWA-sponsored research and monitor for adherence to the selection criteria. For each session, a pool of 12 or 13 senior drivers was selected to allow for cancellations or other contingencies. Those who showed up completed a written questionnaire. Ten candidates were selected from the pool to participate in the discussion. The selection was based on age and gender. An equal number of males and females were chosen from the oldest participants present. Alternates were paid for their time and were sent home. The representativeness of the sample—relative to socio-economic status, race, or driving experience—is not known.

WRITTEN QUESTIONNAIRE

Before each focus group, participants were asked to complete a short written questionnaire (see figure 1). Survey questions included type of area of residence, employment status, number of years driving, conditions under which participants may have restricted their driving, number of miles driven annually, number of trips made weekly, and type of vehicle driven. Participants were also asked to rate their own driving ability under various scenarios and to rank, from a list provided, three factors they dislike most about freeway driving. Overall results are summarized on the following pages.

The sample consisted of 44 men and 44 women ranging in age from 65 to 88. The median age was 70. Fifty-one live in a city, 22 live in a suburb, 10 live in a town, and 2 live in a rural area. (Totals do not equal sample size because not all respondents answered all questions.) Fifty-two are not working, 22 volunteer on a regular basis, 17 hold part-time jobs, 3 are seeking part-time work, and 1 is employed full-time. (Participants were allowed to mark more than one selection.) All have been driving for more than 25 years; they first obtained their driver's licenses between 1923 to 1967.

Participants were asked whether they had voluntarily restricted their driving. Forty-eight indicated they drive less at night than they used to; 44 drive less during rush hour than they used to; and 25 drive less on freeways than they used to. Their reasons for driving less include physical conditions such as diminished vision at night, cataracts, or glaucoma, or the inability to react to situations as quickly as they used to. Changes in lifestyle were also cited; due to retirement, they have little need to drive on the freeways or during rush hour, and many do not go out in the evening as much as they used to.

FREEWAY PANEL QUESTIONNAIRE

AGE: ______________ SEX: ______________

In what type of area do you live?

_____ City _____ Town _____ Suburb _____ Rural _____ Other, specify

What is your current employment status?

_____ working full-time for pay (Occupation: ____________________)
_____ working part-time for pay (Occupation: ____________________)
_____ not working but looking for paid work
_____ regular volunteer (unpaid) work
_____ not working

In what year did you first obtain a driver's license? ____________

Do you drive less at night than you used to? _____ Yes _____ No
Do you drive less during rush hour than you used to? _____ Yes _____ No
Do you drive less on freeways than you used to? _____ Yes _____ No

If you answered Yes to any of the three questions above, please explain why.

For each of the following situations, how would you rate your driving ability compared to most other drivers on the road? (Please circle your answer.)

Driving on city streets:
Excellent Above Average Average Below Average Poor

Driving on a country highway:
Excellent Above Average Average Below Average Poor

Driving at night:
Excellent Above Average Average Below Average Poor

Driving on a freeway when traffic is light:
Excellent Above Average Average Below Average Poor

Driving on a freeway during rush hour:
Excellent Above Average Average Below Average Poor

Driving in poor weather, such as snow or heavy rain:
Excellent Above Average Average Below Average Poor

How often do you use freeways when you drive?
Frequently Moderately Occasionally Seldom Almost Never

Figure 1. Older Driver Freeway Needs Questionnaire.

Think about the periods in your life when you were driving most extensively. How would you describe your use of freeways then?

Frequently Moderately Occasionally Seldom Almost Never

Below are some things that drivers dislike about freeway driving. Please put a "1" next to the item that bothers you the most, a "2" next to the item that bothers you second most, and a "3" next to the item that bothers you the third most.

_____ High speed of travel
_____ Difficulty merging onto the freeway
_____ Large trucks
_____ Getting lost
_____ Signs that are difficult to see or confusing
_____ Exiting from the freeway
_____ Rudeness or dangerous actions of other drivers
_____ Boring view, nothing to look at
_____ Difficulty of maneuvering in traffic
_____ Things happening too quickly

About how many miles do you currently drive a year?

_____ None
_____ less than 1,000 miles
_____ 1,000 - 4,999 miles
_____ 5,000 - 9,999 miles
_____ 10,000 - 14,999 miles
_____ 15,000 - 19,999 miles
_____ 20,000 miles or more

About how many trips (local or otherwise) do you make as a driver in a typical week?

_____ 0
_____ 1 - 2
_____ 3 - 5
_____ 6 - 9
_____ 10 - 15
_____ more than 15 trips per week

If you have not driven a car within the past six months, when was the last time you drove?

____

What kind of vehicle do you usually drive? ______________________________

Do you ever drive a recreational vehicle (motor home)? _____ Yes _____ No
If yes, describe the kinds of travel you do in it.

Do you ever tow a trailer? _____ Yes _____ No
If yes, describe the kinds of travel you do in it.

Figure 1. Older Driver Freeway Needs Questionnaire (Continued).

The next set of questions asked panel members to rate their driving ability, under specified conditions, compared to most other drivers on the road. Results are shown in table 1.

Table 1. Driving ability compared to other drivers.

Condition	Excellent		Above Average		Average		Below Average		Poor	
	No.	%	No.	%	No.	%	No.	%	No.	%
Driving on city streets	20	23	43	50	21	25	1	1	0	0
Driving on a country highway	18	21	45	53	21	25	1	1	0	0
Driving at night	7	8	26	30	41	48	11	13	0	0
Driving on a freeway when traffic is light	30	35	31	36	23	27	1	1	0	0
Driving on a freeway during rush hour	11	13	33	39	35	41	6	7	0	0
Driving in poor weather (e.g., snow or heavy rain)	7	8	36	42	35	41	7	8	0	0

n = 85

The next questions asked participants about their frequency of driving on freeways now, as compared with periods of more active driving in their lives. Table 2 presents the results.

Table 2. Comparison of frequency of driving on freeways.

Condition	Frequently		Moderately		Occasionally		Seldom		Never	
	No.	%	No.	%	No.	%	No.	%	No.	%
Driving on freeways now	44	52	22	26	14	16	4	4	1	1
Driving on freeways previously	51	60	24	28	6	7	2	2	2	2

n = 85

Next, participants were asked to select and rank order from the following list the three factors that they disliked most about freeway driving. A "1" indicates the factor they disliked most, a "2" indicates the factor they disliked second most, and a "3" indicates the factor they disliked third most. Results are shown in table 3.

Table 3. Factors least liked about freeway driving.

Factor	Dislike Most 1		Dislike Second Most 2		Dislike Third Most 3	
	No.	%	No.	%	No.	%
High speed of travel	11	19	9	15	6	10
Difficulty merging onto the freeway	4	4	10	17	4	4
Large trucks	13	15	8	13	6	10
Getting lost	5	8	0	0	4	4
Signs that are difficult to see or confusing	3	3	14	16	10	17
Exiting from the freeway	1	1	1	1	3	3
Rudeness or dangerous actions of other drivers	20	34	14	16	12	20
Boring view, nothing to look at	0	0	0	0	4	4
Difficulty of maneuvering in traffic	0	0	1	1	6	10
Things happening too quickly	3	3	2	3	3	3

n = 59

Participants were asked how many miles they currently drive per year. Results are shown in table 4.

Table 4. Number of miles driven per year.

Miles Driven Per Year	Responses	
	No.	%
None	0	0
Less than 1,000 miles	6	7
1,000 to 4,999 miles	24	28
5,000 to 9,999 miles	22	26
10,000 to 14,999 miles	27	33
15,000 to 19,999 miles	5	5
20,000 miles or more	1	1

n = 85 1 mi = 1.61 km

Participants were also asked how many trips (local or otherwise) they made in a typical week. Table 5 presents the results.

Table 5. Number of trips per week.

Trips Per Week	Responses	
	No.	%
0	0	0
1 to 2	2	2
3 to 5	20	23
6 to 9	23	27
10 to 15	23	27
more than 15	17	20

n = 85

Panel members were asked when was the last time they drove, if they had not driven a car within the past 6 months. None indicated they had not driven in the past 6 months. The next question asked what kind of vehicle they usually drive. Eighty-three participants indicated they drive a sedan, 1 drives a motorcycle, and 1 drives a pickup truck.

The final set of questions asked "Do you ever drive a recreational vehicle?" and "Do you ever tow a trailer?" Eleven indicated they drove a recreational vehicle, mostly for camping, vacations, or cross-country travel. Sixteen participants tow boats, cars, cement mixers, or utility trailers, and 1 of the 16 had towed a house trailer for the circus.

FOCUS GROUP DISCUSSION RESULTS

A summary of the eight focus group sessions is presented below. The major topics of discussion in the focus groups were:

- Extent of overall driving; extent of freeway driving.
- Trip planning—local or distant—that includes or excludes freeways.
- Aspects of freeway driving that are troublesome but unavoidable.
- Likes and dislikes about signage on freeways.
- Effect of trucks on freeway driving.
- Favorable or unfavorable aspects of freeway design.
- Recommendations for making freeway driving safer, more convenient, or more comfortable for senior citizens.

General Comments

- Driving used to be enjoyable; but for some, it is now a source of tension, due to traffic congestion, trucks, or diminishing physical capabilities.
- Driving practices used to be more orderly.
- Nearly half the participants had completed some type of driver safety/refresher course, such as GEICO's "Driving at 55" or the AARP-sponsored program.
- As drivers age, they know their reflexes are not as quick; they don't notice things as quickly; and they misjudge distances at night. However, they compensate by being more careful and paying more attention to the dynamics of traffic. They are more aware of the consequences of their actions. Most felt they are better, more courteous drivers now than they used to be.
- Because their reaction time is somewhat diminished, older drivers might have better protection driving a larger car in case of an accident.
- It is more difficult for seniors to judge traffic conditions in the rain and fog.
- Signage format and placement is inconsistent nationwide.
- There is a fear of getting lost or getting off at wrong exits, especially for those with limited experience driving on freeways.
- Speed limits are inconsistent nationwide. The government should control the speed limits on freeways by posting the limit as 55 mi/h (88.5 km/h) in urban areas and 65 mi/h (104.6 km/h) immediately after drivers pass through the urban area.
- All participants felt comfortable driving at higher speeds, even in excess of the posted speed limit. The consensus is that everyone who drives on the freeway is exceeding the speed limit.
- There are not enough police to enforce traffic regulations. Aerial surveillance could assist in traffic patrol and enforcement.
- The radio/helicopter traffic reports are appreciated, especially those that suggest alternate routes.
- During the 1940s and 1950s it used to be more hazardous to tow a house trailer. Bus and truck drivers that were passing would "suck drivers over" to the next lane. Engineering/design improvements have made this less of a factor.
- When towing, other drivers just cut in and fill the gap in car lengths, unaware that drivers who are towing need a longer braking distance to come to a stop.

- There is a perceived danger from mobile homes/house trailers and double trailers on 18-wheelers becoming unhitched.

- RVs should be required to maintain speed limits on freeways; many of them drive too slowly.

- Campers and RVs must signal way ahead of time if they want to change lanes. The participants who drove RVs indicated they stayed in the right lane most of the trip. Others mentioned the difficulty in seeing around the larger vehicles.

- Travel is not mentally challenging on freeways. Drivers see only trees. The interstates lull drivers into a sense of well-being since they have no lights to be concerned about, and some people become lax in paying attention. Restaurants and rest areas help break up the monotony.

- Driver education classes need to provide more comprehensive instruction, with an emphasis on attitude as well as knowledge and technique. Drivers in Hawaii, Georgia, and North Carolina were noted as being courteous.

- Some States allow drivers to renew their licenses by mail. Participants felt all drivers should be fully tested every 10 years. For older drivers, the test should address vision and reflexes rather than knowledge.

- Because Arizona has no State inspection, there are a lot of unsafe vehicles on the road.

- Drivers liked the policy in some States of limiting trucks to the right lanes or prohibiting them from driving in the left lane.

- People in wheelchairs have difficulty using the self-serve pumps in gas stations. A factor in stopping for fuel is whether an attendant is on duty to pump gas.

- Participants in Phoenix feel that Phoenix "has the worst interstate system in the country."

- Sunglasses, visors, tinted windshields, and adjustable seats help drivers cope with sun glare.

Extent of Overall and Freeway Driving

All participants had been driving for at least 25 years; most had been driving for more than 40 years. While nearly all participants mentioned they no longer drive as much as they used to, they still drive on the freeway. As shown in table 4, the majority drive between 1,000 to 14,999 mi/year (1609 to 24 138 km/year). When making long-distance trips, most participants indicated they felt comfortable driving between 300 to 500 mi/day (483 to 805 km/day).

Participants in San Diego grew up with the freeways, travel on them every day, and have few difficulties with freeway driving. Others are still getting accustomed to driving on freeways due to the loss of a spouse or moving from an area with public transportation to an area that requires them to use the freeways. One woman said she does not drive on the freeways because "they don't go anyplace I want to go."

Route Planning

Participants agreed that the advantages of freeways are distance traveled, time saved, and the avoidance of congested side streets and traffic lights. Some mentioned an increased feeling of safety on the freeways, noting that more traffic accidents occur closer to home. However, in choosing freeways, drivers said they trade speed and convenience for boredom. They also miss the chance to see small-town America. Some participants have either eliminated or greatly reduced the number of long-distance trips they take because of the burden it places on drivers; they fly to their destinations instead.

Most participants agreed that one of the greatest benefits of being retired is the ability to go anywhere they want whenever they want, so they don't have to be on the freeways during rush hour or other periods of heavy traffic. Other comments follow.

- Participants are comfortable using freeways if they know where they're going. They dislike being in the wrong lane and missing their exit in unfamiliar areas.
- For local travel, time of day and the volume of traffic are the two most critical factors in determining whether to use the freeway. All participants avoid trips on freeways during rush hours, if possible.
- For local travel, some participants favor city routes. However, it was noted that many city streets have not been improved over the years, while freeways have been improved.
- Another factor in choosing the freeway over local streets is whether there is a good entrance ramp (i.e., whether it is easy to get onto the freeway).
- On long-distance trips, if time is a factor, freeways are the solution. If time is not a factor, participants prefer "the scenic route."
- At night, a factor in route selection is whether the route is well lit.
- In the snow, participants prefer the freeways because they will be plowed.
- Because of the volume of traffic, drivers have a better chance of receiving assistance on the freeway in case of a vehicle breakdown.
- Several participants avoid the interstates whenever possible. They feel they can relax more on the back roads.

- In some areas, there are no alternatives to the freeway to reach destinations.

- Entering or exiting the freeway is a problem with a motorhome. Some participants choose a longer, slower route to avoid merging onto the freeway.

Night Driving

While some mentioned vision problems as a reason for not driving as much at night, seniors agreed they have plenty of time to do things during the day, so they don't need to go out as much at night as they used to. Most find it stressful to drive at night, especially in unfamiliar areas. They are concerned for their safety. They also recognize that their reaction times are not as quick as they used to be, so many just avoid nighttime driving. Other comments follow.

- Everything looks different and unfamiliar at night.

- In familiar areas, the freeway is a better choice at night because there is no cross traffic, no stop-and-go traffic, and no intersections to contend with.

- Several participants prefer driving at night. Since traffic is lighter, driving is more relaxing.

- High speeds and drunk drivers are a deterrent to night driving.

- Headlights from oncoming traffic, as well as from following traffic, are distracting. Pickup trucks or four-wheel-drive vehicles that sit higher than sedans were mentioned, while other vehicles have headlights that appear excessively bright.

- The glare from oncoming headlights is a distraction if traffic is not separated by a barrier. Concrete barriers would help cut the glare if they were tall enough.

- Painted lane end markings are difficult to see at night and in inclement weather.

- More lights are needed on the freeway for nighttime driving.

- It is difficult to see black or gray cars at night.

- The freeway from Phoenix to Tucson has no lights. Drivers cannot recognize fences or guardrails.

Unfavorable Aspects of Freeway Driving

Senior drivers mentioned several aspects they found unfavorable about freeway driving. However, it should be noted that these conditions could easily apply to all drivers, regardless of age or roadway traveled.

- Discourteous drivers, especially those who are rude, hostile, and aggressive; those who refuse to accommodate drivers who want to merge or change lanes; those who litter the road (construction workers were cited). It was noted that young women have achieved equality with young men in discourteous driving.

- Trucks.

- Nighttime driving.

- Heavy traffic/congestion/backups.

- High speeds of travel.

- Left entrances/exits; difficulties identifying and executing exits and/or merges.

- Lack of left shoulders in some areas, for emergency pulloff and general feeling of extra space when driving.

- The need to cross several lanes of traffic to exit, e.g., on the Dulles Toll Road in Virginia.

- After exiting, having to cross several lanes of traffic immediately to get to a destination, for example, in Washington, DC, exiting I-495 to reach the entrance to the Tysons Corner, Virginia, shopping center.

- Carjacking.

- Tailgating.

- Frequent lane changes, often without signaling.

- Construction sites, road repairs, resurfacing operations.

- Red vehicles of any type. The perception is that people who like to go fast drive red cars.

- Women applying makeup.

- Drivers talking on cellular phones or wearing headsets.

- Rubbernecking near the scene of accidents.

- Debris and loose loads from trucks.

- Police cars along the side of the roadway.

- Pickup trucks with balloon tires; they obstruct vision.

Signage

- Multilane freeways are not intimidating if signage is good.
- The signs on the interstates do a good job of providing notification of turnoffs and directions.
- Signage is poor; directions are not clear; drivers lack advance notice.
- California signs have too much information, especially in the Los Angeles area.
- Many exit signs and arrows are posted too close to the actual exit. Older drivers need about a 2-mi (3.2-km) advance notice of exits. In urban areas, drivers need longer advance notice in order to get over to the proper exit lane. In rural areas, drivers may not need quite so much notice.
- Drivers prefer redundant overhead signs that provide advance notice of upcoming exits, the distances to each, and whether the exit is on the right or left, e.g., "El Cajon, left exit 5 miles," "El Cajon, left exit 3 miles."
- In some situations, the lack of adequate notice causes drivers to speed up to get over to the exit lane, then slow down to exit, or shoot across several lanes of traffic to get to the exit.
- Participants prefer overhead signs as opposed to those on the side of the road. Overhead signs are well lit, highly visible, and easily read.
- Drivers need more advance notice of right-turn-only lanes, exit-only lanes, and whether the driver needs to take the first or second exit.
- Signs that say, "Through traffic, merge left" or "Right lane, exit only," are helpful.
- Directions on exit signs need to be improved for drivers unfamiliar with the area.
- In unfamiliar areas, signs are not consistent.
- Some exit signs are misleading in that they appear too close to a previous exit, when they are actually referring to the next exit; they provide too much advance warning.
- Signs that direct drivers to off-road food, lodging, and fuel are helpful.
- Certain signs were mentioned as being inappropriate on the freeway, e.g., "Watch for Pedestrians," "Watch for Illegal [Immigrant] Crossings," "High Winds Next 68 Miles."

- As recently as 1989, signs and access ramps to the Tampa airport were poor, but they have been improved significantly and now they're all right.

- Speed limits should be included on overhead signs. On interstates, drivers are not sure whether they are in a 65- or 55-mi/h (104.6- or 88.5-km/h) zone.

- Drivers prefer overhead signs with arrows indicating the lanes for specific destinations, e.g., "Miami, these two lanes."

- Drivers prefer large, lighted overhead signs with arrows indicating the lanes for specific destinations, especially if they are approaching a fork. However, the arrows on the overheads don't always point to the correct lane, causing drivers to change lanes needlessly. Signs should indicate when two travel lanes bear to the same destination. Sun City and the Superstition Freeway in Arizona and I-70 in Maryland were mentioned as having examples of good signage.

- Road markings also guide drivers to the exits. However, road markings wear off, so a combination of signs plus road markings is desirable.

- Several participants felt the green background on signs didn't provide enough of a contrast in the Arizona sun. The color is not readily visible. Drivers have to get close up to the sign to read it; by then, they have passed the exit.

- I-10 through Phoenix at the 18th Street Expressway has too many confusing signs.

- Mile markers are difficult to see and they are not posted on all freeways.

- Many participants were not familiar with mile markers. Those who have seen mile markers were unclear as to their purpose, except for checking vehicle odometers. Most admitted they never really noticed them or did not pay any attention to them.

- Several drivers use mile markers to determine how far they've traveled or how far it is to their destination. Mile markers are helpful when they're tied to exits.

- In San Diego, mile markers are not correlated to the end of the roadway.

- If mile markers were tied to exits, a public education campaign would be necessary to explain their purpose. Most drivers felt they would have to make too many calculations to determine which mile marker they were at and the exit they needed to get to. They felt their time would be better spent paying attention to traffic dynamics and signs.

- Mile markers could be useful in an emergency for reporting location.

Freeway Design

- Newer freeways seem to better accommodate today's traffic; older two-lane highways and city roads present more problems.

- Raised pavement markings are more effective than painted lines for keeping drivers in their lane. When they are raised, they help keep drivers alert at night. RPMs are wonderful, especially at night, in poor weather conditions, and in the mountains. They are more cost-effective than painted lines because they are maintenance free. However, some find them confusing when they are used on turnoff lanes.

- Reflectors on guardrails are helpful in guiding drivers.

- A solid white edging line should be painted and properly maintained on the right edge of all interstates as a lane guide. Most edge markings are indistinct; they blend into the roadway, and the paint wears away too soon.

- Painted lane markings are not well marked or well maintained. They are not visible at night, in the rain, or in the fog.

- Some areas have raised pavement delineators to outline exit turn lanes, which is helpful.

- The interrupted flat line at the start of a deceleration lane is helpful in letting drivers know that their lane is exiting.

- Rumble strips or speed bumps help keep drivers alert.

- Entrance and exit ramps are much better designed than they used to be. Newer ramps have a more gradual sweeping circle, which is preferred.

- Some participants indicated that combination entrance/exit lanes are hazardous and difficult to navigate.

- Other participants indicated that combination exit/entrance ramps are not a problem.

- Combination exit/entrance merges require more length to accommodate both traffic streams.

- In some areas, lanes end too abruptly without adequate notice. In Washington, DC, the I-270/I-495 interchange toward Silver Spring, and I-10 to 24th St. and the Central Avenue tunnel in Phoenix were mentioned as being particularly bad.

- Acceleration/merge lanes need to be longer. Drivers can't get up to proper speed at the current lengths in some locations.

- Trying to merge onto the freeway is extremely difficult. Some drivers refuse to accommodate those who want to merge onto the freeway; long acceleration lanes help ease this situation.

- Several drivers have also missed exits because there are long queues in the exit lane and drivers in that lane won't accommodate others who want to exit.

- Participants liked timed signals to regulate traffic flow. Many felt this gave them their only fair chance of merging onto the freeway. However, there is no place to accelerate when entering these lanes. Apparently, the advantages of cloverleaf interchanges outweigh problems that some drivers reported with combined entrance/exit lanes.

- Timed signals seem to have reduced the number of accidents, but they create a backup on local streets.

- Timed access ramps "don't work in Florida because people don't pay attention to the signal."

- Concrete dividers or barriers on freeways promote a feeling of safety.

- Drivers like call boxes on the freeways, except they are all on the right side of the roadway. If drivers traveling in the far left lane need assistance, they must cross several lanes of traffic to reach the call box.

- Participants prefer cloverleaf exits to all others; their configuration is predictable and allows quick reentry if the driver gets off at the wrong exit.

- All interchanges that have exits should also have return entrances.

- I-4 near Sanford, Florida, has outdated accesses. Planners never dreamed the road would carry the traffic volume it does today. So when building roads, make the lanes wide and include all proposed lanes. "Build as you go" was not a good idea. Municipal Master Plans help eliminate this problem.

- In the rain, I-4 and U.S. Rte. 301 in Florida are poorly drained and pockets of water cause hydroplaning. I-95 is contoured, so it drains properly.

- Freeway entry/access is dangerous in some Phoenix locations, e.g., I-10E at 7th Street, Superstition Freeway.

- Some sections of freeway in Phoenix start nowhere and end nowhere, and there is an overpass going to and from nothing. Participants are not sure whether these are part of some future road network.

- Road surfaces are different in the Southwest. The extreme heat calls for a hard-surface asphalt, which doesn't provide any tire grip.

- Low rainfall in the area causes oil buildup; accidents increase because the roadway is so slick within the first 15 minutes of a rainfall.

- Dust storms are a hazard in the Southwest. In a dust storm, drivers are advised to pull off to the right and turn their lights off so others don't follow them off the road or run into them. In dust storms, follow a big truck if possible. Truckers have a better view.

- Drivers like message boards that indicate road conditions ahead.

Trucks

Few other topics generated the extent and intensity of discussion that trucks did—their size, pervasiveness on freeways, high rate of speed, potential for accidents, and general perception of hazardous driving behaviors. Half the participants felt that truckers are the most courteous drivers on the road today and that drivers, especially those in small cars, are rude to truckers. The other half were in favor of banning trucks from the freeways and resurrecting the railways. At a minimum, they felt there should be separate travel lanes for trucks.

- Truckers are usually courteous and willing to help motorists who need assistance.

- Years ago, truck drivers truly were the kings of the road. Today they are rude, they are roadhogs, they tailgate, and they drive at alarming speeds.

- Trucks frequently blocks car drivers' views of traffic signs and signals. Doubles and triples are unstable, they fishtail, and they obstruct a driver's view.

- Tailgating, speeding, loose loads, and jackknifing are safety concerns.

- Convoys are intimidating.

- Driving a motorhome and being passed by a truck is scary.

- Large trucks passing through urban areas present a safety hazard.

- Trucks need a lane of their own, e.g., the left lane or the bus lane.

- Trucks should not be allowed on the freeway during rush hour.

Rest Areas

Participants agreed that they need to stop at rest areas more frequently than they used to, if only to stretch their legs a bit.

- There are never enough rest areas; rest areas should be located every 50 to 75 mi (80.5 to 120.7 km) or every 2 hours of driving time.

- There are plenty of rest areas around, but they are unsafe for women.
- Drivers need more advance notice of rest areas and the distance to the next one.
- Rest area intervals are inconsistent among jurisdictions.
- Some States are much better than others in providing rest facilities. Arkansas, Ohio, Oklahoma, Tennessee, and Texas were mentioned as having good facilities. "Good" was defined as having tourist information, staff to help visitors, picnic tables, trees, and clean buildings and grounds.
- The Gas-Food-Lodging signs are very helpful. They provide good tourist information when drivers are not familiar with the area.
- Safety and security are concerns at rest areas. Too many rest areas are closed because they are unsafe.
- Rest areas and freeways in California are filled with litter.
- Rest areas in rural areas are too far apart; many are not open when drivers need to use them.
- Drivers need a reentry point when they exit at the Gas-Food-Lodging signs.
- Freeway signs should be removed promptly if food, gas, or lodging facilities are no longer in operation.
- Participants like the private operation of franchise restaurants on the freeways (such as the Maryland House in Maryland, the Howard Johnsons on the NJ Turnpike, and restaurants on the Pennsylvania Turnpike). They prefer having a facility directly on the freeway.
- Rest stops should have waste disposal facilities.

RECOMMENDATIONS

- Restrict truck traffic by designating either special routes, lanes, days, or hours for trucks.
- Prohibit trucks from using the left lane, except to pass.
- Enforce existing truck-lane restrictions.
- Ban 18-wheelers.
- Standardize signage, lane markings, conventions on all interstates.

- Provide more advance notice of exits. Place signs at least 1 mi (1.6 km) before the exit and repeat the information 0.5 mi (0.8 km) before the exit to allow drivers enough time to move over to the exit lane.

- Install signs that indicate distances to specific exits. For example, a sign on I-495 in Virginia just past the American Legion Bridge indicates the distances to the exits for the Dulles Access Road, Tysons Corner, etc.

- Install signs that indicate distances to major cities and to the next rest area.

- Provide more lights, signs, and visible directions, especially in unfamiliar areas. (Participants mentioned safety concerns for visitors getting off at the wrong exit into unsafe neighborhoods and meeting with harm.)

- In heavily populated areas, advise drivers that there may be four or five exits for a city, so drivers won't automatically get off at the first exit.

- The sun frequently blocks sign visibility; either place signs lower or add a border around them for better visibility.

- The green background on signs does not provide enough of a contrast in Phoenix.

- Provide message boards advising of traffic or weather conditions ahead.

- Lengthen acceleration/merge lanes for freeway entrances and exits.

- Reduce or eliminate conflicts in access ramps and merges.

- Provide freeway access on the right and exits on the left.

- Eliminate left entrances/exits on freeways.

- Eliminate some existing entrances/exits, especially in some urban areas, where there are too many.

- Provide more advance notice of right-turn-only lanes.

- Educate drivers to recognize the rights of other users of the road.

- Require driver education tests at 10-year intervals and more frequently as drivers become older.

- Regarding licensing of older drivers, panel members vigorously opposed any action that would require them to give up their licenses at a certain age. However, they recommended that:

- Older drivers be required to relinquish their licenses if the police have issued them a certain number of warnings about unsafe driving.

- "Limited" licenses be issued to certain drivers who may have diminished abilities, e.g., city driving only (no freeways) or daytime only.

- Emphasize defensive driver education; participants specifically mentioned driving in inclement weather and avoiding head-on collisions.

- Enforce existing traffic regulations, especially speeding violations, through more radar, unmarked cars, or marked patrol cars, or by raising the fines for these infractions. One participant recommended placing cardboard patrol cars on the freeway to deter speeders.

- Ensure that every driver is a sober driver.

- Standardize and enforce driving rules and regulations nationwide.

- Ensure that the left lane is strictly for passing; stay on the right except to pass.

- Dedicate a far left lane for motorcycles, similar to a bike lane.

- Increase the speed limit on freeways to 70 mi/h (112.7 km/h) in all non-urban areas.

- Reduce the speed limit on freeways and enforce it.

- Provide better road maintenance. I-10 between Phoenix and Tucson is like a washboard, and the potholes on I-70 in Pennsylvania are legendary.

- Encourage drivers to use mass transit, high-occupancy vehicle (HOV) lanes, or van pools; encourage employers to stagger starting and quitting times.

- Require solar-operated vehicles for in-town traffic; offer an alternative for long-distance trips.

- Add more emergency phones on the freeway.

- Equip automobiles with glare shields to reduce blinding sunlight.

- Require that headlights be turned on by a specified time of day. Headlights help drivers locate other vehicles.

- Install in-vehicle navigation systems in all cars at affordable prices.

- Provide more separation between opposing directions of travel on the freeway to reduce glare from oncoming headlights.

- Plant heavy shrubbery to separate service roads from freeways. The headlights approaching from the right lane at night on the service road confuse some drivers.

- Build wider freeways; add more lanes.

- Eliminate toll roads.

- Don't change a thing; the freeways are fine the way they are (mentioned by half the participants in San Diego).

SUMMARY

Eight focus groups with 88 drivers who ranged in age from 65 to 88 were held in Washington, DC; San Diego, CA; Tampa, FL; and Phoenix, AZ. The focus group discussions addressed the problems older drivers have driving on freeways, including:

Extent of Overall and Freeway Driving

- Although most participants do not drive as much as they used to, they still drive on freeways.

Route Planning

- Participants agreed that the advantages of freeways are distance traveled, time saved, and the avoidance of congested local streets and traffic lights.

- Participants avoid trips on freeways during rush hour.

- Participants are generally comfortable using freeways when they know where they are going, but dislike getting lost.

Night Driving

- Participants do not drive as much at night as they used to, partly because they have more time during the day and partly because they find driving at night in unfamiliar areas to be stressful.

- Participants mentioned glare from oncoming and following traffic as a problem. Glare screens and greater distances between opposing lanes are helpful.

- Participants felt that better lighting is needed on freeways.

Unfavorable Aspects of Freeway Driving

- The following were frequently mentioned problems experienced on freeways:

  - Congestion.

- Construction.
- Trucks.
- Discourteous drivers.
- High speeds of travel.
- Left entrances and exits.
- Lack of left shoulders in some areas.
- Having to cross several lanes quickly to exit.

Signage

- If signage is good, multilane freeways are not intimidating.

- Participants would like multiple, redundant overhead signs providing advance notice of exits.

- Participants want more advance notice of right-turn-only lanes and exit-only lanes.

- Participants like overhead signs with arrows that designate specific lanes for specific destinations.

Freeway Design

- Newer freeways are better than the older two-lane ones, especially entrance and exit ramps.

- Participants like raised pavement markers (RPMs), post-mounted reflectors (PMRs), and visible painted edgelines.

- Some participants have problems with combination exit/entrance lanes.

- Merge lanes should be longer. Timed signals are helpful when merging.

- Concrete barriers promote a feeling of safety.

- Participants like changeable message signs that indicate road conditions ahead.

Trucks

- The participants were divided in their opinions about trucks and truckers. Some thought truckers were courteous, while others thought truckers were rude and that trucks represented a serious safety hazard. Those who dislike trucks favor truck lane restrictions and truck time-of-day restrictions.

Rest Areas

- The participants use rest areas frequently. They would like to see more well-lit rest areas with better signing/advance notice.

4. COMPUTERIZED ACCIDENT ANALYSIS

INTRODUCTION

This section describes the results of analyses of accidents involving older drivers on freeways with an overall goal of highlighting specific accident types, contributing factors, and other characteristics that will lead to a better understanding of the problem and identification of additional research that is needed. The following topics are addressed:

I. Objective and Scope
II. Methodology
III. Analysis Results
   A. Analysis of all freeway accidents
      1. Single-vehicle vs. multivehicle involvement
      2. Location and environmental factors
         a. rural vs. urban
         b. ramp vs. mainline
         c. weather and road surface conditions
         d. lighting conditions
      3. Single-vehicle accidents
         a. collision type and severity
         b. contributing factors
      4. Multivehicle accidents
         a. collision type and severity
         b. contributing factors and pretask maneuver
   B. Paired vehicle analysis
   C. Summary of results
      1. All freeway accidents
      2. Paired vehicle analysis
IV. Conclusions

OBJECTIVE AND SCOPE

The objective of the computerized accident analysis was to better quantify the specific safety problems of older drivers on freeways. The accident databases used in achieving this objective included both State and national level files. The five State databases, four of which are presently maintained in the Highway Safety Information System (HSIS), and the years of data included in the analysis are as follows:

- Illinois (1988 - 1991).
- Michigan (1988 - 1991).
- Minnesota (1988 - 1991).
- North Carolina (1988 - 1992).
- Utah (1990 - 1992).

The sample sizes within each State for the single-vehicle, multivehicle, and paired-vehicle accident analyses are shown in table 6. Note that the single-vehicle and multivehicle analyses included only the latest year of data available in each State, while the paired-vehicle analysis included all years. A total of 40,297 crashes were used in the analyses, including 36,142 crashes for drivers ages 31 to 45 and 4,155 crashes for drivers age 66 and older.

Table 6. Sample sizes included in the analyses from the State databases.

State	Number of Accidents				
	Single-Vehicle[1]		Multivehicle[1]		Paired-Vehicle[2]
	31-45	≥66	31-45	≥66	
Illinois	2,088	201	9,586	875	852
Michigan	3,238	336	8,687	1,102	567
Minnesota	1,055	91	4,115	464	346
North Carolina	1,339	194	3,220	475	568
Utah	1,099	143	1,715	274	183
Total	8,819	965	27,323	3,190	2,516

1 The number of single-vehicle and multivehicle accidents includes all accidents in which a driver within the defined age group (i.e., either ages 31 to 45, or age 66 or older) was involved. Only 1 year of data from each State was included in this analysis.

2 Paired-vehicle accidents include those multivehicle accidents in which one older driver (age 66 or older) and one younger driver (ages 31 to 45) were involved. Three to five years of data from each State were included in this analysis.

The national databases included in the analysis were the 1990 files for the Fatal Accident Reporting System (FARS) and the General Estimates System (GES). The FARS database included 936 single-vehicle accidents and 1,097 multivehicle accidents for drivers ages 31 to 45. For drivers age 66 or older, FARS contained 200 single-vehicle accidents and 193 multivehicle accidents. The GES database included 47,280 single-vehicle accidents and 122,203 multivehicle accidents for drivers ages 31 to 45. For drivers age 66 or older, GES contained 6,002 single-vehicle accidents and 14,622 multivehicle accidents. Because exposure data (i.e., number of trips taken or miles traveled) are not available by age group, the relative involvement of the different age groups must be carefully interpreted.

METHODOLOGY

Identifying unique problems of elderly drivers on freeways was the objective of the analysis in this study. The study methodology involved the examination of numerous contingency tables, looking for differences in involvement rates with respect to collision type and other accident characteristics between two groups of drivers. One group included elderly drivers age 66 or older, while the other group served as a comparison and included younger drivers between ages 31 and 45.

The initial analyses included all freeway accidents involving at least one driver from either age group. For this effort, only the latest year of data available in each State was included. The first step in the analysis was an examination of single-vehicle vs. multivehicle accidents to determine relative involvement for each driver age group. Within each category (single vs. multiple), contingency table analyses were then conducted to determine relative involvement of older drivers with respect to:

- Area (rural vs. urban).
- Roadway location (mainline vs. ramp).
- Weather condition (clear vs. rain vs. ice/snow vs. other/unknown).
- Road surface condition (dry vs. wet vs. ice/snow vs. other/unknown).
- Lighting condition (daylight vs. dawn/dusk vs. dark vs. dark w/street lights).
- Collision type (single: run-off-road right vs. run-off-road left, vs. overturn vs. other/unknown; multiple: rear end vs. sideswipe vs. angle vs. other/unknown).
- Accident severity (fatal vs. injury vs. property damage only).
- Contributing factor (speed vs. following too closely vs. improper passing or lane use vs. failure to yield vs. other/unknown).
- Pre-crash maneuver (going straight vs. changing lanes/merging vs. passing/overtaking vs. other/unknown).

The combined State database tables and figures developed for each variable did not always include all five States due to differences in the level of coding or coding definitions applied in a given State. However, data from at least three States were used in the analysis in all cases.

One problem within this analysis was the lack of exposure data by driver age. There are no data available that show the number of freeway drivers in the traffic stream by age in any of the databases used, or in any other known database. Thus, it is not always possible to know if the overinvolvement of a particular age group is due to a safety problem of that age group or whether it is due to differences in exposure. For example, the contingency tables may show older drivers to be overinvolved in daylight accidents as compared to younger drivers. This may simply be the result of older persons driving more during the daylight hours and less during other times of the day when compared to drivers of another age group. Thus, the result, either fully or partially, would be due to exposure differences.

The second set of analyses was undertaken to help control for the lack of exposure data. This "paired-vehicle" analysis effort included only freeway accidents within the five States in which one older driver and one younger driver were involved. This analysis effort also controlled for a number of other variables common to the accident, including area, roadway location, weather condition, road surface condition, lighting condition, collision type, and accident severity.

ANALYSIS RESULTS

The results of the analysis conducted in this effort are provided below. Because of the large sample sizes, some of the relatively small (i.e., 3 to 4 percent) differences were found to be statistically significant (χ^2). Such small percentage differences are not useful when describing the differences between older and younger drivers. The emphasis of the following analysis will be a discussion of the meaningful differences and similarities between the accident involvement of younger and older drivers. Where appropriate, figures and tables are provided to help illustrate or clarify the results.

Analysis of All Freeway Accidents

The first set of analyses was conducted using all freeway accident involvements from both age groups. The results of these analyses begin with a comparison of single-vehicle vs. multivehicle accident involvement. Following those results are the outcomes of the contingency table analyses related to location and environmental variables for single-vehicle and multivehicle accidents. Separate sections are then provided for single-vehicle and multivehicle accidents in which collision type, contributing factor, pre-crash maneuver, and severity are examined.

Single-Vehicle vs. Multivehicle Involvement

Table 7 shows the number of accident involvements for the older and younger age groups for both single-vehicle and multivehicle accidents. The most important result from this table is the lack of difference in the involvement percentages between the two age groups with respect to single-vehicle vs. multivehicle accidents. Younger drivers were involved in single-vehicle accidents 24.4 percent of the cases, while older drivers were involved in 23.2 percent of the cases. Younger and older drivers were involved in multivehicle accidents 75.6 and 76.8 percent of the cases, respectively.

Location and Environmental Factors

Rural vs. Urban

From the combined State database, older drivers were more likely than younger drivers to have been involved in single-vehicle accidents on rural freeways (69.1 vs. 54.8 percent, respectively; see table 8). The FARS data showed similar results for the older driver age group with 71.5 percent of their fatal involvements occurring on rural freeways. For younger drivers, fatal involvements were almost evenly distributed between rural (50.8 percent) and urban (49.2 percent) freeways. The GES database showed no difference between the two age groups with respect to location.

Table 7. Involvement percentages and frequencies for single-vehicle and multivehicle accidents.

State	Ages 31-45		Ages ≥66	
	Single	Multiple	Single	Multiple
Illinois	2,088[1] (17.9)	9,586 (82.1)	201 (18.7)	875 (81.3)
Michigan	3,238 (27.2)	8,687 (72.8)	336 (23.4)	1,102 (76.6)
Minnesota	1,055 (20.4)	4,115 (79.6)	91 (16.4)	464 (83.6)
North Carolina	1,339 (29.4)	3,220 (70.6)	194 (29.0)	475 (71.0)
Utah	1,099 (39.1)	1,715 (60.9)	143 (34.3)	274 (65.7)
Total	8,819 (24.4)	27,323 (75.6)	965 (23.2)	3,190 (76.8)

[1] Numbers in parentheses are involvement percentages of all accidents for each age group.

For multivehicle accidents, results from the combined State database showed both driver age groups to have been involved in a much greater percentage of urban accidents compared to the single-vehicle accident results (see table 8); this was expected since urban freeways typically carry higher volumes of traffic, which results in greater densities, more vehicle interactions, and thus, more multivehicle accidents.

Table 8. Percentage of involvement by area for single-vehicle and multivehicle accidents in the combined State database.

Driver Age	Single-Vehicle Accidents		Multivehicle Accidents	
	Rural	Urban	Rural	Urban
31-45	54.8	45.2	24.8	75.2
≥ 66	69.1	30.9	31.2	68.8

Consequently, younger drivers were involved in a higher proportion of accidents on urban freeways when compared to older drivers. The results from the FARS database showed similar patterns, although not as extreme, with respect to the driver age groups; older drivers experienced 54.4 percent of their fatal involvements on rural freeways compared to 49.8 percent for the younger age group. Note that both age groups experienced an increase in fatal accident proportions for rural freeways compared to the proportions for all accidents used from the State database. This is most likely attributed to the higher speed associated with rural freeway accidents.

For both single-vehicle and multivehicle accidents, it is not clear from these results whether older drivers have more problems on rural freeways or whether they simply drive more of their mileage on rural freeways compared to younger drivers.

Ramp vs. Mainline

The combined State database results showed a higher proportion of older drivers to have been involved in single-vehicle accidents on the mainline when compared to younger drivers (90.6 vs. 85.3 percent, respectively). Consequently, as shown in table 9, a higher proportion of younger drivers were involved in single-vehicle accidents on ramps than older drivers (10.1 vs. 5.5 percent). The results from the FARS database showed similar results, with 12.0 percent of the fatal involvements for younger drivers occurring on ramps compared to 10.5 percent for older drivers. This result could imply that, on ramps, older drivers are handling their vehicles more safely or are driving at lower speeds than younger drivers. However, this result could also imply that older drivers are encountering more problems on the mainline.

Table 9. Percentage of involvement by location for single-vehicle and multivehicle accidents in the combined State database.

Driver Age	Single-Vehicle Accidents		Multivehicle Accidents	
	Mainline	Ramp	Mainline	Ramp
31-45	85.3	10.1	79.2	14.0
≥ 66	90.6	5.5	77.3	15.0

In multivehicle accidents, older drivers experienced about the same proportion of accidents as did younger drivers on ramps (15.0 vs. 14.0 percent, respectively) and on the mainline (77.3 vs. 79.2 percent, respectively). Results from the FARS data showed older and younger drivers to have a lower fatal involvement percentage at ramps (5.7 vs. 6.8 percent, respectively). It is not known whether this is because older drivers may be driving slower or whether they are having fewer accidents at ramps. These small differences imply that older drivers are no more likely to be involved in a multivehicle accident at a particular location (i.e., on a ramp or on the mainline) than are younger drivers.

Weather and Road Surface Conditions

An examination of the weather and road surface conditions within the combined State database showed both age groups more likely to have been involved in a single-vehicle or multivehicle accident when the weather was clear (see figure 2) and the road surface was dry (see figure 3). This, of course, was expected due to the fact that clear weather and dry road surface conditions occur more frequently than rain, snow, ice, and other adverse conditions. Older drivers were more likely than younger drivers to have been involved in an accident under these "good" conditions. In contrast, younger drivers were more likely than older drivers to have been involved in an accident when the weather was adverse (27.9 vs. 22.8 percent for single-vehicle and 22.9 vs. 18.9 for multivehicle, respectively) and the road surface consisted of wet or frozen precipitation (40.1 vs. 32.3 percent for single-vehicle and 32.0 vs. 25.7 for multivehicle, respectively). These results may simply reflect the fact that older drivers are less likely to drive under adverse weather or road surface conditions.

For multivehicle accidents, the GES data showed younger drivers are more likely than older drivers to have been involved in the rain (18.0 vs. 13.3 percent, respectively) and when the road surface was wet (22.9 vs. 20.3 percent, respectively). With respect to ice/snow conditions, no difference in older and younger drivers was found for road surface condition (7.3 vs. 7.4 percent, respectively) and was less pronounced for weather condition (5.3 vs. 4.5 percent, respectively) when compared to the combined State database results.

For single-vehicle accidents, results from the GES database showed younger drivers are more likely than older drivers to have been involved in an accident when the precipitation was snow/ice (9.2 vs. 0.1 percent, respectively) and when the road surface contained snow/ice (11.0 vs. 6.1 percent, respectively). Again, this could be partially due to the younger group driving more under these adverse conditions compared to older drivers. However, in contrast to the combined State database, the GES data showed older drivers are more likely than younger drivers to have been involved in a single-vehicle accident under rain conditions (21.4 vs. 13.5 percent, respectively) and when the road surface was wet (22.2 percent vs. 18.5 percent). The reason for this difference between the combined State database and the GES database is unclear, except that GES data represent a sample of crashes nationwide that may not be fully representative of all crash trends (e.g., a higher proportion of injury and fatal accidents may be included in the GES sample than is representative of most State databases).

Results from the FARS database showed that younger drivers are slightly more likely than older drivers to have been involved in a fatal single-vehicle accident when the road surface was wet (11.2 vs. 8.5 percent, respectively). However, older drivers are more likely than younger drivers to be involved in a fatal single-vehicle accident for snow/ice weather conditions (4.0 vs. 1.9 percent, respectively) and for snow/ice

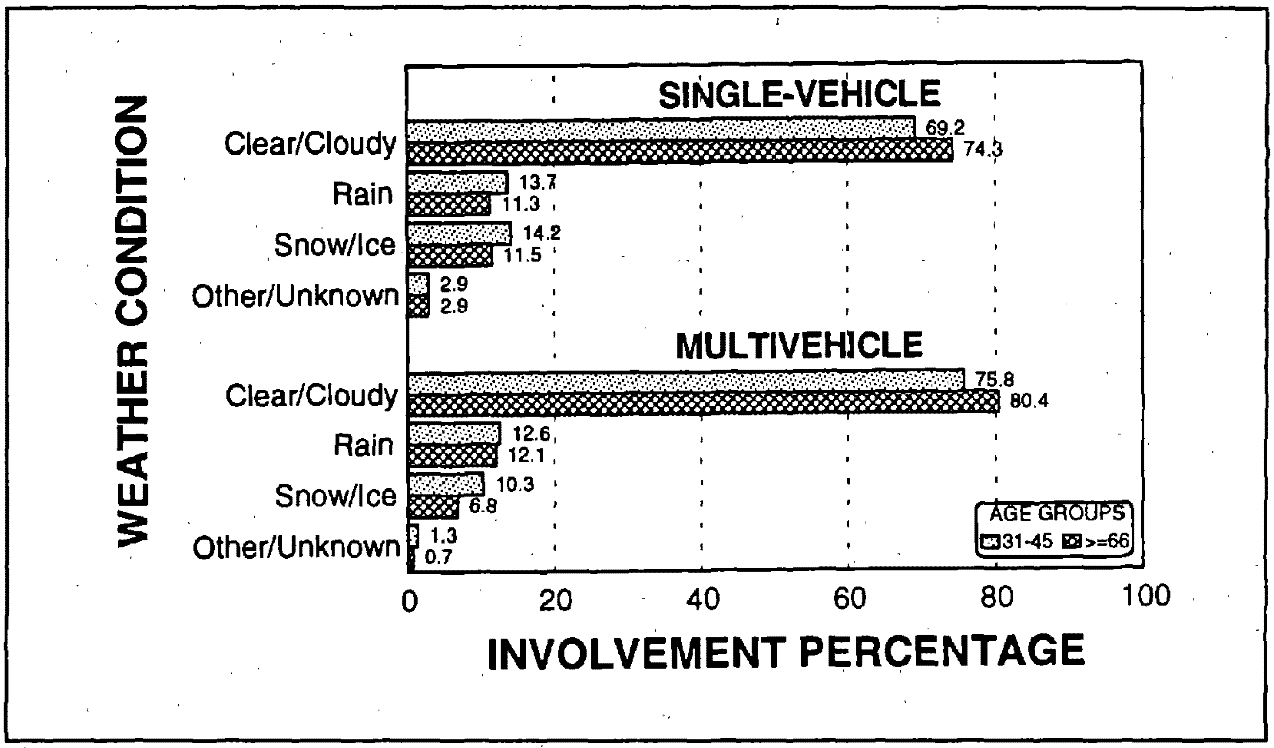

Figure 2. Percentage of involvement by weather condition for single-vehicle and multivehicle accidents in the combined State database.

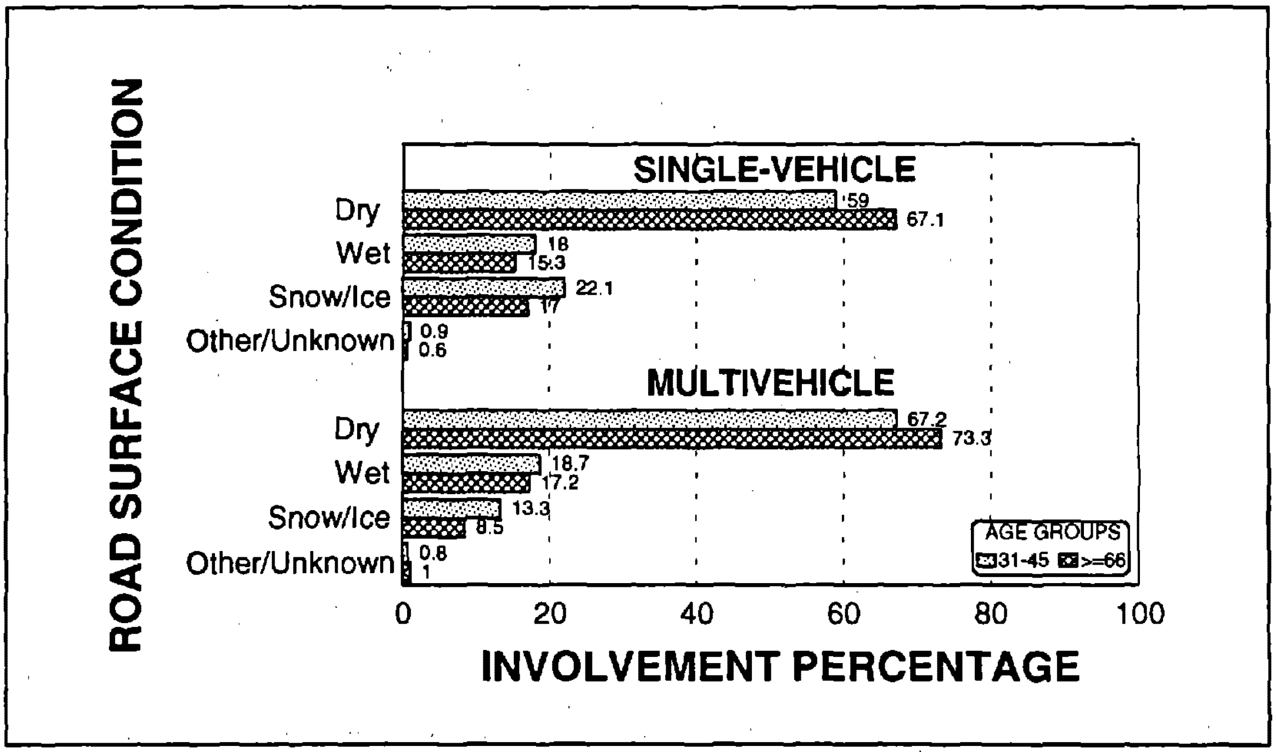

Figure 3. Percentage of involvement by road surface condition for single-vehicle and multivehicle accidents in the combined State database.

road surface conditions (6.5 vs. 3.9 percent, respectively). The reason for these differences between FARS and the other databases is not clear, but may be a result of sample size.

For multivehicle accidents, the FARS data showed that 5.4 percent of younger drivers' fatal accidents occurred in snow/ice weather conditions and 7.4 percent on snow/ice road surface conditions. Only 1.6 percent of the older drivers' fatal accidents were in snow/ice weather conditions and 3.6 percent on snow/ice road surface conditions. Finally, no real differences were found in involvement for older and younger drivers in rainy weather conditions or on wet road surfaces.

Lighting Conditions

The results from the combined State database showed older drivers are much more likely than younger drivers to have been involved in an accident during daylight conditions (73.0 vs. 52.3 percent, respectively, for single-vehicle and 84.2 vs. 73.5 percent, respectively, for multivehicle). Younger drivers, on the other hand, were more likely than older drivers to be involved in accidents during dark and dawn/dusk conditions, as shown in figure 4. Results from the GES database revealed similar trends, with one exception—older drivers were more likely than younger drivers to have been involved during dawn/dusk conditions for single-vehicle accidents only (6.5 vs. 4.3 percent, respectively).

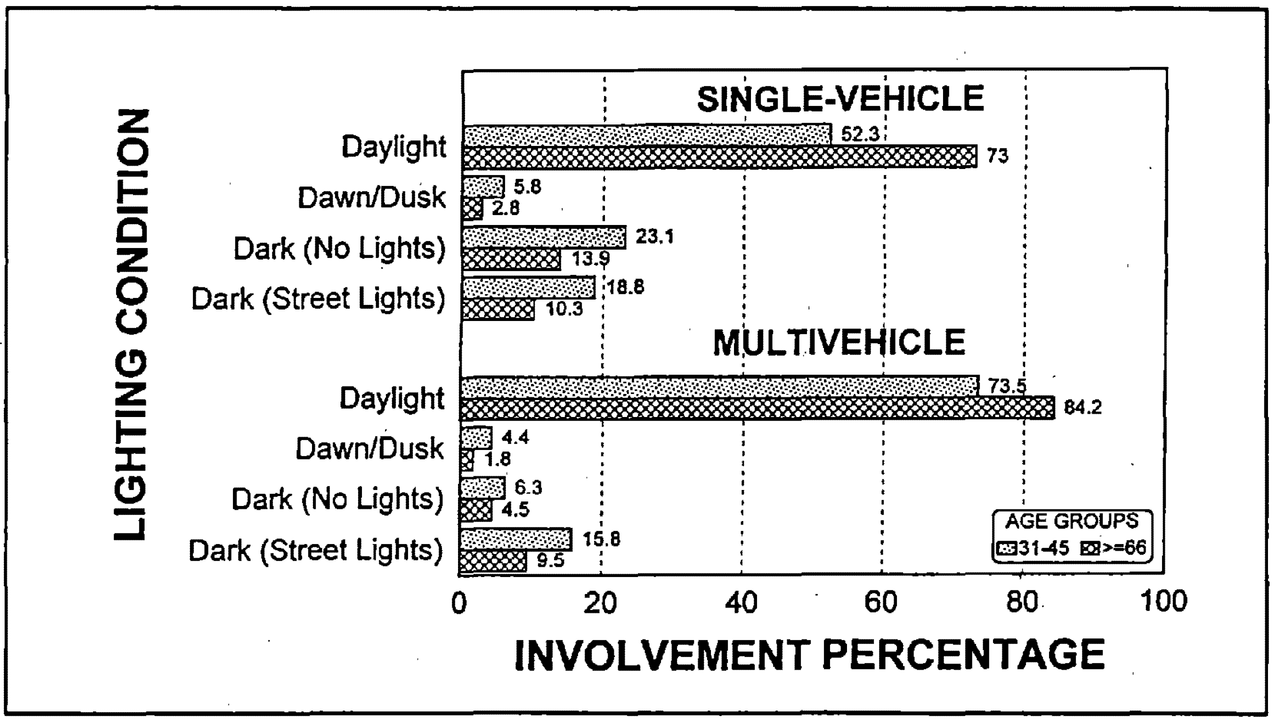

Figure 4. Percentage of involvement by lighting condition for single-vehicle and multivehicle accidents in the combined State database.

The FARS data showed a more pronounced difference in the two driver age groups with respect to lighting condition. Under daylight conditions, older drivers were much more likely to have been involved in a fatal accident when compared to the younger age group (80.0 vs. 38.7 percent, respectively, for single-vehicle and 72.5 vs. 53.8 percent, respectively, for multivehicle). Consequently, younger drivers were much more likely to have been involved in a fatal accident under dark conditions (58.3 vs. 17.0 percent, respectively, for single-vehicle and 41.6 vs. 23.3 percent, respectively, for multivehicle). These results most likely reflect the fact that older persons drive more during daylight hours and less at night compared to younger persons. Older persons often choose not to drive at night, whereas younger persons are often driving at night for recreational purposes.

Single-Vehicle Accidents

Collision Type and Severity

An examination of collision type within the combined State database (see figure 5) showed older drivers are more likely to have been involved in run-off-road accidents than younger drivers, both to the left (23.9 vs. 20.7 percent, respectively) and to the right (22.2 vs. 18.5 percent, respectively). Overturn-type accidents represented only 2.1 and 1.5 percent for younger and older drivers, respectively. These results may imply that older drivers are leaving the travel lane and ending up in an accident more often than younger drivers, or are leaving the travel lane no more often, but are unable to recover as quickly as younger drivers due to slower reaction and response times.

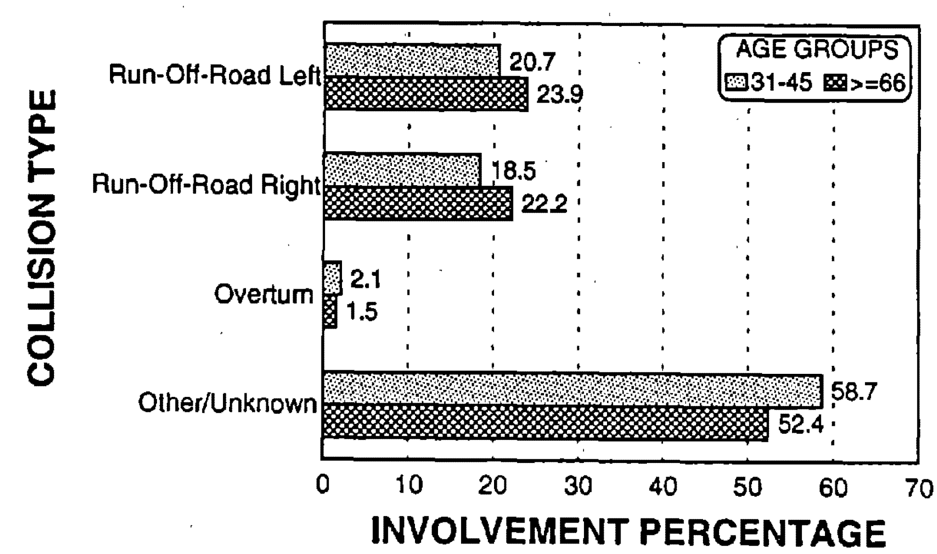

Figure 5. Percentage of involvement by collision type for single-vehicle accidents in the combined State database.

A large percentage of accidents for both age groups fell into the "other/unknown" category. The majority of these collision types included fixed or other object, animal, and other undefined accidents; and, in most cases, the younger drivers experienced a higher proportion of accidents in the various categories than the older drivers. For example, in North Carolina and Utah, 12.0 percent of the single-vehicle accidents for younger drivers involved striking an animal; this compares to 9.9 percent for older drivers involved in collisions with animals. Similarly, fixed/other object collisions in these two States accounted for 13.5 and 10.9 percent of the "other" accidents for younger and older drivers, respectively. In Minnesota, 29.7 and 22.0 percent of the accidents for younger and older persons, respectively, were classified as "other."

Regarding accident severity, both driver age groups were most likely to have been involved in property-damage-only accidents (as shown in figure 6). However, older drivers were killed in 2.6 percent of single-vehicle crashes, compared to 1.6 percent for younger drivers. The older group was also slightly more likely to have been involved in an injury accident than the younger drivers (33.6 vs. 31.0 percent, respectively). These results may simply illustrate the increased frailty of older persons involved in accidents when compared to younger persons. Of course, other factors that may affect crash severity include the impact speed, size and type of vehicle, and use of seatbelts/airbags, etc.

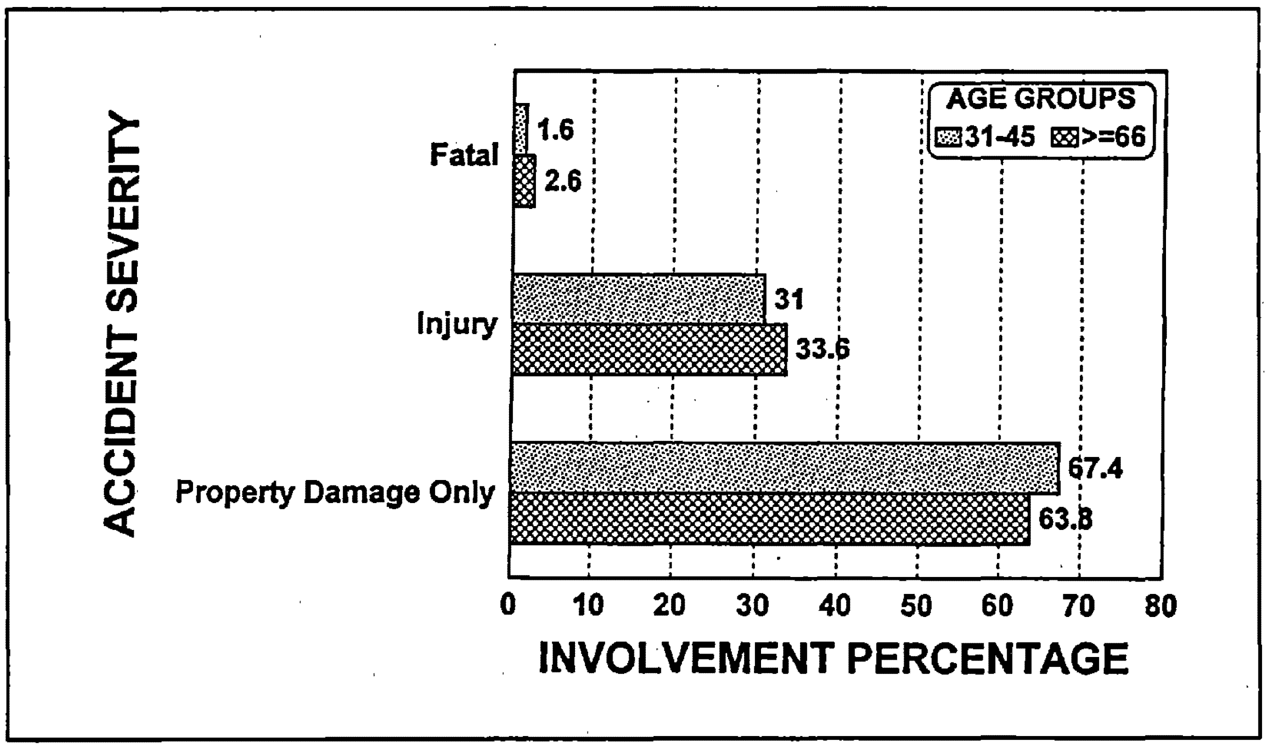

Figure 6. Percentage of involvement by accident severity for single-vehicle accidents in the combined State database.

Contributing Factors

The results from the combined State database showed the predominant contributing factor for both age groups (see figure 7) to be speed, with younger drivers more likely than older drivers to be involved in a speed-related single-vehicle accident (26.7 vs. 17.1 percent, respectively). Following too closely was a contributing factor in only 1.3 and 0.5 percent of the crashes for younger and older drivers, respectively. Older drivers were slightly more likely than younger drivers to be involved in accidents where the contributing factor was improper lane use/passing (3.2 vs. 1.6 percent, respectively). Although the differences are small, these results may imply that older drivers are having more problems than younger drivers related to maneuvering within the traffic stream.

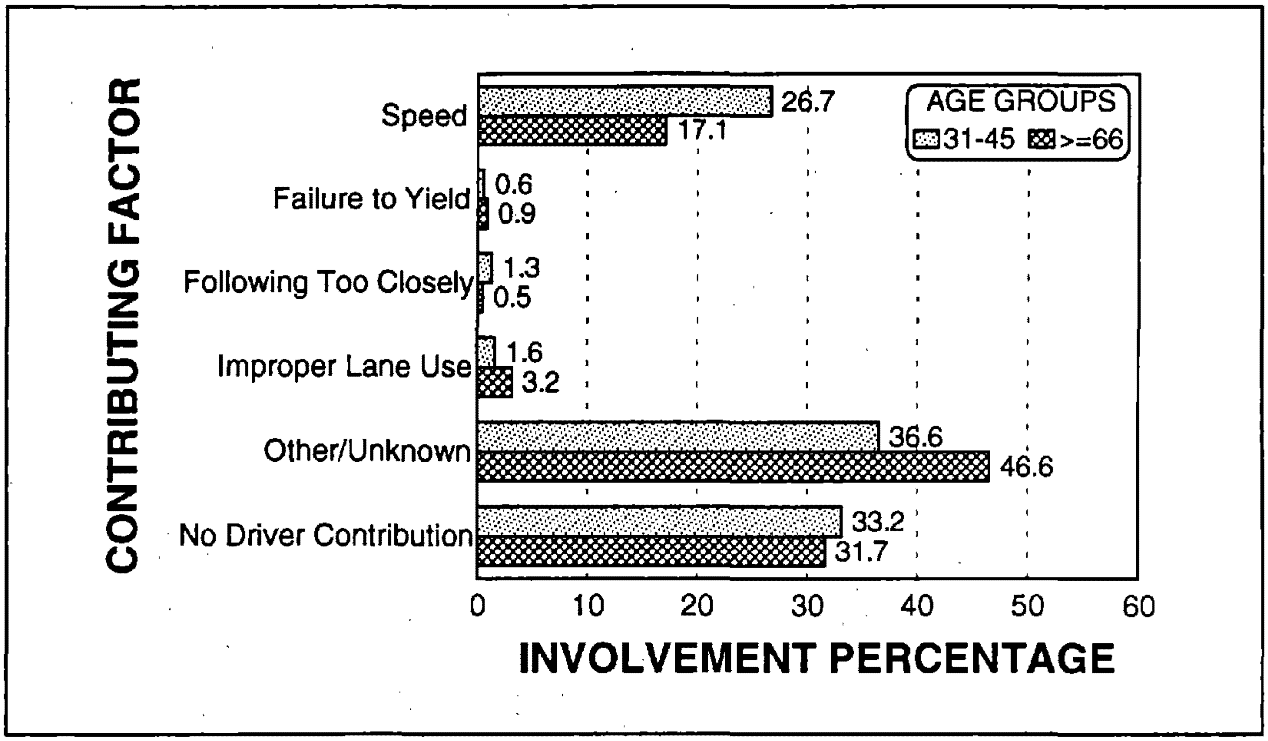

Figure 7. Percentage of involvement by contributing factor for single-vehicle accidents in the combined State database.

Factors in the "other/unknown" category ranged from vehicle equipment problems to driving under the influence. In Utah, 19.6 percent of the older drivers were involved in accidents where the contributing cause was being asleep, fatigued, or ill compared to only 5.2 percent of the younger drivers. In Minnesota, 15.4 percent of the older drivers were involved in accidents in which the contributing cause was driver inattention compared to 8.1 percent of the younger drivers. Younger drivers, on the other hand, were more likely to be involved in accidents in which alcohol was a contributing factor (4.7 vs. 0.8 percent in Utah and 4.3 vs. 2.1 percent in North Carolina for younger and older drivers, respectively).

Multivehicle Accidents

Collision Type and Severity

Results from the combined State database revealed that a rear-end collision was the predominant collision type for both driver age groups (see figure 8) with younger drivers involved in a higher proportion (56.1 percent) than older drivers (49.7 percent). However, older drivers, when compared to younger drivers, were slightly overinvolved in angle collisions (9.9 vs. 7.1 percent, respectively) and sideswipe collisions (18.2 vs. 16.5 percent, respectively). These results imply that older drivers are slightly more likely than younger drivers to be involved in accidents in which there was a lane change, merge, or passing maneuver. Sideswipe and angle collisions typically result from such maneuvers.

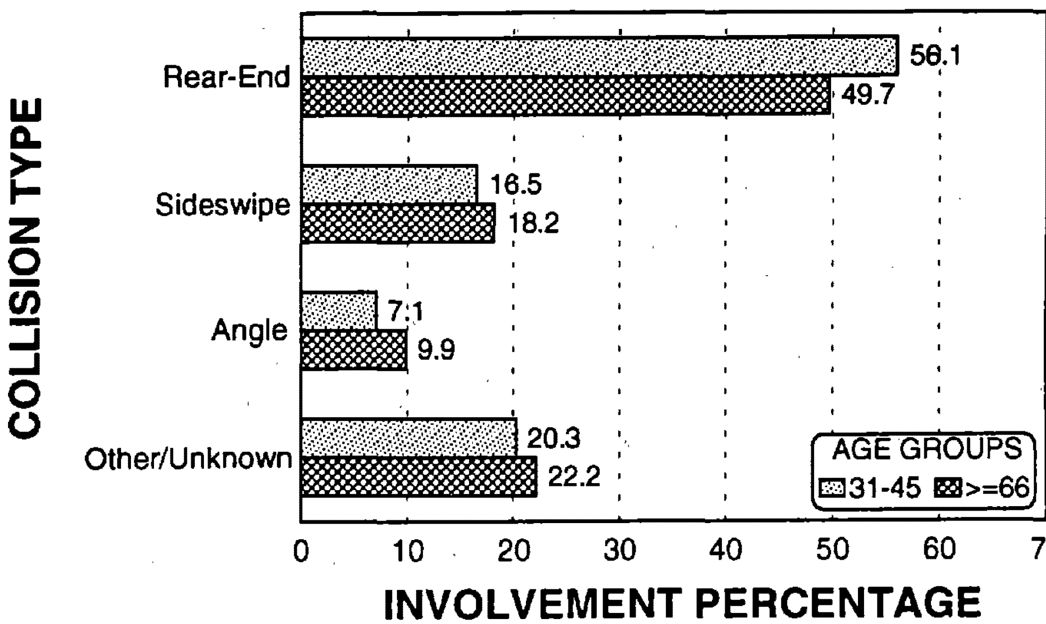

Figure 8. Percentage of involvement by collision type for multivehicle accidents in the combined State database.

The GES database results also showed younger drivers to have a much higher rate of rear-end collisions when compared to older drivers (58.4 vs. 43.8 percent, respectively). As in the combined State database, older drivers were more likely than younger drivers to have been involved in angle collisions (25.5 vs. 21.9 percent, respectively) and sideswipe collisions (25.3 vs. 16.5 percent, respectively). The FARS data produced similar results for rear-end and sideswipe accidents. However, for angle collisions, the FARS data showed that older drivers are less likely than younger drivers to have been involved in such a collision (17.6 vs. 20.8 percent, respectively).

Property-damage-only accidents were most frequent for both driver age groups (see figure 9). However, older drivers were only slightly more likely than younger drivers to have been involved in a fatal accident (1.0 vs. 0.5 percent, respectively) or an injury accident (38.8 vs. 37.1 percent, respectively). These small differences may be due to the increased frailty of older persons when they become involved in accidents.

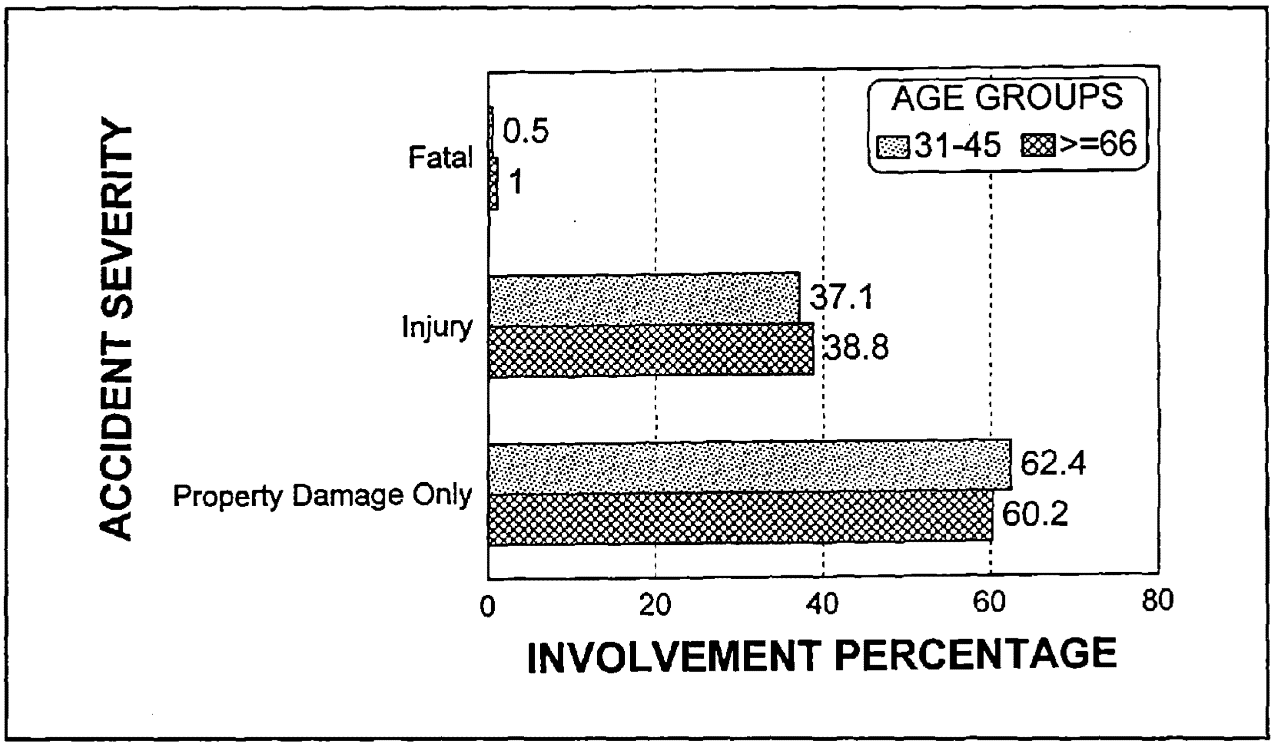

Figure 9. Percentage of involvement by accident severity for multivehicle accidents in the combined State database.

Contributing Factors and Pre-Crash Maneuvers

The combined State database results (see figure 10) showed that speed was the most frequently cited contributing factor for both age groups, with younger drivers involved in more multivehicle accidents than older drivers (13.6 vs. 11.6 percent, respectively). Younger drivers were also involved slightly more than older drivers in accidents where following too closely was a contributing factor (9.3 vs. 8.0 percent, respectively).

In contrast, older drivers were more likely than younger drivers to have been involved in an accident where the contributing factor was failure to yield (6.0 vs. 2.2 percent, respectively) or improper passing/lane use (4.2 vs. 3.4 percent, respectively). As shown in figure 11, older drivers were overinvolved in angle collisions when compared to younger drivers (32.6 vs. 17.5 percent, respectively). These results imply that older drivers are more likely than younger drivers to be involved in accidents in which merging is required. The underinvolvement of older drivers as compared to younger drivers in sideswipe collisions (8.7 vs. 20.2 percent, respectively) suggests that older drivers do not have a problem maintaining their lane.

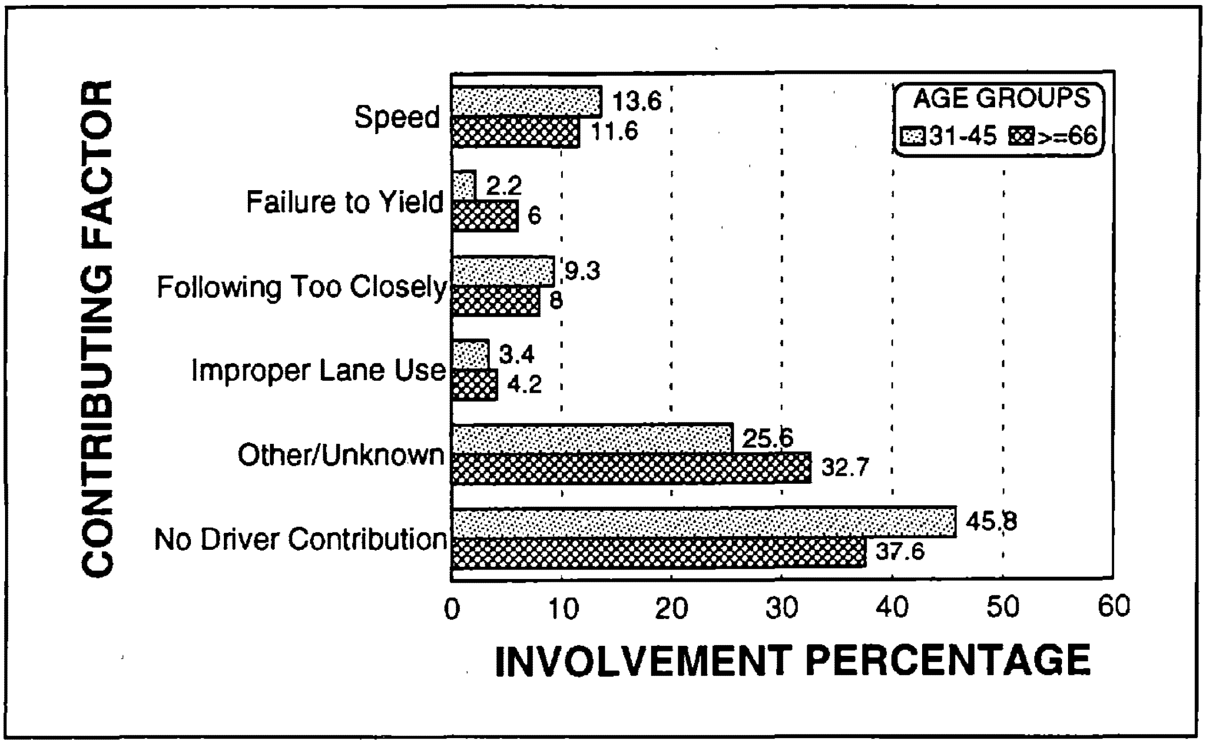

Figure 10. Percentage of involvement by contributing factor for multivehicle accidents in the combined State database.

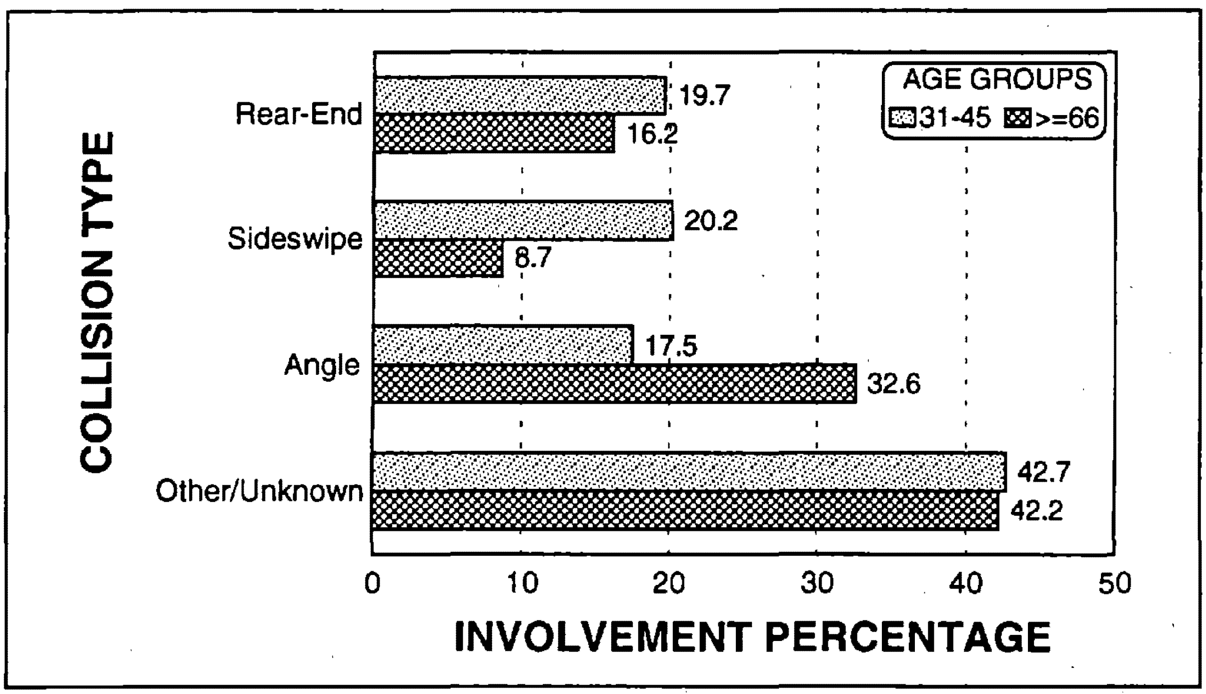

Figure 11. Percentage of involvement by collision type for multivehicle accidents in the combined State database where failure to yield was a contributing factor.

Older drivers were more likely than younger drivers to have been involved in an accident in which the pre-crash maneuver was merging or changing lanes (11.8 vs. 8.0 percent, respectively). For the remaining pre-crash maneuvers, including passing/overtaking, there were very few differences between the two age groups (see figure 12). Results from the GES database showed older drivers were much more likely than younger drivers to be merging/changing lanes (19.9 vs. 9.8 percent, respectively) or passing/overtaking (2.6 vs. 1.0 percent, respectively) prior to an accident.

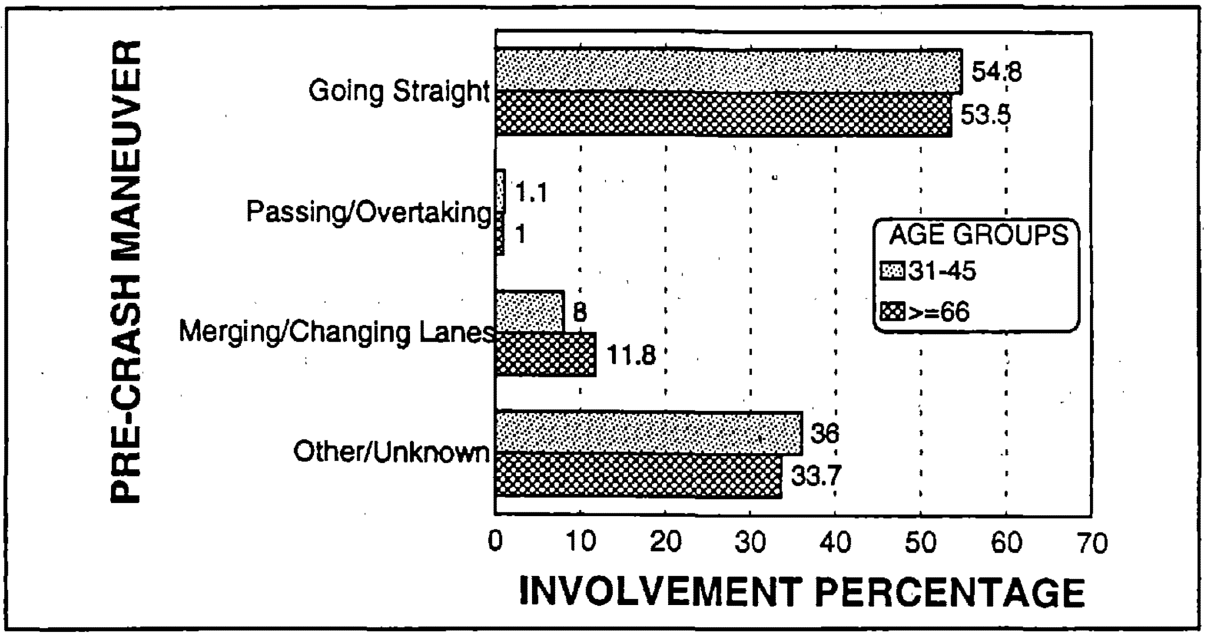

Figure 12. Percentage of involvement by pre-crash maneuver for multivehicle accidents in the combined State database.

These results suggest that older drivers are more likely than younger drivers to be involved in accidents in which a lane-change maneuver is required; from these results, it appears that the merge/lane-change maneuver is most problematic for older drivers, followed by passing/overtaking.

Further examination of the collision types associated with the merge/lane-change maneuver within the combined State database showed that older drivers are overinvolved in rear-end and sideswipe collisions (see figure 13). For the remaining accident types, older drivers were slightly underinvolved. The GES results showed that for accidents involving a merge or lane-change maneuver, older drivers were more likely than younger drivers to be involved in a rear-end collision (18.1 vs. 8.8 percent, respectively) or angle collision (51.2 vs. 41.8 percent, respectively). For those accidents involving a passing maneuver, the GES results showed that older drivers are much more likely than younger drivers to be involved in a sideswipe collision (99.0 vs. 63.1 percent, respectively).

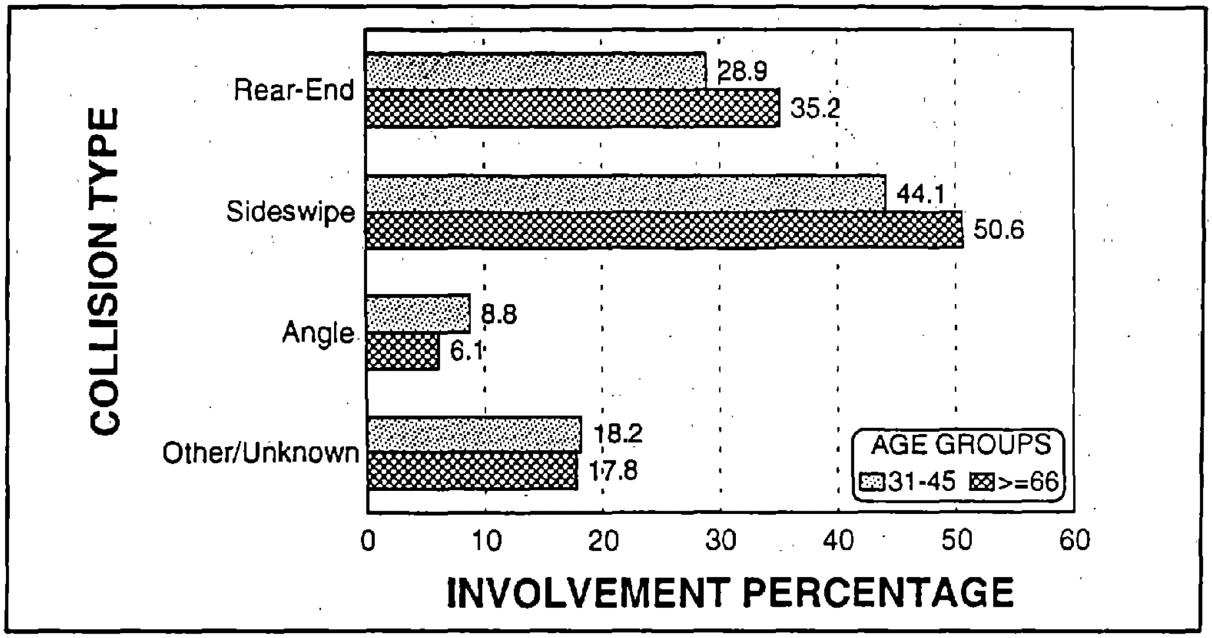

Figure 13. Percentage of involvement by collision type for multivehicle accidents in the combined State database that involve a merge/lane-change pre-crash maneuver.

Paired-Vehicle Analysis

As noted previously, this second set of analyses was undertaken to help control for the lack of exposure data and it included only freeway accidents within the five States in which one older driver and one younger driver were involved. Variables common to each accident included area, roadway location, weather condition, road surface condition, lighting condition, collision type, and accident severity.

As shown in figure 14, younger drivers were charged with no contributing factor 52.8 percent of the time, compared to 36.9 percent for the older driver age group. The two contributing factors that were greater for older drivers compared to younger drivers were failure to yield and improper lane use/passing. Only 3.0 percent of the younger drivers were charged with failure to yield, while 6.5 percent of the older drivers failed to yield. Similarly, only 4.2 percent of the younger drivers were charged with improper lane use/passing compared to 6.6 percent of the older drivers.

Some researchers have hypothesized that reporting biases of officers often result in older drivers being charged as the "at-fault" driver, regardless of whether they were actually at fault. While this may explain part of the differences shown in figure 14, the magnitude of some of the differences and the consistency across all factors make this proposed hypothesis somewhat unlikely. Regardless of what one chooses to believe, proving or disproving such bias is virtually impossible.

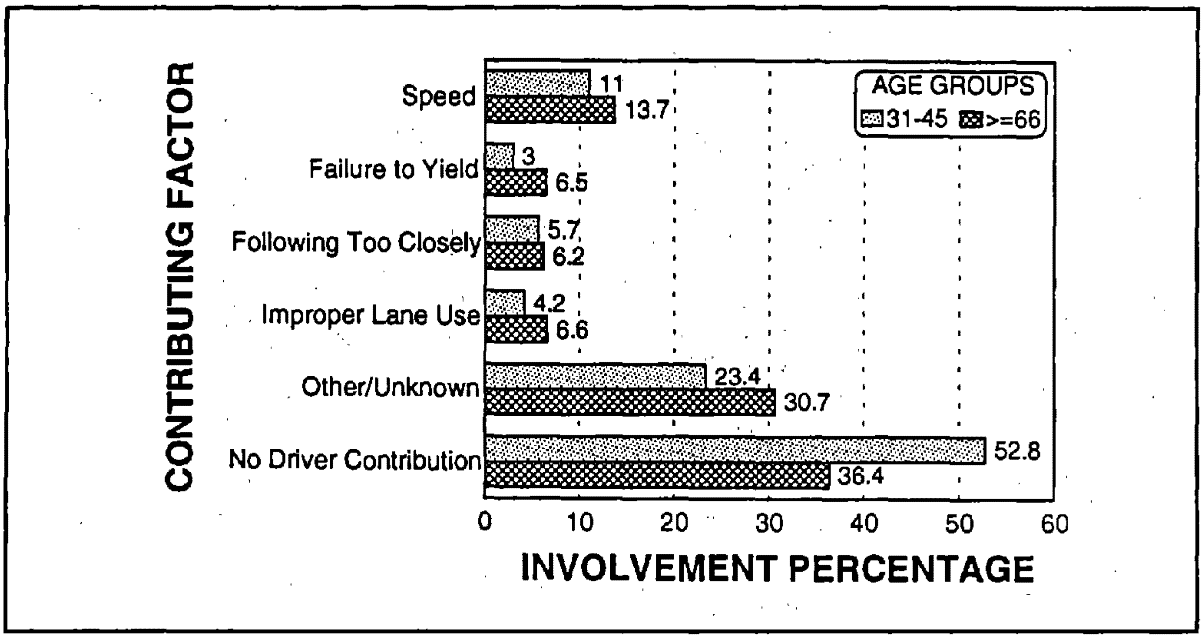

Figure 14. Percentage of involvement by contributing factor for the paired-vehicle accident analysis.

The results with respect to the pre-crash maneuver are shown in figure 15. They indicate that younger drivers were going straight (61.8 vs. 54.8 percent) or passing (2.2 vs. 1.6 percent) more often than older drivers just prior to the crash. The only notable difference in the pre-crash maneuvers is that older drivers were more likely than younger drivers to be merging/changing lanes prior to the crash (13.7 vs. 8.4 percent, respectively).

Since older drivers appear to be overinvolved when they are merging into the traffic stream or changing lanes, an examination of the contributing factors associated with the merge/lane-change accidents was undertaken. Figure 16 shows the contributing factors for all accidents involving a merge/lane-change maneuver. The contributing factor with the greatest relative difference between age groups was failure to yield (9.4 vs. 1.8 percent, respectively). This is the same contributing factor that exhibited the greatest relative difference for all accidents, regardless of the pre-crash maneuver. Older drivers were also more likely to be cited with a speeding violation or improper lane use/passing violation than were younger drivers when performing a merge/lane-change maneuver.

The results of the contributing factors and pre-crash maneuvers analysis for the paired-vehicle accidents confirmed what was suspected from the multivehicle analysis of the same variables, i.e., older drivers are more likely than younger drivers to have difficulties merging or changing lanes and, as a result, cause an accident by failing to yield right-of-way, improperly using a lane, or improperly passing.

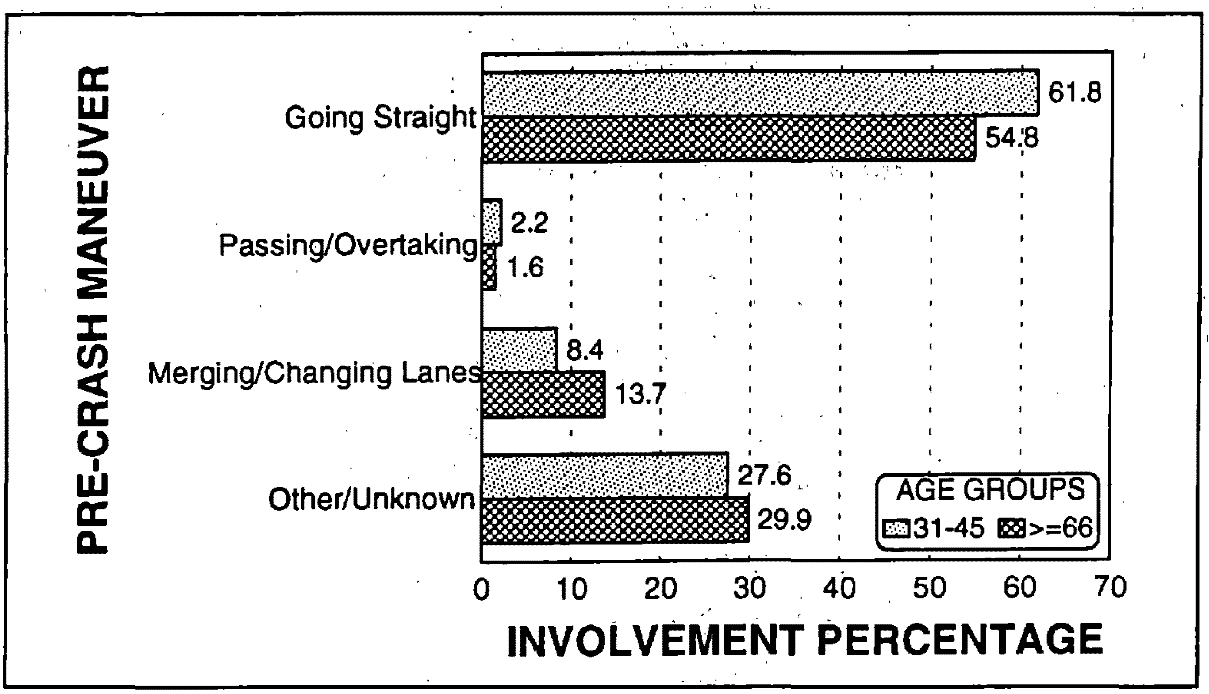

Figure 15. Percentage of involvement by pre-crash maneuver for the paired-vehicle accident analysis.

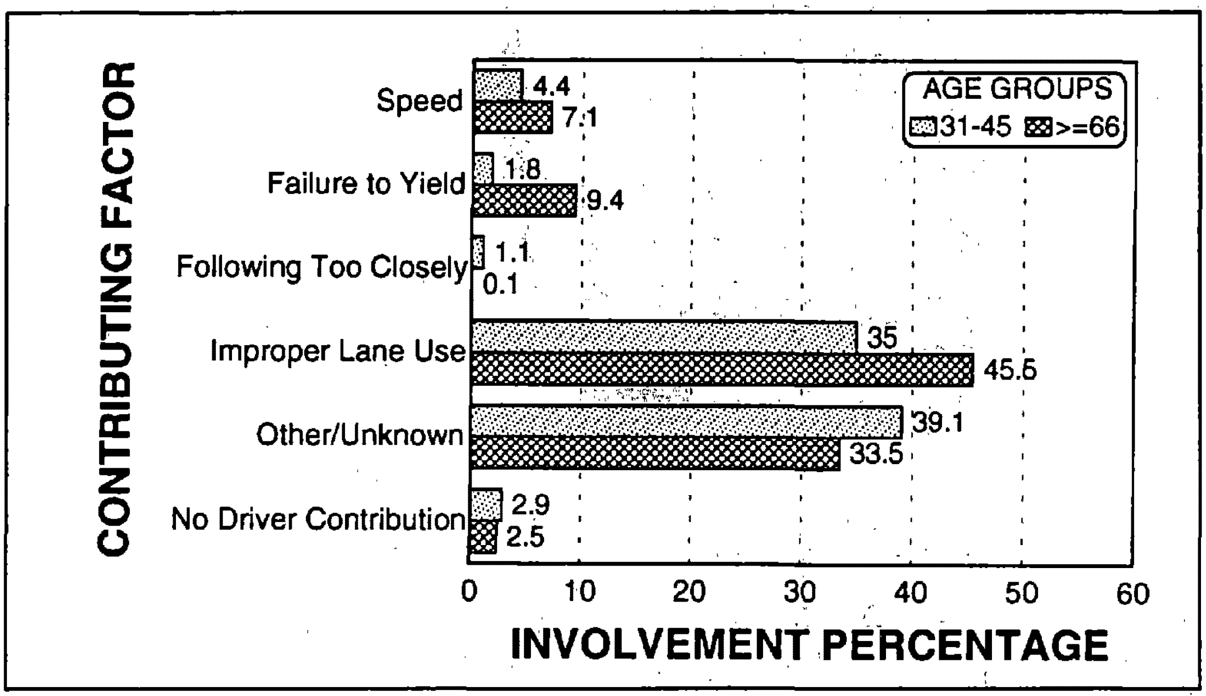

Figure 16. Percentage of involvement by contributing factor for all paired-vehicle accidents involving a merge/lane-change maneuver.

Finally, an examination of accident severity (see figure 17) showed that older drivers are more likely than younger drivers to be involved in an accident in which they or someone in their vehicle was injured or killed. As noted in previous analyses, these results may simply reflect the increased frailty of older persons involved in accidents.

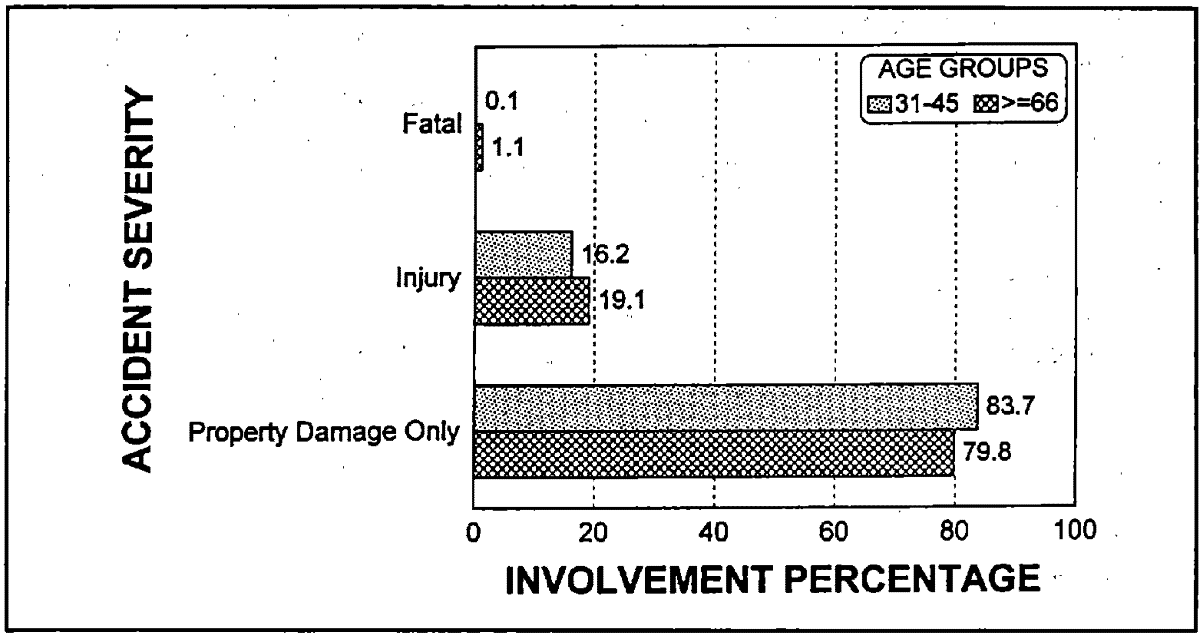

Figure 17. Percentage of involvement by accident severity for the paired-vehicle accident analysis.

Summary of Results

All Freeway Accidents

A summary of the results of the analysis of all freeway accidents that involved either an older (age 66 or older) or younger (ages 31 to 45) driver is provided below.

- The likelihood of being involved in a multivehicle accident as opposed to a single-vehicle accident is no greater for older drivers when compared to younger drivers. The ratio of multivehicle accidents to single-vehicle accidents for both age groups was approximately three to one. While there were no differences in the involvement ratios, it is important to note that the types of collisions within each category (single-vehicle vs. multivehicle) and other factors associated with the accidents were different for the two age groups as documented below.

- Older drivers appear to be overinvolved in both single-vehicle and multivehicle accidents on rural freeways and, consequently, underinvolved on urban freeways when compared to younger drivers. This outcome may simply be the result of differences in exposure between the two age groups. Younger drivers are likely to drive on urban freeways more often (e.g., commuting to/from work, due to time constraints from busy schedules, etc.), which, in turn, increases their exposure. In contrast, many older drivers may avoid urban freeways due to high vehicle volumes, close headways, and difficult merge maneuvers at high speeds. On rural freeways, however, they may be more comfortable since the traffic is typically less dense. However, this result may also reflect problems of older drivers on higher speed facilities. Even though the traffic is less dense on rural freeways compared to urban freeways, the speeds are typically greater by 7 to 10 mi/h (11.3 to 16.1 km/h). This increase in speed requires quicker decisions and actions from the driver. The ability to perform more quickly is not an attribute commonly found in older drivers and, thus, could result in an increased accident potential.

- Older drivers were slightly overinvolved in both single-vehicle and multivehicle accidents when the weather and road surface conditions were good (i.e., clear/cloudy and dry) and slightly underinvolved when the weather and road surface conditions were bad (i.e., rain/wet or ice/snow) when compared to younger drivers. This outcome may also be influenced by the differences in exposure between the two age groups. Older drivers may choose to conduct most of their trips under clear weather and dry road surface conditions. This, in turn, increases their exposure under these "good" conditions and decreases it under adverse conditions.

- Older drivers were overinvolved in both single-vehicle and multivehicle accidents under daylight conditions and, consequently, underinvolved during nighttime conditions when compared to younger drivers. As with weather and road surface conditions, this outcome may also be influenced by the differences in exposure between the two age groups. Older drivers may be more likely to select the midday hours to travel, which allows them to avoid peak periods when traffic volumes are heaviest and nighttime periods in which their diminished vision capabilities may adversely affect their performance.

- Older drivers were overinvolved in single-vehicle run-off-road accidents to the right and left when compared to younger drivers. This outcome implies that older drivers are running off the road more than their younger counterparts, or are running off the road no more frequently, but are unable to recover as often. If the latter is true, it is a problem of older drivers not being able to decide and react quickly enough once they leave the travel lane.

- Older drivers were slightly overinvolved in multivehicle sideswipe collisions and were underinvolved in rear-end collisions when compared to younger drivers in all databases examined. For angle collisions, the results were mixed. The combined State database and the GES database showed older drivers to be overinvolved in angle collisions, while the FARS database showed older drivers to be underinvolved in fatal angle collisions. These results imply that older drivers are more likely than younger drivers to be involved in accidents in which at least one of the parties was performing a maneuver to change lanes. This may include merging from an on-ramp into the mainstream of traffic, passing another vehicle, or simply changing lanes. It is during these types of maneuvers that sideswipe and angle collisions often occur on freeways.

- Older drivers were overinvolved in fatal and injury single-vehicle and multivehicle accidents and were underinvolved in property-damage-only accidents when compared to younger drivers. This result simply illustrates the vulnerability of older persons in a crash. It also confirms previous reports showing drivers over age 69 to be more than twice as likely as middle-aged drivers to be involved in a fatal accident.

- Older drivers were overinvolved in single-vehicle and multivehicle accidents in which the contributing factor was failure to yield or improper lane use/passing when compared to younger drivers. They were underinvolved in accidents where speed or following too closely were contributing factors.

- Older drivers were overinvolved in multivehicle accidents involving a merge/lane-change maneuver when compared to younger drivers. Further examination of the collision types associated with merge/lane-change maneuvers showed older drivers to be overinvolved in both rear-end and sideswipe collisions. These results confirmed that older drivers are more likely than younger drivers to be involved in an accident in which a lane-change maneuver was being performed and that failure to yield was the most prevalent contributing factor associated with such an accident.

Paired-Vehicle Analysis

A summary of the analysis of accidents involving one older and one younger driver is provided below.

- Older drivers were more than twice as likely to be cited with failure to yield and more likely to be cited with improper lane use/passing or speed violations when compared to younger drivers.

- Older drivers were 63 percent more likely to be merging or changing lanes just prior to the accident than were younger drivers. Older drivers were five times more likely than younger drivers to be cited with failure to yield when merging or changing lanes. Older drivers were also more likely than younger drivers to be cited with improper lane use or improper speed in this maneuver.

- Older drivers and/or their passengers were more likely than younger drivers and/or their passengers to suffer an injury or fatality during an accident.

The results from the paired-vehicle analysis indicated that it was most often the older driver performing the lane change or merge maneuver previously identified in the multivehicle accident analysis. It was also the older driver who most often caused the accident by failing to yield, with improper lane use and improper speed being secondary and tertiary factors.

SUMMARY

The clearest result from this analysis effort related to the pre-crash maneuvers and contributing factors of older drivers in multivehicle accidents. It appears that older drivers were overinvolved to the greatest degree in accidents in which they had to change lanes; these accidents were often sideswipe or angle collisions. The contributing factor with which older drivers were most often cited was failure to yield (twice as often as younger drivers for all accidents and five times as often for those accidents involving a lane-change maneuver). On freeway facilities, lane changes typically occur when a vehicle is entering the freeway from an on-ramp, exiting the freeway onto an off-ramp, or passing another vehicle on the freeway. The results with regard to location (ramp vs. mainline) showed no differences between the two age groups with respect to multivehicle accidents. Thus, it cannot be assumed that older drivers are having more problems with this lane-change maneuver at the on- and off-ramps as opposed to the mainline itself. A more detailed analysis of those accidents involving a lane-change maneuver may be needed to better define the problem area.

Older drivers also appeared to be overinvolved in run-off-road single-vehicle accidents, both to the left and the right. These results indicate that older drivers are either running off the road into a resultant accident more often than younger drivers, or are running off the road no more often, but are unable to recover and avoid an accident as often as younger drivers. The latter may be a result of the diminished reaction and response times of older persons.

An increased vulnerability of older persons who do become involved in accidents was also found in this analysis, even though it is possible that older drivers may be more likely to drive larger cars, wear seatbelts more often, and drive slower than younger drivers. In all of the analyses undertaken, the older driver was more likely to have been injured or killed in an accident when compared to the younger driver.

Finally, older drivers appeared to be overinvolved in both single-vehicle and multivehicle accidents during daylight hours, clear/cloudy weather conditions, and on dry road surfaces when compared to the younger age group. While these results are most likely due to exposure differences, they also indicate the times when older drivers are most likely to be on the freeway, which is important for any planned observational work.

5. HARD-COPY ACCIDENT ANALYSIS

INTRODUCTION AND BACKGROUND

The Task Analysis and Focus Group discussions identified a variety of problems that older drivers could experience on freeways. However, which of these potential problem areas actually result in accidents was not known. The purpose of the Hard-Copy Accident Analysis was to identify specific driving situations that result in accidents. These situations were identified by reading the accident narrative of hard-copy accident reports and examining collision diagram information typically not coded into computerized accident databases. Comparisons were made between the accident types experienced by older drivers and those experienced by a control group of younger drivers in order to identify those circumstances that are more hazardous for the older driver. The remainder of this section addresses the following topics:

- Methodology.
- Results.
- Single-vehicle accidents.
- Multivehicle accidents.
- Subjective data elements (accident types):
  - Contributing driver actions.
  - "Fault"—accident causation.
  - Accident types—single-vehicle crashes.
  - Accident types—multivehicle crashes.

METHODOLOGY

Hard-copy accident reports were obtained from Arizona, Florida, Illinois, and Maryland. These States were selected to provide a reasonable mix of geographic diversity. Interstate roadway segments were selected in each State until about 50 urban and about 50 rural accidents involving drivers over age 65 were obtained. A sample of about 50 accidents from the same roadway segments involving drivers ages 50 to 56 was selected as a control group. The 50 to 56 age group is considered close to the 65+ age group chronologically, but it lacks many of the age-related deficiencies that may be associated with those over age 65. The target sample from each State included:

	Urban	Rural
Drivers ages 50 to 56	50	50
Drivers age 65 or older	50	50

The urban segments were selected from interstates passing through or near large cities (population 500,000 or larger). The rural segments were selected from the same interstate routes, but from counties classified as rural. Printouts of interstate accidents tabulated by age group and county were used. Counties were selected until the desired sample was obtained. Thus, the basic sampling unit was an interstate segment in a county. The four cooperating States provided copies of accident reports for the selected interstate/county segments for calendar year 1992.

The sample included 917 accidents—441 from rural areas and 476 from urban areas; they were distributed as follows:

Arizona	255
Florida	216
Illinois	176
Maryland	270
	917

The following 45 data items were manually coded for each of the 917 accident reports:

- GENERAL IDENTIFYING INFORMATION
  - State of crash
  - Identification number
  - Experimental/control group
  - Rural/urban interstate
  - Interstate number
- ENVIRONMENTAL PROFILE
  - Month crash occurred
  - Day of week
  - Time of crash
  - Lighting conditions
  - Weather
  - Road surface condition
- ROADWAY PROFILE
  - Posted speed limit
  - Number of travel lanes
  - Road grade
  - Road surface type
  - Unusual road conditions
  - Median type
- DRIVER PROFILES
  - Driver's date of birth
  - Driver's gender
  - Driver's involvement (hit, or hit by, other vehicle)
  - Driver's county of residence in relation to crash
  - Driver's physical condition (before crash)
  - Other driver's date of birth (month/year)
  - Other driver's gender
  - Other driver's physical condition (before crash)
  - Speed driver was traveling
  - Speed other driver was traveling
  - Number of passengers in driver's vehicle
  - Driver's vehicle number in crash scenario
  - Violations committed by driver and/or other driver
  - Number of fatalities
  - Location of fatalities

Total number of persons injured
Injury severity of driver
Injury severity of other driver
Most severe injury of any of driver's passengers
Most severe injury of any of other driver's passengers
Driver re-examination required
Other driver re-examination required

VEHICLE PROFILE
V-1 vehicle type
V-2 vehicle type
V-1 condition (defects)
V-2 condition (defects)

CRASH PROFILE
Crash type
Site of crash

Preliminary analysis revealed that 120 accidents involved subjects driving heavy trucks and tractor-trailers. Nearly all of these accidents, n=108 or 90 percent, were from the 50-to-56 age group. This represented about a fourth of the accidents from that age group. Since the purpose of the project is to identify differences between older drivers and the younger control group, a control group consisting of a large proportion of professional drivers driving 80,000-lb (36 000-kg) rigs would skew the analysis. The major difference between the experimental and control groups should be driver age, not vehicle type or driver profession. Thus, all accidents in which the subject driver was operating a large truck, tractor-trailer, or unknown vehicle were eliminated from the sample. Cases where the subject driver struck or was struck by a large truck or tractor-trailer were retained. Removing professional drivers from the sample resulted in the following distribution:

	Drivers age 65+	Drivers ages 50-56	Row Total
Rural	220	145	365
Urban	190	219	409
Column Total	410	364	774

This configuration deviates somewhat from the idealized equal cell size distribution that was originally planned. However, the within-cell samples are still sufficient to permit comparisons between the two driver groups.

RESULTS

Since single-vehicle accidents are conceptually very different from multivehicle accidents, the analysis focuses on these two distinct groups. The final sample of 774 cases included 213 accidents (28 percent) that involved only 1 vehicle. The following sections first describe single-vehicle accidents and then multivehicle accidents. The emphasis is on comparing the accidents involving drivers over age 65 and those in the control group (ages 50 to 56). The goal is to identify accident situations in which older drivers are overinvolved and to identify any driver characteristics or diminished abilities that may have led to that overinvolvement. Ultimately, we would like to be able to identify treatments, countermeasures, and/or practices to reduce this overinvolvement.

SINGLE-VEHICLE ACCIDENTS

The entire sample included 213 freeway accidents (28 percent) that involved only 1 vehicle. The characteristics of this subset were analyzed separately. All variables described in the previous section were statistically examined; t-tests were used for the numeric variables and chi-squares were used for the categorical variables. Comparisons were made between the older driver group (age 65+) and the control group (ages 50 to 56). The single-vehicle accidents had the following urban/rural distribution:

	Drivers age 65+	Drivers ages 50-56	Row Total
Rural	92	69	161
Urban	29	23	52
Column Total	121	92	213

Table 10 shows the distribution of some of the variables analyzed for single-vehicle accidents. Variables are included in the table for one of three reasons: (1) a significant difference was found between the older and younger drivers in single-vehicle acci-dents; (2) a significant difference was found between younger and older drivers in multivehicle accidents and the variable is included here for comparison; or (3) the distributions are interesting, even though there are no significant differences.

As shown in table 10, 70.2 percent of the older driver group are males and 78.3 percent of the younger group are males. This difference is not significant. The date-of-birth variable shows that the older driver sample is an average of 19.3 years older than the younger sample. The time-of-day distribution shows some interesting and significant differences. Over half (55.8 percent) of the older driver accidents occur during the middle of the day (10 a.m. to 3 p.m.), while one-third (34.8 percent) of the younger drivers have accidents at those times. The survey data indicated that older drivers try to avoid periods of congestion. However, they are still having accidents, even though they are driving during times of less congestion.

The lighting condition distributions show similar and significant trends. Older drivers have 82.6 percent of their accidents during daylight hours. Older drivers also have less than half as many accidents at night as younger drivers, whether or not there is roadway lighting. The survey data indicate that older drivers avoid driving at night. The road surface condition data are comparable. Older drivers have significantly fewer accidents under conditions they tend to avoid (wet and icy roadways). Unfortunately, the degree to which older drivers avoid driving during periods of congestion, at night, or on wet roadways is not known. Thus, the exact relationship between their accident involvement and their driving exposure under various conditions is unknown. However, in terms of absolute numbers, accidents at night, in the rain, and on ice are not a major part of the older driver accident problem.

Table 10. Characteristics of single-vehicle crashes.

Variable	Category	Driver's Age		Significance	
		65-94	50-56		
Driver's sex	Male Female	70.2 29.8	78.3 21.7	χ^2=1.343	ns
Driver's age	Mean age	73.1	53.9	t=40.78	<0.0001
Time of day	7 a.m. - 9 a.m. 10 a.m. - 3 p.m. 4 p.m. - 6 p.m. 7 p.m. - 10 p.m. 11 p.m. - 6 a.m.	10.0 55.8 15.0 8.3 10.8	14.1 34.8 15.2 8.7 27.2	χ^2=13.462	0.0092
Lighting condition	Daylight Dark, no lighting Dark, lighting	82.6 13.9 3.5	62.6 26.4 11.1	χ^2=11.025	0.0040
Road surface condition	Dry Wet Snow/Ice	83.5 11.3 5.2	68.1 19.8 12.1	χ^2=6.890	0.0319
Number of lanes	1-2 3 4-7	82.6 7.3 10.1	70.0 23.8 6.3	χ^2=10.445	0.0054
County of residence	Same county Adjacent county Same State, not adjacent Adjacent State Out of State, not adjacent Same State, unknown county	16.0 6.7 17.6 11.8 28.6 19.3	21.7 19.6 18.5 9.8 15.2 15.2	χ^2=12.655	0.027
Driver's physical condition	Apparently normal Drinking BAC test Fatigue/asleep	72.7 3.6 23.6	80.2 5.8 14.0	χ^2=3.190	ns
Involvement	Hit vehicle Hit object Hit by object Ran off road Other single vehicle Non-collision	1.7 13.3 3.3 57.5 7.5 16.7	0 15.2 3.3 60.9 12.0 8.7	*	ns

* χ^2 cannot be used because 20 percent or more of the cells have expected frequencies <5.
ns = not significant.

The next variable listed in table 10 is the number of traffic lanes. The younger drivers have about twice as many accidents (30.1 percent) on three- and four-lane sections as the older drivers (17.4 percent), possibly because more younger drivers are commuting in urban areas. However, the important conclusion is that the older drivers apparently do not have an accident problem on three- or four-lane freeway sections.

In order to get a possible indication of the driver's familiarity with the accident site, the proximity of the driver's county of residence was determined relative to the county where the accident occurred. This was manually determined using maps of the area. As shown in table 10, 22.7 percent of the older drivers live in either the county where the accident occurred or in an immediately adjacent county. For the younger drivers, 41.3 percent live in the same or an adjacent county. Although 28.6 percent of the older drivers live in another State that was not adjacent, only 15.2 percent of the younger drivers are from another nonadjacent State. These differences indicate that the older drivers are involved in accidents that are not as close to home as the younger drivers. These differences are significant. It is reasonable to assume, therefore, that the older drivers may not be as familiar with the accident locations as the younger control group, possibly because they only live in the area for part of the year.

The data on driver physical condition is very interesting. Almost a quarter (23.6 percent) of the older drivers were reported by the investigating officer as being either fatigued or asleep. About half as many (14.0 percent) of the younger drivers were similarly classified. These differences are not statistically significant ($p=0.0957$). The data are especially intriguing since only 17.4 percent of the older driver accidents occurred when it was dark. Apparently, fatigue is a serious problem for older drivers in single-vehicle accidents.

The "involvement" variable indicates the dynamics of the collision. In the most common scenario, the vehicle runs off the roadway. Almost 60 percent of both the older and younger drivers were so classified. Other common scenarios included hitting an object (i.e., guardrail, signpost) and noncollisions (i.e., vehicle fires). The distribution of involvement scenarios is not significantly different for the older and younger drivers.

In addition to the variables shown in table 10, statistical comparisons of the other variables were also performed. The following variables were examined and no significant differences were found:

Day of week
Month of accident
State where accident occurred
Land use—urban/rural
Posted speed limit
Weather
Road grade (straight/level, etc.)
Surface type (concrete/asphalt)
Road condition—construction/no defects
Median type
Speed driver was traveling

Number of passengers in driver's vehicle
Violations committed by driver
Number of fatalities
Injury severity
Vehicle types (driver's vehicle)
Mechanical defects/vehicle defects
Accident location

The lack of significant differences in several of these variables is interesting. The lack of involvement of older drivers in accidents in construction zones suggests that they either successfully avoid construction zones or that the problems they indicated in the focus group discussion and the AARP survey do not result in single-vehicle accidents. The lack of involvement in accidents at exit/entrance ramps indicates that they do not have a problem at those locations.

MULTIVEHICLE ACCIDENTS

Of the 774 accidents in the sample, 561 (72 percent) involved 2 or more vehicles. Table 11 shows the distributions of some of the variables analyzed for multivehicle accidents. Like table 10, the variables selected for the table: (1) showed significant differences between older and younger drivers in multivehicle accidents, (2) showed significant differences in the previously discussed single-vehicle accidents, or (3) were interesting.

	Drivers age 65+	Drivers ages 50-56	Row Total
Rural	128	76	204
Urban	161	196	357
Column Total	289	272	561

The drivers' ages, older and younger, are comparable with those for the single-vehicle accidents. The older drivers are 20 years older. The "other driver" in the older driver accidents is slightly older, 40.2 vs. 38.0 years; but the difference is not significant. The drivers' gender differences, however, are significant. While 79.2 percent of the older drivers are male, only 69.9 percent of the younger drivers are male. This is in contrast to the single-vehicle accidents, where only 70.2 percent of the older drivers were male (see Table 10).

The time-of-day distributions indicate that older drivers are significantly more involved in midday accidents and less involved in both early morning and late night accidents. The older drivers are having more accidents during off-peak times when congestion is less common. Interestingly, this same trend is not apparent in the lighting condition distributions. There are no significant differences in lighting conditions. There are also no significant differences in the road surface condition variable, unlike the single-vehicle accidents where significant differences were found between the older and younger drivers.

Table 11. Characteristics of multivehicle accidents.

Variable	Category	Driver's Age		Significance	
		65-94	50-56		
Driver's age	Mean age	73.3	53.7	t=59.31	<.0001
Other driver's age	Mean age	40.2	38.0	t=1.85	ns 0.065
Driver's sex	Male Female	79.2 20.8	69.9 30.1	χ^2=6.042	0.014
Time of day	7 a.m. - 9 a.m. 10 a.m. - 3 p.m. 4 p.m. - 6 p.m. 7 p.m. - 10 p.m. 11 p.m. - 6 a.m.	13.5 44.3 26.0 9.7 6.6	20.2 34.6 26.5 7.4 11.4	χ^2=11.701	0.020
Lighting condition	Daylight Dark, no lighting Dark, lighting	79.3 8.3 12.3	77.5 8.8 13.7	χ^2=0.300	ns
Road surface condition	Dry Wet Snow/Ice	77.2 17.5 5.3	74.1 18.9 7.0	χ^2=1.028	ns
Number of lanes	1-2 3 4 5-7	44.0 30.1 18.4 7.5	30.2 38.4 19.2 12.2	χ^2=12.213	0.007
Land use	Urban Rural	55.7 44.3	72.1 27.9	χ^2=15.487	0.0001
Road surface	Asphalt Concrete	68.8 31.2	59.0 41.0	χ^2=4.330	0.038
County of residence/ accident county	Same Adjacent Not adjacent (same State) Adjacent State Out of State, not adjacent Same State, unknown county	36.7 15.7 9.8 8.7 15.4 13.6	49.4 20.7 7.0 4.4 7.0 11.4	χ^2=21.454	0.0007
Driver's physical condition	Apparently normal Drinking BAC test Fatigue/asleep	95.4 2.3 2.3	97.3 1.5 1.1	*	
Other driver's physical condition	Apparently normal Drinking BAC test Fatigue/asleep	94.1 3.5 2.4	95.9 2.1 2.1	χ^2=1.048	ns

Table 11. Characteristics of multivehicle accidents (continued).

Variable	Category	Driver's Age		Significance	
		65-94	50-56		
Vehicle type—subject	Passenger car	78.9	73.2	15.171	0.0017
	Passenger van	5.9	8.8		
	Recreational vehicle	4.2	0.4		
	Light truck/pickup	11.1	17.6		
Vehicle type—other vehicle	Passenger car	54.9	58.6	6.000	ns
	Passenger van	8.4	8.0		
	Recreational vehicle	0.7	1.5		
	Light truck/pickup	13.2	15.6		
	Heavy truck	5.5	2.3		
	Tractor-trailer	17.2	14.1		
Vehicle speed, mi/h (km/h)	0	20.2	21.5	χ^2=2.001	0.736
	1-20 (1.6-32.2)	12.9	17.7		
	30-54 (48.3-86.9)	29.8	28.5		
	55-64 (86.9-103.0)	29.8	25.3		
	65+ (104.6+)	7.3	7.0		
Mean speed—subject vehicle	Mean speed	36.07	33.02	t=1.18	0.238
Other vehicle speed, mi/h (km/h)	0	16.0	24.8	χ^2=18.112	0.0012
	1-20 (1.6-32.2)	11.7	22.9		
	30-54 (48.3-86.9)	29.6	22.9		
	55-64 (86.9-103.0)	23.5	21.7		
	65+ (104.6+)	19.1	7.6		
Other vehicle—mean speed	Mean speed	40.25	29.53	t=3.90	0.000
Number of passengers in vehicle	0	51.0	64.3	χ^2=19.75	0.0002
	1	38.9	21.7		
	2	4.9	7.4		
	3	5.2	6.6		
Speed other vehicle exceeding speed limit	Mean	-17.62	-26.49	t=3.51	0.001
Involvement	Hit vehicle	37.7	41.6		
	Hit object	49.7	46.1		
	Hit by object	1.0	1.1		
	Ran off road	1.0	1.8		
	Other single-vehicle	0.0	0.4		ns
	Non-collision	1.4	10.4	χ^2=4.865	0.676
	Hit by vehicle, then hit other vehicle	7.3	7.4		

* χ^2 cannot be used because 20 percent or more of the cells have expected frequencies <5.
ns = not significant.

Significant differences were found between the younger and older drivers in the number of lanes variable for multivehicle crashes. Older drivers are involved in more accidents (44.0 percent) on two-lane freeways than the younger drivers (30.2 percent). This is related to the finding that older drivers are more involved in rural (as opposed to urban) crashes. These three significant effects are probably closely related to the next variable—county of residence. While 70.1 percent of the younger drivers involved in multivehicle accidents resided in the same or an adjacent county, only 52.4 percent of the older drivers were that close to home. Similarly, 15.4 percent of the older drivers were from a nonadjacent State, while 7.0 percent of the younger drivers lived that far from the accident location. This finding is similar to that for single-vehicle accidents, except that an even larger proportion of the single-vehicle older drivers were from a nonadjacent State. Unlike the single-vehicle accidents, however, fatigue does not seem to be a problem. Only 2.3 percent of the older drivers in multivehicle accidents were reported as being fatigued or asleep, far fewer than were fatigued or asleep in the single-vehicle accidents. Statistical comparisons between the older drivers and the control group cannot be made on this variable because of low expected cell frequencies.

The next variable listed is the type of vehicle that the subject driver was driving. The older drivers are more likely to be driving a recreational vehicle (4.2 percent) and somewhat less likely to be driving a pickup or light truck (11.1 percent) than the younger control group. The differences are significant at the 0.001 level. The vehicle type for the other vehicle involved in the accident is more interesting. Almost a fourth (22.7 percent) of the older driver accidents involved a heavy truck or tractor-trailer, while 16.4 percent of the younger driver accidents involved these vehicles. While these differences are not significant, the sheer magnitude of the effect is important— almost a quarter of the older drivers in multivehicle accidents strike or are struck by a truck.

The next variable is the speed that the subject vehicle was traveling. There are no significant differences between the older and younger drivers. However, there are significant differences in the speed that the other vehicle was traveling. Older drivers are less likely than younger drivers to be involved with slower moving vehicles (27.7 percent vs. 47.7 percent, respectively, for speeds of less than 30 mi/h [48 km/h]) and more likely to be involved with vehicles going 65 mi/h (104.6 km/h) or greater (19.1 percent vs. 7.6 percent, respectively). The mean speed of the other vehicle in the older driver crashes (40.25 mi/h [64.8 km/h]) was over 10 mi/h (16.1 km/h) faster than the mean speed for the younger driver crashes (29.53 mi/h [47.54 km/h]). This suggests that older drivers may have problems seeing or reacting to faster vehicles, or they may drive in a way that makes them more likely to be struck by a faster vehicle. This is also supported by the next variable, the speed by which the other vehicle exceeded the speed limit. The other vehicle in the older driver crashes was exceeding the speed limit to a significantly greater degree than the other vehicle in the younger driver crashes.

The younger drivers are more likely to be driving alone (64.3 percent) than the older drivers (51.0 percent). Since more of the younger driver trips occur during commuting hours, they probably are solo work trips. It is interesting that about half of both the older and younger drivers involved in single-vehicle accidents were also alone.

The last variable in table 11 describes the type of involvement in the collision; older drivers appear no more likely than younger drivers to hit the other vehicle (36.7 percent vs. 41.0 percent, respectively) or to be hit by the other vehicle (49.7 percent vs. 46.1 percent, respectively). Other situations—hitting an object, being hit by an object, running off the road, and being hit by one vehicle and subsequently striking a third vehicle—also appear to be experienced in comparable degrees by both age groups. Unfortunately, because of low expected cell frequencies, a χ^2 comparison cannot be made.

In addition to the variables shown in table 11, statistical comparisons of the other variables were also performed. The following variables were examined and no significant differences were found:

Day of week
Month of accident
State where accident occurred
Road grade
Unusual road conditions (construction)
Median type
Other driver's sex
Violations committed by driver
Violations committed by other driver
Number of fatalities
Location of fatalities
Injury severity—driver
Injury severity—other driver
Vehicle condition/mechanical defects
Accident location (lane, exit, etc.)

It is interesting that the multivehicle crashes, like the single-vehicle crashes, failed to show an overinvolvement of older drivers in construction zones. Despite the continual recurrence of construction zones as an older driver problem in both the surveys and the focus groups, there is apparently no work zone accident problem.

As discussed, the other vehicle in older driver crashes was exceeding the speed limit to a significantly greater degree than it was in the younger driver crashes. Despite this, the other vehicle was found to be no more likely to receive a violation.

There were also no significant differences in crash location. The vast majority of the crashes occur on the main roadway. Other locations that were the site of crashes included: exit ramps (1.1 percent of older driver crashes/2.0 percent of younger driver crashes), entrance ramps (1.5 percent of older driver crashes/1.2 percent of younger driver crashes), merge/transition lanes (1.9 percent of older driver crashes/1.6 percent of younger driver crashes).

SUBJECTIVE DATA ELEMENTS: ACCIDENT TYPES

The preceding analysis addressed objective data items that were coded from the hard-copy accident reports. In addition, the hard-copy report narrative and collision diagram were reviewed in an attempt to quantify some of the more subjective aspects of the accident. The purpose of this review was to determine the types of accident scenarios that were experienced by the older drivers and the comparison group of younger drivers. The narrative and collision diagram of each report were read and coding categories were developed to quantify four aspects of each accident. These aspects were:

- Contributory Driver Actions: behavior of one or both drivers that may have contributed to causing the accidents.
- "Fault": subjective judgment as to which driver caused the accident.
- Crash Scenarios for Single-Vehicle Accidents: description of the vehicle movements that preceded the accident.
- Crash Scenarios for Multivehicle Accidents: description of the movements of each of the vehicles involved in the accident.

Contributing Driver Actions

The behaviors or actions of the drivers that may have caused the accidents are shown in table 12. This information was coded for 753 accidents. Multivehicle accidents with three or more vehicles were eliminated from the sample. Four differences between the older drivers and the control sample of 50- to 56-year-old drivers are apparent. The most frequently specified behavior was careless driving. Of the older drivers, 44.7 percent were coded as driving carelessly, as opposed to 37.5 percent of the younger sample. The younger drivers were coded more often as driving too fast for conditions (40.8 percent), relative to the older drivers (25.4 percent).

One of the biggest differences between the two groups of drivers involved falling asleep/fatigue. While 10.3 percent of the older drivers were found to have fallen asleep or were fatigued, only 4.2 percent of the younger sample were so coded. Although it occurred relatively infrequently, it is interesting that 2.8 percent of the older drivers were coded as making an improper turn, while only 0.8 percent of the younger sample were so coded.

No major differences are apparent between the two groups relative to: inattention, unsafe lane change, failure to yield right-of-way, following too closely, faulty equipment, exceeding speed limit, unsafe passing, and reckless driving.

Table 12. Contributing driver actions by age group.

Behavior/violation/ contributing cause	Age Group				Total Cases	
	65 to 94		50 to 56			
	N	%	N	%	N	%
Careless driving	178	44.7	133	37.5	311	41.3
Speed too fast for conditions	101	25.4	145	40.8	246	32.7
Inattention	59	14.8	60	16.9	119	15.8
None	63	15.8	55	15.5	118	15.7
Unsafe lane change	45	11.3	37	10.4	82	10.9
Fell asleep, fatigue	41	10.3	15	4.2	56	7.4
Following too closely	11	2.8	10	2.8	21	2.8
Drinking/drugs/meds	7	1.8	12	3.4	19	2.5
Failure to yield	11	2.8	7	2.0	18	2.4
Faulty/missing equip.	10	2.5	8	2.3	18	2.4
Improper turn	11	2.8	3	0.8	14	1.9
Exceeded speed limit	5	1.3	3	0.8	8	1.1
Unsafe passing	2	0.5	5	1.4	7	0.9
Reckless driving	3	0.8	2	0.6	5	0.7

"Fault"—Accident Causation

When each accident was reviewed, a subjective judgment was made to determine which driver was "at fault." The results of this effort are shown in table 13. Table 13 shows that the driver who was not in either the age 65 or older sample or the 50- to 56-year-old sample was found to be at fault in 49.5 percent of the crashes. The most interesting comparison is the indication that 26.1 percent of the accidents were caused by the age 65+ sample, while only 20.2 percent were caused by the younger sample.

Even though slightly more than half (54 percent) of the sample involved subject drivers age 65 or older, this 26.5 percent vs. 19.8 percent difference is more than would be produced by this slight difference in sample size. Apparently, the older drivers are at fault slightly more often than the drivers in the younger control group.

Table 13. Fault—driver who caused the accident.

Value Label	Frequency	Percent
Not subject driver	383	49.5
Subject, age 65+	202	26.1
Subject, age 50-56	156	20.2
Both drivers	9	1.2
Unknown/unclear	24	3.1
Total	774	100

Accident Types—Single-Vehicle Crashes

Accident types or accident scenarios were developed to describe the vehicle actions and collision dynamics involved in the single-vehicle accidents. These scenarios were developed to group the crashes into categories with similar causative elements/ preconditions. In the development of the accident scenarios, single-vehicle and multivehicle accidents were defined differently than in the previous analysis. If a vehicle ran off the road, crossed the median, or lost control and subsequently struck another vehicle or was struck by another vehicle, the accident was classified as a single-vehicle accident. Accidents were classified in this manner when the collision with the second vehicle was determined to be a *result* (as opposed to a *cause)* of the accident (i.e., the first vehicle lost control prior to striking the second vehicle and the second vehicle and the presence of the second vehicle did not contribute to causing the accident). Table 14 shows that the most common single-vehicle accident types involved the vehicle running off the roadway. Most frequently, there was no prior loss of control. The most obvious difference in the distribution of scenarios involving the older and middle-aged drivers was in the run-off-roadway scenario. The older drivers were more likely (39.9 percent) than the middle-aged drivers (23.6 percent) to run off the roadway without previously losing control. The middle-aged drivers were more likely (39.6 percent) to lose control and then run off the road than were the older drivers (30.0 percent). These differences are probably related to the increased incidence of fatigue/falling asleep among the older drivers. The older drivers are also less involved in accidents where they either hit a loose object or were hit by a loose object. This is possibly because older drivers avoid driving during periods of congestion, when such situations are more likely to occur.

Table 14. Single-vehicle crash types by driver age group.

Single-vehicle crash scenario	Age Group				Total Cases	
	65 to 94		50 to 56			
	N	%	N	%	N	%
Ran off roadway, no prior loss of control	55	39.9	25	23.6	80	32.8
Ran off roadway, lost control prior to running off	40	29.0	42	39.6	82	33.6
Lost control, did not run off roadway	4	2.9	5	4.7	9	3.7
Hit object/animal on roadway (not moving)	18	13.0	20	18.9	38	15.6
Hit by loose object	4	2.9	7	6.6	11	4.5
Forced off roadway by other vehicle/animal, etc.	5	3.6	3	2.8	8	3.3
Unusual circumstances, not countermeasure corrective	12	8.7	4	3.8	16	6.6
Total cases	138	100	106	100	244	100

Accident Types—Multivehicle Crashes

Accident types or accident scenarios were also developed to categorize the vehicle actions and collision dynamics involved in multivehicle crashes. The scenarios were structured to identify which vehicle was the striking vehicle and what each of the vehicles was doing. Table 15 shows the distribution of the multivehicle crash scenarios for the two driver age groups.

The most common scenarios involve situations where the subject driver was either hit by another vehicle while slowing or stopped (24.5 percent of all multivehicle crashes), or where the subject driver hit another vehicle that was slowing or stopped (22.8 percent of all multivehicle crashes). Together, these crash types account for almost half of the crashes. The older driver sample has slightly fewer of these types of crashes. However, the difference is not very large. The next most frequently occurring scenarios involved the subject vehicle being hit by another vehicle that was either changing lanes or was out of control. Each of these types involved 8.1 percent of the entire sample (7.4 percent of the older sample and 8.9 percent of the middle-aged sample). Again, there was not a large difference between the two age groups. While 7.0 percent of the total sample involved being hit by another vehicle while going slower (not while slowing or stopped), this type involved 8.8 percent of the older

Table 15. Multivehicle crash types by driver age group.

Multivehicle crash scenarios	Age Group				Total	
	65+		50-56			
	N	%	N	%	N	%
Hit by other vehicle:						
while slowing or stopped	62	22.8	68	26.4	130	24.5
while changing lanes	7	2.6	3	1.2	10	1.9
while changing lanes suddenly to exit	2	0.7	1	0.4	3	0.6
after intentionally crossing median	3	1.1	-	-	3	0.6
while out of control	4	1.5	2	0.8	6	1.1
while going slower—rear-ended	24	8.8	13	5.0	37	7.0
that was changing lanes	20	7.4	23	8.9	43	8.1
that was merging with traffic	2	0.7	2	0.8	4	0.8
that failed to stay in own lane	5	1.8	6	2.3	11	2.1
that was out of control	20	7.4	23	8.9	43	8.1
Hit by other vehicle: Subtotal	149	54.8	141	54.7	290	54.7
Hit other vehicle:						
while changing lanes	22	8.1	7	2.7	29	5.5
while merging with traffic	5	1.8	2	0.8	7	1.3
while failing to stay in own lane	5	1.8	3	1.2	8	1.5
while out of control	1	0.4	6	2.3	7	1.3
that was slowing or stopped	57	21.0	64	24.8	121	22.8
that was changing lanes	-	-	4	1.6	4	0.8
that was changing lanes suddenly to exit	3	1.1	-	-	3	0.6
that was merging with traffic	2	0.7	1	0.4	3	0.6
that was intentionally crossing median	1	0.4	-	-	1	0.2
that was out of control	7	2.6	12	4.7	19	3.6
that was going slower—rear-ended	8	2.9	11	4.3	19	3.6
Hit other vehicle: Subtotal	111	40.8	110	42.6	221	41.7
Unusual circumstances: Not preventable	5	1.9	5	1.9	10	1.9
Inadequate information	7	2.6	2	0.8	9	1.7
Total: All scenarios	272	100	258	100	530	100

sample and 5.0 percent of the younger sample. This suggests that older drivers may present an increased hazard because of their slower traveling speeds or that younger drivers are more hazardous due to their higher traveling speeds. The scenario where the subject driver hit another vehicle while changing lanes involved only 5.5 percent of the entire sample; however, it did account for 8.1 percent of the older sample versus 2.7 percent of the middle-aged group. This represents three times more involvement for older drivers. Thus, it appears that older drivers are having some difficulty with lane changing. This is also supported by the older drivers' overinvolvement in cases where they are hit by another vehicle while changing lanes. That scenario accounts for 2.6 percent of the older sample versus 1.2 percent of the middle-aged group.

The relatively infrequent occurrence of scenarios involving either being hit by another vehicle or hitting another vehicle while merging or changing lanes to exit suggests that these maneuvers are not a problem for the older driver.

Table 15 shows subtotals for the scenarios where the subject driver was either hit by another vehicle or hit the other vehicle. As indicated, older drivers are hit about as often (54.8 percent) as the younger drivers (54.7 percent). They also hit other vehicles about as often (40.8 percent) as the younger drivers (42.6 percent).

The distributions of accident scenarios for the older driver sample and the younger driver sample indicate that the two groups have very similar accident experiences. Although the older drivers apparently have difficulties with lane changing and with being rear-ended by faster-moving vehicles, their involvement frequencies in the other accident scenarios are very similar to those of the younger driver sample. It is worth mentioning that being rear-ended by a faster-moving vehicle is most likely the fault of the faster-moving vehicle.

SUMMARY

Hard-copy accident reports for about 800 urban and rural freeway accidents from 4 States were analyzed. The sample was selected so that accidents from the same segments of freeway involving drivers over age 65 and drivers between the ages of 50 and 56 could be compared.

Single-Vehicle Accidents

About a quarter of the accidents were classified as single-vehicle accidents. Older drivers were no more or less likely to be involved in single-vehicle accidents than younger drivers. The older drivers were more likely than the younger drivers to be involved in single-vehicle crashes during daylight hours, dry weather, or on two-lane freeways. Older drivers were also overinvolved in accidents occurring farther from their homes. Fatigue was a factor in about a quarter of the single-vehicle accidents involving older drivers.

Multivehicle Accidents

Multivehicle accidents involving older drivers were more likely to occur from 10 a.m. to 3 p.m. on two-lane freeways in rural areas. As with the single-vehicle accidents, older drivers were more likely to be in accidents that occur farther from their home. However, unlike single-vehicle accidents, fatigue was not a factor in the older driver multivehicle accidents. Older drivers were also more likely to be struck by a fast-moving vehicle (over 65 mi/h [104.6 km/h]). Either older drivers have problems seeing and reacting to fast-moving vehicles or they drive in a way that increases the chances of being struck by a fast-moving vehicle.

Subjective Analysis—Accident Scenarios

The older drivers were overinvolved in single-vehicle crashes where they ran off the roadway prior to losing control. They were underinvolved in single-vehicle accidents where they either hit an object or animal in the road or where they were hit by a loose object. In multivehicle accidents, older drivers were somewhat more likely to be struck (rear-ended) while going slower or to be struck while changing lanes. Older drivers were also more likely to be hit by another vehicle while they were merging with traffic.

6. AARP SURVEY

In order to identify some of the problems experienced by older drivers on freeways and interstates, a survey of American Association of Retired Persons (AARP) members was conducted. This survey was designed to quantify the experiences and opinions of a relatively large sample of older drivers. The following topics are related to the management of the survey and the analysis of the results are addressed in this section:

- Sampling procedure.
- Survey administration.
- Survey development.
- Results.

SAMPLING PROCEDURE

AARP agreed to assist in the survey by providing the names of chapter representatives who were interested in participating in the study. These individuals were identified by sending a project announcement to all 4,000 AARP chapters. The representatives of interested chapters were asked to return a form on which they provided their chapter name and number, and the number of questionnaires that they would need. They also indicated whether the chapter represented an urban, suburban, small town, or rural community. Participating chapters were offered a $1 incentive for each completed questionnaire. AARP forwarded the first 15,740 questionnaire requests from 242 chapters to the Center for Applied Research, Inc. (CAR).

A distribution across community types for the 15,740 requests was computed. It was determined that the four community types accounted for the following percentages of the AARP chapter population: 25 percent urban, 28 percent suburban, 39 percent small town, and 8 percent rural. To ensure that at least 1,000 completed surveys would be received, a sample with chapters representing 2,500 members was selected. The distribution, by community type, was the same as that of the distribution of the AARP chapters requesting questionnaires. In order to avoid "overrepresentation" by any single chapter, it was arbitrarily decided to eliminate the 19 chapters that requested more than 100 questionnaires. To get a geographically distributed sample, AARP chapters were randomly selected from those requests first received so that there was only one chapter in each community type from any one State. In this manner, 66 chapters representing 2,520 members in 39 States were selected. The questionnaires were administered during chapter meetings held during June 1994.

SURVEY ADMINISTRATION

Chapter representatives were sent the requested number of questionnaires and instructions for administering the questionnaires at their next chapter meeting. They were also provided with a postage-paid envelope for returning completed forms. When the completed forms were received, a thank-you note and a check for the $1/completed form incentive were sent to the chapter representative.

SURVEY DEVELOPMENT

The purpose of the AARP survey was to identify the types of problems experienced by older drivers on freeways. The identification of potential problem areas began with a review of the Task Analysis conducted during Task A. The Task Analysis was reviewed and a listing of potential problem areas was prepared. The following general areas were identified:

- Signing.
- Delineation.
- Lighting.
- Entering/exiting.
- Lane tracking.
- Fatigue.
- Toll plazas.
- Rest areas.
- Seeing/operating vehicle controls.
- Weather.
- Work zones, construction.
- Congestion.
- Trucks.

A series of questions addressing these topics was generated and reviewed by FHWA personnel. The questions were modified based on this review. The modified questions were prepared in questionnaire format and pilot tested using paid subjects at several Northern Virginia senior centers. A focus group format was used to "debrief" subjects after they completed the questionnaire. Based on this experience, the questionnaire was further modified and subjected to additional pilot testing. It became obvious that the entire 11-page questionnaire was too long to be completed in the 15 to 20 min that were available at the AARP chapter meetings. Thus, two shorter versions of the questionnaire were developed, each of which was found in further pilot testing to take between 15 to 20 min. To control for any "order of presentation" effects, two versions of each of the two questionnaires were developed that presented the questions in a different order. The final questionnaires consisted of one 8-page version (Version A) and one 7-page version (Version B). The first three pages and the last page of each version were the same. The middle three pages of Version B and the middle four pages of Version A were different. The order of these middle pages was reversed to create two additional questionnaire formats. The questionnaire pages and their order in each of the four versions were as follows:

Version A:	1, 2, 3, 4, 5, 6, 10, 11
Version B:	1, 2, 3, 7, 8, 9, 11
Version C:	1, 2, 3, 10, 6, 5, 4, 11
Version D:	1, 2, 3, 9, 8, 7, 11

Equal numbers of each version were sent to each participating AARP chapter.

RESULTS

Completed questionnaires were received before the cutoff date from 57 of the 66 chapters (86.4 percent) contacted. Of the nine chapters not included, three chapters returned their questionnaires after the cutoff date, for which they were paid the incentive even though the data were not processed. The rest of the questionnaires were returned by the chapter representatives because their chapters had no meetings scheduled during June, July, or August. The 57 chapters returned 1,392 usable questionnaires: 692 sets of Versions A and C, and 700 sets of Versions B and D. Preliminary analysis found no differences between the various versions, so they were combined in subsequent analyses.

A copy of all 11 pages of the questionnaire is included as Appendix A. The responses of the drivers are shown on the questionnaire. Subjects ranged in age from 50 to 97. The mean age of the respondents was 72.2, the median age was 72.0, the mode was 73, and the standard deviation was 7.35. To better identify driver characteristics or problems that may be age-related, it was decided to divide the sample into two groups. The two groups were defined as the "younger" old drivers (young-old, age 72 or younger), and the "older" old drivers (old-old, age 73 or older). There were 683 drivers classified as young-old drivers and 657 drivers classified as old-old drivers; 52 of the 1,392 survey participants did not give their age and were eliminated from the analysis. The distributions of the responses of both groups to each questionnaire item were compared. Significance was tested using a chi-square test for the categorical variables. When the two groups of drivers were found to be significantly different at the 0.05 level, two percentage values are shown on the questionnaire, separated by a slash. When there was no significant difference between the young-old and old-old drivers, a single value is shown.

The remainder of this section discusses the survey results on the following topics:

- Subject characteristics.
- Freeway avoidance/preference.
- Freeway driving—dislikes.
- Misjudging distances.
- Changes in driving habits.
- Milepost markers.
- Signing.
- Lane changing/lane selection.
- Lane preference/rationale.
- Fatigue.
- Rest areas.
- Toll plazas.
- Weather, night driving, and glare.
- Driving speed.
- Vehicular controls.
- Construction/work zones.

- Trucks.
- Lane lines.
- Lane tracking.
- Lighting.
- Highway features.
- Driver looking behavior.
- Cruise control.
- Entering/exiting behavior.
- Construction/congestion avoidance.
- Traffic tickets and accidents.
- Other problems.

Subject Characteristics

As discussed, the mean age of the sample was 72.2, and 35 percent of the respondents were male and 65 percent were female. All but 12 of the 1,392 drivers were still driving. The 12 who had stopped driving had done so in the last 7 months. The young-old drivers had an average of 45 years of driving experience, while the old-old drivers had an average of 54 years of experience.

Not surprisingly, the old-old drivers tend to drive less. Thirty-four percent of the old-old respondents drive less than 5,000 mi (8047 km) yearly, while only 23 percent of the young-old respondents drive that amount. While 18 percent of the young-old drivers log more than 15,000 mi/year (24 140 km/year), only 8 percent of the old-old drivers log that many miles. There was no difference in the number of short trips made by the old-old and young-old drivers, either on freeways or on other roadway types. There was a difference between the old-old and young-old drivers in the number of longer trips (more than 2 h long) that were made. The young-old drivers averaged 8.0 long trips per month on freeways and 8.2 long trips on other roads. For the old-old drivers, the mean values were 5.1 and 4.1, respectively. This indicates that the old-old drivers do not avoid freeways any more than the young-old drivers when selecting routes for long trips.

Ten percent of the entire sample indicated that they drive a recreational vehicle (RV), and 12 percent said that they have towed a trailer. Unfortunately, the questions were phrased "Do you ever drive an RV?" "Do you ever tow a trailer?" It is not known if the respondents are still actively doing so. In hindsight, the question should have been "In the last year, have you . . . ?" The point remains, however, that the respondents do drive RVs and tow trailers; this finding is clearly supported by the involvement of these vehicles in the Hard-Copy Accident Analysis (see section 5).

Forty-seven percent of the young-old drivers and 58 percent of the old-old drivers have taken a driving safety refresher course. Since the respondents are active AARP members and AARP offers its 55 Alive program to its members, these high percentages are probably not representative of the general population of old-old drivers.

Freeway Avoidance/Preference

When specifically asked if they avoided freeways, 24 percent of the entire sample indicated that they did. There was no difference between the young-old and the old-old drivers. Table 16 shows the responses of the 24 percent of the drivers who indicated that they avoided freeways. Multiple responses were allowed. The percentage shown is the percentage of all drivers (n=281) providing that response. The most frequently mentioned reason was heavy traffic on the freeways (39.5 percent). The drivers indicated that they don't like to drive in heavy, congested traffic and that they avoid rush hour. Although speed-related responses were the second most frequently mentioned reason (19.6 percent), many of these drivers specifically indicated that too many other vehicles are exceeding the speed limit. The data suggest that old-old drivers do not have as much of a problem driving at freeway speeds as they do with those who are driving even faster. This is also supported by the accident data in that older drivers were more likely than younger drivers to be struck by faster-moving vehicles (see section 5). Interestingly, 11.4 percent indicated that they avoid freeways because they prefer to take a more leisurely or scenic route.

Table 16. Reasons provided for avoiding freeways.

Why Do You Avoid Freeways?	Number*	Percent
Heavy traffic	111	39.5
High travel speeds	55	19.6
Prefer more leisurely/scenic route	32	11.4
Trucks	22	7.8
Stressful, dangerous, uncomfortable	21	7.5
Heavy traffic and high speeds	19	6.8
Difficulties merging/changing lanes	12	4.3
Frequent construction	10	3.6
Unfamiliar	6	2.1
Afraid of bad weather	5	1.8
Reckless drivers	5	1.8
Poor vision/cannot see	5	1.8
Security/personal safety	3	1.1
Hard to read signs	2	0.7
Miscellaneous	4	1.4
Don't drive freeways, only local	18	6.4

* Number of respondents answering the question = 281. Percentages do not sum to 100 because multiple responses were allowed.

The remaining responses constitute less than 10 percent of the reasons provided. About 7.8 percent of the reasons involved trucks. Old-old drivers feel that there are too many trucks and that the trucks drive too fast. About 4.3 percent of the reasons involved difficulties merging and/or changing lanes, while 1.8 percent avoided freeways because they are not familiar with them. Many of these reasons were also mentioned during the focus group discussions.

Frequent construction was included in 3.6 percent of the reasons provided. Although 1.8 percent of the reasons for avoiding freeways involved the old-old drivers' poor vision, only two drivers (less than 1 percent) specifically indicated that signs were hard to read. Security/personal safety concerns were also rarely mentioned. When asked if they prefer freeways, 67 percent of the young-old drivers indicated that they do, while only 59 percent of the old-old drivers indicated the same preference.

The reasons provided for preferring freeways are shown in table 17. The most frequently mentioned reason was that freeways are faster/quicker (49.4 percent). Drivers also like the fact that there are no signals (27.6 percent) and that it is safe and less stressful (22.0 percent). They also appreciate that the roads are in better condition (3.7 percent); there are rest areas and better access to businesses (3.4 percent); there are large, legible signs (1.1 percent); and the roads are straighter (0.5 percent).

Freeway Driving—Dislikes

Respondents were given the opportunity to indicate the things that they dislike about freeway driving. There are some very interesting differences between the young-old and old-old drivers. Thirty-six percent of the young-old drivers indicated that they dislike the high speed of travel, while 45 percent of the old-old drivers indicated the same. While 38 percent of the young-old drivers indicated that they dislike merging onto freeways, only 32 percent of the old-old drivers mentioned that they dislike merging. The most common dislike about freeway travel was trucks. More than half (55 percent) of the drivers indicated that they dislike trucks. This finding is supported by some of the focus group discussions. About a fifth (20 percent of the young-old and 15 percent of the old-old drivers) indicated that they dislike getting lost. This is supported by the indication that 48 percent of the young-old drivers and 43 percent of the old-old drivers find signs confusing or difficult to see. Several additional items targeted signs on freeways. Only 12 percent of the respondents indicated that they dislike exiting freeways. This is in contrast to the 38 percent and 32 percent for the young-old and old-old drivers, respectively, that indicated they dislike merging onto freeways.

The most disliked aspect of freeway driving is the "rudeness or dangerous actions of other drivers." Sixty-four percent of the young-old drivers and 57 percent of the old-old drivers checked this item. It is interesting that more than half of the drivers indicated that they most dislike trucks and other drivers.

Table 17. Reasons for preferring freeways.

Why Do You Prefer Freeways?	Number*	Percent
Faster, quicker	362	49.4
No signals, avoid towns, better long distance	202	27.6
Safer, easier, less stressful	161	22.0
Traffic moves better, more lanes	118	16.1
Shortest, most direct	74	10.1
Steady speed, less braking	32	4.4
Roads in better condition	27	3.7
Better business access, rest areas	25	3.4
Large, readable signs, better marked	8	1.1
Straighter roads, less curves	4	0.5

* Number of respondents answering the question = 735. Percentages do not sum to 100 because multiple responses were allowed.

A "boring view" was indicated as a dislike by 16 percent of the young-old drivers and 11 percent of the old-old drivers. Apparently, "highway hypnosis" is not seen as a problem by the AARP sample. Of the items listed, the least disliked aspect of freeway driving is the difficulty of maneuvering in traffic. Only 11 percent of all the respondents checked this item. As discussed earlier, 36 percent and 45 percent of the young-old and old-old drivers, respectively, indicated that they dislike the high speed of travel. In response to a related item, 21 percent and 26 percent of the young-old and old-old drivers, respectively, indicated that they dislike that things happen too quickly. The fact that the old-old drivers dislike both the higher speeds and things happening too quickly significantly more than the young-old drivers is possibly related to the reduced visual capabilities and reduced reaction times of old-old individuals.

Misjudging Distances

Twenty-eight percent of the sample indicated that they either occasionally (24 percent) or often (4 percent) misjudge distances. Thirty-five percent of the old-old drivers and 16 percent of the young-old drivers no longer drive at night. Of those who still drive, 30 percent indicated a problem with exits and 21 percent have problems with construction zones. Twenty-six percent of the young-old drivers and 20 percent of the old-old drivers indicated a problem judging the length of merge or entrance lanes. The differences between the age groups are probably a result of the fact that fewer old-old drivers are still driving at night. Relatively few drivers indicated a problem judging distances to other vehicles either in front of them (9 percent), next to them (7 percent), or on the side of the road (12 percent).

Changes in Driving Habits

Several items asked how the respondents have changed their driving as they age. Most of the respondents indicated that they drive less at night (66 percent of the young-old drivers and 80 percent of the old-old drivers), during rush hour (59 and 65 percent, respectively), in snowy weather (60 and 69 percent, respectively), and in foggy weather (46 and 58 percent, respectively). Only 29 percent of the entire sample indicated that they drive less in the rain. Far more of the old-old drivers (49 percent) than the young-old drivers (33 percent) indicated that they drive less on freeways. This is possibly related to the earlier mentioned finding that old-old drivers take fewer long trips on freeways. When asked why they changed their driving, 25 percent of the young-old drivers and 31 percent of the old-old drivers mentioned reduced vision, while only 1 and 3 percent, respectively, indicated that their hearing was a reason.

The 534 drivers who indicated that they drive less on freeways than they used to were asked to indicate why (see table 18). Most indicated that they drive less on freeways because they drive less in general (56 percent). They also indicated that it is stressful, dangerous, and that they are not as confident as they once were (8.8 percent). They also indicated that congestion (6.4 percent), a faster speed limit (4.5 percent), and other drivers being reckless/too fast (3.6 percent) were reasons why they drive less on freeways. Reduced vision (1.1 percent) and reduced reflexes (0.7 percent) were mentioned infrequently.

Table 18. Reasons for driving less on freeways.

Why Do You Drive Less on Freeways?	Number*	Percent
Drive less	299	56.0
Not as confident, stressful, dangerous	47	8.8
Congestion	34	6.4
Speed limit too fast	24	4.5
Other drivers reckless or too fast	19	3.6
Reduced visual capability	6	1.1
Reduced reflexes	4	0.7
Miscellaneous	38	7.1
Not specific	106	19.9

* Number of respondents answering the question = 534. Percentages do not sum to 100 because multiple responses were allowed.

The 28 percent of the drivers who indicated that they changed the way they drive because of their vision provided some interesting responses (see table 19). Most frequently, they indicated that they don't drive or they drive less at night (45.7 percent).

Several of the responses merely indicated that the drivers have problems. Several drivers said that they cannot see or that things look different (22.6 percent), while 6.4 percent mentioned problems with glare and/or headlights. A variety of "defensive driving" tactics were provided. Drivers indicated that they are more cautious (10.9 percent), they drive slower (6.4 percent), and they keep greater distances from other vehicles (1.9 percent).

Table 19. Ways driving changed because of vision problems.

Ways Driving Changed Because of Vision Problems	Number*	Percent
Do not drive or drive less at night	172	45.7
Cannot see, things look different	85	22.6
More cautious	41	10.9
Glare, headlights	24	6.4
Drive slower, drive right lane	24	6.4
Not as confident, stressful, dangerous	15	4.0
Drive less	13	3.5
Do not drive in bad weather	12	3.2
Do not drive long distance or unfamiliar areas	9	2.4
Keep greater distance	7	1.9
Other drivers	4	1.1
Avoid freeways	3	0.8
Miscellaneous	15	4.0
Not specific	29	7.7

* Number of respondents answering the question = 376. Percentages do not sum to 100 because multiple responses were allowed.

Milepost Markers

Respondents were asked to indicate the purpose of milepost or mile markers. This "check all that apply" item was included to see if drivers are aware that milepost markers indicate the distance to the State line or the end of the interstate and that they match the exit numbers in some States. While 12 percent admitted that they don't know what the milepost markers indicate, a surprising number (43 percent) indicated that mileposts show the distance to the next major city. Eight percent indicated that they were only for highway department use and 4 percent indicated that they were for snowplow operators. While nearly two-thirds (64 percent) indicated that mileposts show the distance to the

State line, only one-third (32 percent) realize that milepost markers match the exit numbers in some States.

Signing

Additional items addressed signing on freeways. They were included in Versions A and C and were completed by 692 respondents. With the exception of the last two items on the page, there were no significant differences between the old-old and young-old respondents. While 11 percent of all drivers said the signs were too small, 20 percent said they were not easy to read. This implies that an increase in the size and visual contrast of freeway signing would help old-old drivers. The fact that only 4 percent of all drivers indicated that messages were often confusing or hard to understand and 3 percent indicated the same for symbols further implies that the problem is primarily sign visibility as opposed to sign comprehension. Ten percent indicated that directional signs/guide signs do not provide the information they need. It is not known whether the drivers don't understand the information or if they need additional information. Almost three-fourths (74 percent) prefer overhead signs as opposed to roadside signs. Presumably this is because overhead signs are easier to read. A similar number of young-old and old-old drivers (74 and 61 percent, respectively) indicated that they prefer signs that display the distances to several exits, as opposed to signs that show the distance to only the next exit. The fact that 39 percent of the old-old drivers prefer signs that show the distance to just the next exit suggests that these drivers may have more of an information overload problem than the young-old drivers when confronted with complex signs. The final item on the questionnaire indicates that there are not enough advance signs for exits, gas, food, and lodging on interstates. Fifty-seven percent of the young-old drivers and 66 percent of the old-old drivers indicated that this was the case.

Lane Changing/Lane Selection

Several items were related to lane-changing behavior and lane choice. Almost a fifth of the respondents (17 percent) indicated that they *frequently* slow down and follow a slower vehicle rather than pass it. While 56 percent of the young-old drivers and 41 percent of the old-old drivers indicated that they frequently pass slow-moving vehicles in the slow lane, only 15 percent indicated that they frequently pass slow-moving vehicles in the fast lane. There is, of course, more opportunity for the former. Of greater interest is that: (1) they never (1 and 2 percent, for the young-old and old-old drivers, respectively) and almost never (5 percent and 5 percent, respectively) pass a slow-moving car in the slow lane, and (2) they never (17 percent of all drivers in the sample) and almost never (23 percent) pass a slow-moving car in the fast lane. Drivers appear reluctant to change lanes. It appears that they would rather change their speed than change lanes. When asked if they try to stay out of the other drivers' blind spot, only 75 percent of the entire sample said yes. A very surprising 21 percent said they didn't know. Unfortunately, we can't tell if the respondents are unsure of the concept that vehicles have blind spots or whether they are just not familiar with the term *blind spot.*

Lane Preference/Rationale

Drivers were also asked to indicate the lane in which they usually drive: far left lane, center lane, or far right lane. They were then given two open-ended questions—"Why do you use that lane?" and "Why would you drive in other lanes?" Table 20 shows the lane selected cross-tabulated by the reason for selecting that lane and the lane selected cross-tabulated by the reason for using another lane. Since multiple responses were allowed, the percentages do not add up to 100 percent. Six percent of the young-old drivers and 4 percent of the old-old drivers said they usually drive in the far left lane. They said they did so because it was the "fastest lane" (44.4 percent of the sample). Fifty-two percent of the young-old drivers and 41 percent of the old-old drivers choose the center lane. The most common reasons given were: allows access to both right and left exits (14.1 percent), safest (12.9 percent), allows others to pass (11.3 percent), and allows others to exit/enter (10.9 percent).

Forty-two percent of the young-old drivers and 54 percent of the old-old drivers indicated that they usually drive in the far right lane. The reasons given for selecting the right lane included: safest (24.1 percent), allows others to pass (17.2 percent), most comfortable (13.5 percent), obeys the speed limit (11.3 percent), allows them to regulate their speed (10.6 percent), and it's not the fastest lane (10.6 percent). When the reasons for lane selection are tabulated across the lane choices, the following are the most common: safest (18.0 percent), allows others to pass (13.6 percent), most comfortable (11.3 percent), allows them to regulate their own speed (8.6 percent), and obeys speed limit (8.3 percent).

When asked why they would drive in another lane, those who usually drive in the far left lane indicated that they would do so to exit (39.1 percent), to keep up with traffic (13.0 percent), or to avoid traffic (13.0 percent). Those who usually drive in the center lane said they would drive in another lane to pass (59.4 percent) or to turn off or exit (55.1 percent). Those who usually travel in the right lane would change lanes to pass (77.0 percent), to turn off or exit (17.8 percent), to allow others to enter/merge (5.2 percent), or because their chosen lane is in bad repair/condition (4.3 percent). It appears that drivers have developed a reasonable rationale for their lane selection/ lane-changing behavior. It is interesting that truck traffic does not play a more important role in this process.

Fatigue

The respondents were asked if they ever get tired or fatigued while driving. Forty-seven percent of the young-old drivers and 43 percent of the old-old drivers indicated that this happens occasionally, while 4 and 2 percent, respectively, indicated that they often become fatigued. This finding is also supported by the Hard-Copy Accident Analysis (see section 5 of this report). They were then asked how they know when they are tired or fatigued when driving. Their responses are shown in table 21. Not surprisingly, the most frequent responses (43.7 percent) are drowsy or started nodding

Table 20. Lane preferences.

Why Do You Use That Lane?	In What Lane Do You Usually Drive?						All Lanes	
	Left		Center		Right			
	n*	%	n	%	n	%	n	%
Safest	1	3.7	33	12.9	66	24.1	100	18.0
Allow Others to Pass			29	11.3	47	17.2	76	13.6
Most Comfortable	1	3.7	25	9.8	37	13.5	63	11.3
Regulate Own Speed	1	3.7	18	7.0	29	10.6	48	8.6
Obey Speed Limit	2	7.4	13	5.1	31	11.3	46	8.3
Access Right/Left Exits	1	3.7	36	14.1	8	2.9	45	8.1
Not Fastest Lane	1	3.7	6	2.3	29	10.6	36	6.5
Stay Traffic Flow			16	6.3	14	5.1	30	5.4
Allow Others to Exit/Enter			28	10.9	1	0.4	29	5.2
Don't Watch Merging Vehicles	1	3.7	24	9.4	2	0.7	27	4.8
Easier to Change Lanes			23	9.0	4	1.5	27	4.8
More Options			21	8.2	5	1.8	26	4.7
Steadiest Speed	4	14.8	19	7.4	3	1.1	26	4.7
Easiest Lane	12	44.4	6	2.3	2	0.7	20	3.6
Stay to Right, Required by Law			1	0.4	11	4.0	12	2.2
Can See Better			5	2.0	3	1.1	8	1.4
Avoid Truck Traffic	3	11.1	1	0.4	1	0.4	5	0.9
Total Respondents	27		256		274		557	
Why Would You Use Other Lanes?								
To Pass	2	8.7	123	59.4	177	77.0	302	65.7
To Turn Off/Exit	9	39.1	114	55.1	41	17.8	164	35.7
To Slow Down	1	4.3	17	8.2	3	1.3	21	4.6
Keep Up With Traffic	3	13.0	10	4.8	4	1.7	17	3.7
To Speed Up	1	4.3	9	4.3	6	2.6	16	3.5
Chosen Lane Was Under Repair	1	4.3	4	1.9	10	4.3	15	3.3
Allow Others to Enter/Merge			1	0.5	12	5.2	13	2.8
Chosen Lane Full	2	8.7	7	3.4	4	1.7	13	2.8
Traffic	3	13.0	6	2.9	1	0.4	10	2.2
Avoid Heavy Trucks			1	0.5	2	0.9	3	0.7
Miscellaneous	2	8.7	4	1.9	4	1.7	10	2.2
Total Respondents	23		207		230		460	

* Number of responses (n) do not sum to total number of respondents and percentages do not sum to 100 because multiple responses were allowed.

Table 21. How do you know when you are tired/fatigued?

How Do You Know When You Are Tired/Fatigued?	Number*	Percent
Drowsy/Nodding	194	43.7
Mind/Body Let Know	84	18.9
Neck Pain, Back, etc.	75	16.9
Eyes Hurt, Blurred	64	14.4
Hard to Focus on Driving	53	11.9
Need to Stretch, Stiff	28	6.3
Slow Reflexes	12	2.7
Avoid Long Trips, Never Happens	12	2.7
Become Bored	7	1.6
Missing Road Signs	3	0.7
Nervous Reactions	3	0.7
Hungry, Thirsty	2	0.5

* Number of respondents answering the question = 444. Percentages do not sum to 100 because multiple responses were allowed.

(43.7 percent). Others provided general responses indicating that their mind and/or body lets them know (18.9 percent). A number of drivers provided relatively specific symptomology, including neck and/or back pain (16.9 percent), sore eyes and/or blurry vision (14.4 percent), and difficulty focusing on driving (11.9 percent).

They were next asked what they do when they become tired or fatigued while driving (see table 22). The most common response was to rest or stop at a rest area (38.6 percent). Other common responses included stopping to walk and/or stretch (25.4 percent) or just stopping (21.6 percent) without specifically mentioning a rest area. The remaining responses consist of individual "tricks" for staying alert, including coffee (17.2 percent), opening the window (2.4 percent), etc. The respondents apparently frequently use rest areas as a way of reducing fatigue. This makes the provision of rest areas a highway safety issue as well as a comfort or convenience issue.

Rest Areas

Forty percent of the sample felt there are not enough rest areas. However, it appears that the old-old driver is a less frequent user of rest areas than the young-old driver. Forty-two percent of both groups reported they "sometimes" use them, while 36 percent of the young-old drivers and 27 percent of the old-old drivers "often" use rest areas. They also indicated that rest areas could be improved by offering more services (35 and 24 percent, respectively), better lighting (36 and 24 percent, respectively), and security guards (44 percent of the total sample).

Table 22. What do you do when you are tired/fatigued?

What Do You Do When You Are Tired/Fatigued?	Number*	Percent
Rest/Stop at Rest Area	225	38.6
Stop/Walk/Stretch	148	25.4
Stop	126	21.6
Coffee/Soda	100	17.2
Change Drivers	63	10.8
Stop/Nap	61	10.5
Open Window	14	2.4
Change Seat Position	8	1.4
Turn Radio On	7	1.2
Stop/Wash Face	5	0.9
Look Around More	4	0.7
Sit Up Straight	4	0.7
Take "No Doz"	2	0.3
Keep on Driving	2	0.3
Use Car Phone	1	0.2
Change Routes	1	0.2

* Number of respondents answering the question = 583. Percentages do not sum to 100 because multiple responses were allowed.

Respondents would like rest areas at an average of 68.3 mi (109.9 km) apart and 71 percent would like more advance notice. They were also nearly unanimous in their wish to have signs provide an indication of the next few rest areas. More than 95 percent indicated this would be "helpful" or "very helpful."

Toll Plazas

One item addressed difficulties the drivers have with toll plazas. There were no differences between the young-old and old-old drivers. Fifteen percent of the drivers sometimes or often have problems knowing that a toll plaza is coming up. Twenty-one percent sometimes or often have trouble telling which booths are open, while 20 percent sometimes or often have trouble getting the toll money ready. Somewhat fewer (16 percent) often or sometimes have difficulty depositing the toll or getting the toll ticket.

The most frequently reported problems experienced at toll plazas involved merging with other vehicles. Thirty-three percent reported often or sometimes having difficulties merging into line while approaching the plaza, while 27 percent often or sometimes had problems merging with traffic after the plaza. This supports some of the difficulties anticipated by the old-old driver task analysis (see section 2).

Weather, Night Driving, and Glare

The drivers were asked to tell us about any problems they have driving at night, in foggy weather, in bright sunlight, in rain, and in snowy weather. The responses provided are in table 23. Multiple responses were allowed. Thirty-eight percent of the drivers indicated that they had problems driving at night. The most common problems enumerated by the drivers included difficulties with glare and/or headlights (42.9 percent), and an inability to see/things look different (24.0 percent). Although not as frequently mentioned, hard-to-see lane lines and edge lines (5.4 percent), poor lighting (3.1 percent), and hard-to-see signs (3.1 percent) account for a sizable percentage of the problems encountered.

About a quarter (24 percent) of the drivers indicated that they have problems driving in foggy weather. The problems involve a general inability to see (38.7 percent) and a more specific indication of problems with distance and/or depth perception (11.1 percent). Other problems involve hard-to-see lane lines and edge lines (8.0 percent), poor lighting (3.5 percent), and hard-to-see signs (1.4 percent).

Driving in bright sunlight was reported as a problem by 17 percent of the respondents. Most of the problems mentioned involve glare and/or reflections off cars (31.6 percent). Unfortunately, the drivers merely indicated that they had problems because it is bright and did not provide specific enough information to determine if the problem involves such issues as sign visibility, lane tracking, and other more specific topics.

Driving in the rain was reported as a problem by 18 percent of the drivers (about the same percent as for bright sunlight). Most of the problems mentioned include difficulties seeing (19.9 percent) and other nonspecific problems, i.e., rain/heavy rain (12.4 percent), drive slower (11.6 percent), drive less or not drive (10 percent). The most specific problems involve slippery surface (13.7 percent), hard-to-see lane lines/edge lines (8.7 percent), glare and reflection off cars (5.0 percent), freezing rain on windows (5.0 percent), truck splash and spray (4.6 percent), and hard-to-see signs (2.5 percent).

Only 8 percent of the drivers reported problems driving in snowy weather, undoubtedly, because many AARP members live in areas with little or no snow. Most of the problems listed involve the slippery surface (40.9 percent) and general visibility problems (9.3 percent). Difficulties seeing lane lines/edge lines made up 6.6 percent of the problems mentioned, while problems seeing signs made up 1.2 percent of the problems.

Headlight glare was a frequently reported problem. Fifty-eight percent of the young-old drivers and 69 percent of the old-old drivers reported that they have problems with glare from oncoming vehicles. Headlight glare from vehicles behind them bothered 48

Table 23. Problems driving under various visual conditions.

Variable	Number*	Percent
Problems Driving at Night		
Glare, Headlights	152	42.9
Cannot See, Things Look Different	85	24.0
Not Drive or Drive Less	45	12.7
Painted Lane or Road Edge Lines	19	5.4
Distance, Depth Perception	17	4.8
Poor Lighting	11	3.1
Signs Hard to See	11	3.1
Not as Confident, Stressful, Dangerous	10	2.8
Locations Are Hard to Find	5	1.4
Other Drivers	3	0.8
Miscellaneous, Not Specific	25	7.1
Total Respondents	354	100
Problems Driving in Foggy Weather		
Cannot See, Things Look Different	111	38.7
Do Not Drive or Drive Less	42	14.6
Distance, Depth Perception	32	11.1
Painted Lane or Road Edge Lines	23	8.0
Drive Slower	18	6.3
Not as Confident, Stressful, Dangerous	17	5.9
Other Drivers	16	5.6
Poor Lighting	10	3.5
Glare, Headlights	7	2.4
Signs Hard to See	4	1.4
Miscellaneous, Not Specific	29	10.14
Total Respondents	287	100
Problems Driving in Bright Sunlight		
Glare, Reflections Off Cars, etc.	68	31.6
Wear Glasses	53	24.7
Cannot See, Things Look Different	43	20.0
Facing Sun, Sunrise/Sunset	24	11.2
Sun Visor	12	5.6
Do Not Drive or Drive Less	7	3.3

Table 23. Problems driving under various visual conditions (continued).

Variable	Number	Percent
Distance, Depth Perception	2	0.9
Miscellaneous	28	13.0
Total Respondents	215	100
Problems Driving in Rain		
Cannot See, Things Look Different	48	19.9
Slippery	35	13.7
Rain, Heavy Rain	30	12.4
Drive Slower	28	11.6
Do Not Drive or Drive Less	24	10.0
Painted Lane or Road Edge Lines	21	8.7
Other Drivers	13	5.4
Glare, Reflections Off Cars, etc.	12	5.0
Freezing Rain on Windows, Windshield Wipers	12	5.0
Splash/Spray Trucks	11	4.6
Rain at Night	9	3.7
Distance, Depth Perception	7	2.9
Signs Hard to See	6	2.5
Miscellaneous	31	12.9
Total Respondents	241	100
Problems Driving in Snowy Weather		
Snow, Ice on Road, Slippery	106	40.9
Do Not Drive or Drive Less	62	23.9
Cannot See, Things Look Different	24	9.3
Painted Lane or Road Edge Lines	17	6.6
Drive Slower	15	5.8
Other Drivers	12	4.6
Frost on Windows, Windshield Wipers	7	2.7
Signs Hard to See	3	1.2
Distance, Depth Perception	3	1.2
Glare	2	0.8
Miscellaneous	37	14.3
Total Respondents	259	100

* Number of responses (n) do not sum to total number of respondents and percentages do not sum to 100 because multiple responses were allowed.

percent of all drivers. This suggests that the increased use of glare screens would benefit the older drivers.

Driving Speed

Not all of the respondents feel comfortable driving at freeway speeds. While 95 percent of the young-old drivers reported that they felt comfortable, only 88 percent of the old-old drivers reported the same.

Drivers were given the opportunity to indicate how they choose which speed to drive (see table 24). The majority (65.7 percent) indicated that they drive the speed limit, while 28 percent were influenced by traffic flow and congestion. The road condition and/or type (17.6 percent) and weather (12.6 percent) were also frequently mentioned responses.

Table 24. How do you choose which speed to drive?

Variable	Number*	Percent
Speed Limit	380	65.7
Traffic Flow, Congestion	162	28.0
Road Condition/Type	102	17.6
Weather	73	12.6
Comfort Level	35	6.1
Day/Night	11	1.9
Familiarity with Area	11	1.9
Driver Physical Condition	2	0.3

* Number of respondents answering the question = 578. Percentages do not sum to 100 because multiple responses were allowed.

Vehicular Controls

Seeing the controls inside the car appears to be a relatively small problem, especially for the older driver. Although 7 percent of the young-old drivers and 14 percent of the old-old drivers said they have problems seeing the controls, they are apparently able to operate the controls properly because 95 percent indicated they have no problems operating the controls.

Construction/Work Zones

A fifth (21 percent) of the drivers reported that they have problems with work zone and construction areas on freeways. It is interesting that there were no differences between the young-old and old-old drivers. The same percentage of drivers (21 percent) reported that they had problems misjudging distances in work zones.

The drivers who indicated that they have problems with work zones were given the opportunity to specify the kinds of problems they have. The responses of the 159 drivers who provided codable information are shown in table 25. The most common problem involved congestion and delays (25.2 percent). The next most frequently mentioned problem involved the lack of adequate warning (15.7 percent). They also reported problems with work zones being too narrow (10.7 percent) and with lane shifts and lane closures (8.8 percent). They also indicated that obstructions are unclear (7.5 percent) and that it is hard to tell where to drive (3.1 percent). Only two drivers (1.3 percent) indicated that poor lighting is a problem. This is not too surprising since many older drivers avoid driving at night, and, thus, do not encounter construction zones when it is dark.

Table 25. Problems with work zones/construction sites on freeways.

Variable	Number*	Percent
Congestion, Delays	40	25.2
Signs, Not Enough Warning	25	15.7
Other Drivers	24	15.1
Too Narrow	17	10.7
Lane Shifts/Closures	14	8.8
Unclear, Obstruction	12	7.5
Not Sure Where to Drive	5	3.1
Drive Slower	5	3.1
Poor Lighting	2	1.3
Miscellaneous, Not Specific	37	23.3

* Number of respondents answering the question = 159. Percentages do not sum to 100 because multiple responses were allowed.

Trucks

The respondents provided information on the types of problems they have with trucks. The items were included in Versions B and D and were completed by 700 drivers. Sixty-five percent indicated that trucks tailgate them and 43 percent indicated that trucks cut them off when they change lanes. Eighty-two percent of the respondents felt that trucks drive too fast, 21 percent reported they have problems staying in their lane when passed by a truck. Truck headlights bother 43 percent of the drivers. There were no differences between the young-old and old-old drivers in any of the truck-related items.

Lane Lines

While lane lines were reported to be adequate in daylight by 94 percent of the respondents, drivers indicated the lines are not visible enough during snow (82 percent), fog (71 percent), rain (40 percent), or at night (40 percent). Surprisingly, there were no differences between the old-old and young-old drivers. Perhaps some of the maneuvering and lane-changing problems experienced by older drivers could be reduced by increasing the visibility of the lane lines.

Lane Tracking

The respondents next indicated the kinds of things that make it difficult for them to stay in their lane. The most frequently reported factor was worn/faded lane markings (56 percent). This supports the findings discussed above about the importance of adequate lane markings to the older driver. The task analysis suggested that older drivers tend to rely on left-lane delineation for lane positioning. If this were the case, we would expect them to be more bothered by construction or barriers on the left than on the right. This is apparently not the case since barriers/construction to the drivers' right (25 percent) and the drivers' left (22 percent) were equally troublesome. Large trucks were mentioned by 24 percent of the drivers. Nearby vehicles, other than trucks, do not appear to be a major distraction to the lane-tracking task.

Lighting

The respondents were asked to indicate if more lighting is needed on freeways. This page was included in Versions B and D and was answered by 700 subjects. The majority (70 percent) feel that more lighting is needed. When asked where the lighting is needed, the following percentages of the respondents mention these locations:

Exit ramps	45 percent
Rest stops	37 percent
Construction areas	31 percent
Interchanges	26 percent
Rural interstates	23 percent
Urban interstates	11 percent
Toll plazas	8 percent
Other	3 percent

It appears that the drivers would like additional lighting where they have the most problems, i.e., merging areas and construction zones. Interestingly, there were no significant differences between the young-old and old-old samples in their requests for additional lighting.

Highway Features

The next item asked the drivers how helpful were various roadway features. They indicated that the following "helped a lot":

Painted lane line	90 percent
Lane-marking reflectors	78 percent
Guardrails	68 percent
Post-mounted reflectors	68 percent
Rumble strips	50 percent

Very few drivers indicated that these features were "not very helpful." There were no differences between the young-old and old-old drivers. Again, it is clear that drivers appreciate the assistance provided by the devices.

Driver Looking Behavior

The respondents were asked to indicate how far ahead they look while driving. The answer could have been stated in feet, car lengths, or parts of a mile. The averages provided were 370 ft (112.8 m), 5.2 car lengths, and 0.39 mi (0.63 km). Although the lack of comparability between the three different scales is unexplained, it is apparent that older drivers understand, at least at a cognitive level, that they should keep their eyes well down the road.

Cruise Control

Seventy-six percent of the drivers surveyed indicated their cars have cruise control. Of those that have cruise control, only 17 percent indicated that they do not use it. Interestingly, 11 percent of those with cruise control indicated that they have difficulty maintaining their speed without it.

Entering/Exiting Behavior

The questionnaire had several items on entering and exiting behavior. They were in Versions A and C and were completed by 692 subjects. While 90 percent said they use their turn signals and 81 percent use their mirrors, undesirable behaviors were indicated by a surprising number of drivers. Twenty-five percent of the drivers said they stop before merging. It is surprising that this many drivers actually admit to this undesirable behavior. Almost as many drivers (17 percent) indicated that they have trouble finding a large enough gap in traffic. This problem is supported by the fact that 34 percent of the young-old drivers and 26 percent of the old-old drivers wish that entrance lanes were longer. Thirty-nine percent of the young-old drivers and 27 percent of the old-old drivers indicated that they have more problems entering a freeway when entrance and exit lanes are combined than when there are separate exit and entrance lanes.

When asked about their freeway exiting behavior, 96 percent of the young-old drivers and 91 percent of the old-old drivers indicated that they use their turn signals, and 86 percent of the young-old drivers and 79 percent of the old-old drivers use their mirrors. More than half (52 percent) of all the subjects said that they slow down before entering the exit lane, yet only 13 percent wish that exit lanes were longer. Sixty percent slow down after they enter the exit lane. Although the numbers are small, 4 percent of the young-old drivers and 1 percent of the old-old drivers indicated that they sometimes take the wrong exit. Combined entrance and exit lanes are a problem for 34 percent of the young-old drivers and 27 percent of the old-old drivers when exiting.

Construction/Congestion Avoidance

The respondents were asked whether they usually take a different route or get off the freeway to avoid road construction or heavy traffic congestion. Thirty-four percent indicated that they avoid construction. This is higher than the percentage of drivers who indicated that they avoid freeways (24 percent). But it is not surprising since 21 percent indicated that they have problems misjudging distances in construction zones. Even more drivers (51 percent) indicated that they usually take a different route to avoid heavy traffic congestion. Apparently, a large proportion of the drivers will attempt to avoid the driving situations that they dislike.

Traffic Tickets and Accidents

The last group of questions asked the drivers if they have had a traffic warning, ticket, or accident in the last 3 years. All 1,392 drivers completed this group of questions. Three percent indicated that they had received a warning, 4 percent had received a traffic ticket, and 9 percent had been involved in a traffic accident. Surprisingly, there were no differences between the old-old and young-old drivers. The old-old drivers apparently limit their driving enough to maintain a comparable accident involvement rate, in spite of their presumably reduced capabilities.

Other Problems

The last item on the last page of the questionnaire gave the drivers an opportunity "to tell us about any freeway/interstate driving problems you have that we haven't asked you about." Of the 1,392 respondents, 250 provided a useful response; these are shown in table 26. Some of the problems mentioned involved other drivers, while other problems involved the roadway. The most frequently provided response involved other drivers changing lanes (17.2 percent), while speeding vehicles (16.4 percent) and trucks (either passing, splashing, or speeding) (16.0 percent) were also frequently indicated. Other responses involving other drivers included: other drivers not allowing merging at exits/entrances (4.0 percent); other drivers getting into the fast lane while going too slow (3.6 percent); other drivers that stay in the left lane and do not pass (2.8 percent); and drunk drivers (1.6 percent). It is interesting that several of these

Table 26. Other freeway problems.

Variable	Number*	Percent
Other Drivers Changing Lanes	43	17.2
Speeding Vehicles	41	16.4
Trucks Passing, Splashing, Speeding	40	16.0
Confusing, Inconsistent Signs	24	9.6
More Advance Warning Exits, Lane Drops, Construction	22	8.8
Road in Need of Repair	14	5.6
Not Enough Rest Areas, Too Much Distance Between Exits	13	5.2
Other Drivers Do Not Allow Merge, Exit/Entrance	10	4.0
Too Much Construction	10	4.0
Other Drivers Entering Fast Lane at Slow Speeds	9	3.6
Debris on Roadway	9	3.6
Exit/Entrance Ramps Close, Not Long Enough	8	3.2
Other Drivers in Left Lane That Do Not Pass	7	2.8
Not Enough Emergency Phones	6	2.4
Blind Spots in Car Mirrors	6	2.4
Lane Markings Hard to See	5	2.0
Inappropriate Speed Limits on Exit/Entrance Ramps	4	1.6
Drunk Drivers	4	1.4
Adjusting to Unfamiliar Area in Heavy/Fast Traffic	4	1.6
Not Enough Freeways	4	1.6
Poor Lighting	4	1.6
Bad Weather	4	1.6
Speed Limits Too Low, Change Too Often	3	1.2
Miscellaneous	18	7.2

* Number of respondents answering the question = 250. Percentages do not sum to 100 because multiple responses were allowed.

behaviors are those that are frequently attributed to older drivers. Many of the drivers provided very specific responses concerning problems with the roadway. Confusing, inconsistent signs (9.6 percent), and the need for more advance warning of exits, lane drops, and construction (8.8 percent) were the most common. Problems with roads in need of repair (5.6 percent) and too much construction (4.0 percent) indicated that older drivers want repairs, but do not like the repair process. Other roadway-related problems involved difficulties with exits and entrances being too close or too short (3.2 percent), faded lane markings (2.0 percent), inappropriate speed limits on exit/entrance ramps (1.6 percent), and poor lighting (1.6 percent).

SUMMARY

An 11-page written questionnaire was completed by 1,392 AARP members. The members ranged in age from 50 to 97, with a mean of 72.2 years and a median of 72 years. Fifty-seven AARP chapters in 39 States were represented. Statistical comparisons between those older and younger than 72 years were made to identify the age-related difficulties the respondents encountered when driving on freeways. The following summarizes the findings.

Freeway Avoidance/Preference. Only a quarter of the sample indicated that they avoided driving on freeways. The reasons indicated for avoiding freeways included: congestion/heavy traffic, high travel speeds, and difficulties merging and changing lanes.

Freeway Driving/Dislikes. The respondents indicated that they disliked trucks, high travel speeds, and merging onto freeways. Many indicated that signs were confusing or hard to see. They also disliked the rudeness and dangerous actions of other drivers.

Misjudging Distances. Many of the respondents indicated problems judging distances at night. Construction/maintenance zones and merge/entrance lanes were mentioned as being especially problematic.

Changes in Driving Habits. Although more than two-thirds of the respondents drive less at night and more than half avoid rush hour, snow, and fog, less than a third of the respondents avoid driving in the rain. Decreases in visual abilities were mentioned by about a fourth of the drivers as the reason for these changes.

Milepost Markers. Many of the respondents do not understand the purpose of milepost markers. A third did not understand that they indicate the distance to/from the State line or that they match the exit number in some States.

Signing. The responses provided suggest that older drivers find that some signs are hard to see. This appears to be a visibility problem and not a matter of message comprehension. The vast majority prefer overhead (as opposed to shoulder-mounted) signs and would like to see more advance signing for exits, gas, food, and lodging.

Lane Changing/Lane Selection. The respondents indicated a reluctance to change lanes. Apparently they would rather change speeds, i.e., slow down, than change lanes.

Lane Preference/Rationale. About half of the drivers indicated that they usually drive in the right-most lane. They do so because they consider it safer, because it allows others to pass, and so they can regulate their speed. The center lane is also the choice of about half of the drivers. They chose the center lane because it allows access to both right and left exits, because they think it is safer, and because it allows others to enter and exit. About 5 percent of the drivers usually use the far left lane.

Fatigue. Fatigue appears to be a serious problem with the older driver. Almost half indicated that they occasionally became fatigued while driving. The high occurrence of fatigue-related accidents was noted in both the computerized and hard-copy accident analyses. Frequent use of rest areas was reported as a way to deal with fatigue.

Toll Plazas. Many of the respondents indicated problems at toll plazas, specifically merging into line when approaching the toll plaza and merging with traffic when leaving.

Weather, Night Driving, and Glare. Many of the respondents reported problems driving at night. Problems with headlight glare and difficulties seeing roadway delineation and highway signs were mentioned. Glare, edge line/lane lines that are hard to see, and signs that are hard to read were also reported as being problems when older drivers were driving in the rain.

Driving Speed. While the majority of the respondents indicated that they drive at the posted speed limit, almost 10 percent indicated that they were uncomfortable driving at freeway speeds.

Vehicular Controls. About 1 respondent in 10 indicated that he or she had problems with seeing vehicular controls. Half of these drivers also had problems operating the controls. Perhaps vehicle manufacturers should consider the capabilities of older drivers when designing vehicle interiors.

Construction/Work Zones. About 20 percent of the respondents indicated that they had problems negotiating work zones. The specific problems encountered included congestion/traffic, lack of adequate warning, narrow lanes, lane closures and lane shifts, and staying in their lane.

Trucks. Many of the older drivers reported problems with trucks tailgating and cutting them off when changing lanes. They reported problems staying in their lane when being passed by a truck and with truck headlight glare.

Lane Tracking. The respondents rely heavily on roadway delineation to help them stay in their lane. More than half indicated that worn or faded markings make it more difficult for them to stay in their lane.

Lighting. Most of the respondents (70 percent) indicated that more lighting is needed on freeways. Areas needing more lighting include interchanges, construction zones, and toll plazas.

Highway Features. Certain highway features were indicated as being very helpful to older drivers. These include: delineation, raised pavement markers (RPMs), post-mounted reflectors (PMRs), guardrails, and rumble strips.

Cruise Control. Most of the respondents have cruise control and use it.

Entering/Exiting Behavior. One-quarter of the respondents indicated that they stop before merging. More than half slow down before entering the deceleration lane. The adequacy of current exit/entrance lane design relative to the capabilities of older drivers needs to be examined.

Construction/Congestion Avoidance. The respondents indicated that they frequently change their route to avoid both construction and congestion. They indicated that they avoid congestion and construction more than they avoid freeways.

Other Problems. Other problems mentioned by the respondents include: other drivers changing lanes; speeding vehicles; trucks; confusing/inconsistent signing; and inadequate advance warning of exits, lane drops, and construction.

7. TRAVEL DIARY STUDY

INTRODUCTION

A travel diary study was conducted to determine the freeway usage and freeway avoidance behaviors of older drivers. The basic methodology involved having a sample of older drivers keep a 2-week written account of their driving trips, recording the following information:

- Date/day of week.
- Time: starting and ending.
- Odometer reading: starting and ending.
- Origin/destination.
- Route used—freeway usage.
- Reason(s) for route selection.
- Problem(s) encountered.

The data were analyzed to determine trip characteristics, route selection criteria, freeway usage and avoidance, and problems encountered. The remainder of this section addresses the following topics:

- Sampling characteristics.
- Survey administration.
- Diary format development.
- Results:
  - Subject characteristics.
  - Trip characteristics.
  - Freeway avoidance/preference.
  - Problems on freeways.

SAMPLING PROCEDURE

The American Association of Retired Persons (AARP) survey of older drivers included a sample of 1,392 respondents who completed an 8-page questionnaire about their experiences driving on freeways. The last page of that questionnaire included the following notice:

> We will be recruiting drivers to take part in a travel diary study. We will pay drivers $35 to keep a record of all of the trips, including errands, they make over a 2-week period.

Interested drivers were asked to provide their name and address, and 208 drivers responded to this request. Drivers younger than 65 years of age were eliminated. Furthermore, to limit the sample to one response per household, half of the same-household responses were randomly eliminated. The final sample consisted of 178 drivers.

SURVEY ADMINISTRATION

Each of the 178 drivers in the sample received a survey package that included:

- Letter explaining the trip diary survey.
- 98-page trip diary booklet.
- $35 incentive check.
- Postage-paid postcard.
- Postage-paid return envelope.

Drivers were asked to sign and return the postcard indicating their willingness to participate, use the travel diary during the last 2 weeks of September 1994, and, at the end of the 2 weeks, return the diary in the postage-paid envelope and cash the check. If they were not interested in participating, they were asked to return the blank trip diary booklet and the check in the postage-paid envelope. A total of 157 individuals completed and returned usable trip diaries. Eighteen drivers (12 percent) returned the blank trip diary and the check. Three questionnaires that were not completed were unusable. Many of those who returned the unused diary indicated that they were unable to participate because they had been ill or had been away and could not complete the diary within the specified period.

DIARY FORMAT DEVELOPMENT

Several different diary formats were developed and pilot-tested. Early pilot-testing revealed that many older drivers had difficulty using a tabular format. Four different versions were pilot-tested on 10 to 12 drivers. The protocol evolved from a one-line-per-trip table to a one-page-per-trip checklist.

The final format consisted of a one-page instruction sheet as the cover of a multiple-page booklet, so that drivers filled out one page for each trip. A trip was defined as the time from when the driver started the car until the driver turned off the engine. This is explained in the trip diary instructions, which are reproduced as figure 18. The first two pages of the booklet were two pages of the diary filled out as examples. The rest of the booklet consisted of 98 identical pages. During pilot-testing, it was found that older drivers average 7 trips a day, so that 14 days x 7 trips, or 98 pages, would be needed for the 2-week diary. A copy of a page from the trip diary is reproduced as figure 19.

RESULTS

The 157 diaries contained 7,713 completed pages, representing the same number of trips. The diaries were reviewed and the data were keypunched for analysis. Frequency distributions and cross tabulations were run to describe the older drivers' trip-making behavior. Results are discussed for the following topics:

TRIP DIARY INSTRUCTIONS

- Fill out one page for every trip that you make. Every time you get into your car, start it, drive somewhere, turn off the engine, and get out of your car is considered one trip. For example, when you go from your home to the store, that's one trip; when you come back from the store, that's another trip.

- The first two pages are filled out as examples. They show how a trip to the store and the trip back home would take two pages. In the example, the driver decided to use the interstate to go to the store and traffic was very heavy. He decided to take another route home.

- The rest of this booklet has blank Trip Diary pages. Complete one page for each trip. Remember, the beginning of a trip is when you start your car. The end of a trip is when you turn off your car. Some of your trips will be short; others might be longer. Be sure to fill out one page of the Trip Diary for each trip.

- Start using the Trip Diary tomorrow, even if you don't plan to do any driving. Use the Trip Diary for two weeks or until you have filled out all the pages. We are interested in your normal driving patterns, so don't change your plans in any way. If you don't drive a lot, that's fine. Just keep track of whatever driving you do.

- At the end of two weeks, mail the booklet to us in the return envelope. Accept our check and sincere thanks for your help.

Age______________ Sex_________

Figure 18. Trip diary instructions.

COMPLETE THIS PART BEFORE YOU START YOUR CAR

Today's Date: September ____, 1994 Day of week: M Tu W Th F Sat Sun

Time: _____:____ AM PM Odometer (no tenths): ____________

Starting place:

___1 Your own home
___2 Home of family or friend
___3 Store, shopping mall, grocery
___4 Doctor, dentist, clinic, hospital
___5 Place of worship
___6 Bank, post office
___7 Hotel or motel
___8 Social/recreation facility
___9 Place of employment
___10 Restaurant, movie
___11 Beauty shop, barber
___12 Gas station, rest stop
___13 Educational facility, library
___14 Other ______________

COMPLETE THIS PART WHEN YOU TURN YOUR CAR OFF

Time: _____:____ AM PM Odometer (no tenths): ____________

Ending place:

___1 Your own home
___2 Home of family or friend
___3 Store, shopping mall, grocery
___4 Doctor, dentist, clinic, hospital
___5 Place of worship
___6 Bank, post office
___7 Hotel or motel
___8 Social/recreation facility
___9 Place of employment
___10 Restaurant, movie
___11 Beauty shop, barber
___12 Gas station, rest stop
___13 Educational facility, library
___14 Other ______________

About what part of this trip was on an interstate, freeway, expressway, or toll road?

____ All or most ____ 3/4 ____ ½ ____ 1/4 ____ None

Could you have chosen another route that involved more interstate?

____ Yes ____ No

Why did you decide to use the roads you used? (Check all that apply.)

___1 Shortest, fastest way
___2 Most familiar route
___3 Better road—wider, good signs, etc.
___4 Better facilities, such as gas, food
___5 Most scenic/enjoyable route
___6 Safest, avoid bad neighborhoods
___7 Only route available
___8 To avoid congestion/heavy traffic
___9 To avoid construction
___10 To avoid local streets/highways
___11 To avoid interstates/freeways
___12 To avoid toll
___13 Other ______________

While on the interstate part of your trip, did you have any problems? (Check all that apply.)

___1 Did not use the interstate
___2 No problems
___3 Heavy traffic
___4 Trouble reading traffic signs
___5 Got lost/disoriented
___6 Discourteous car drivers
___7 Discourteous truck drivers
___8 Glare from headlights
___9 Got tired or fatigued
___10 Bad weather
___11 Took the wrong road
___12 Construction
___13 Accident/fire
___14 Rough road, potholes
___15 Other______________

Figure 19. Page from the trip diary.

- Subject characteristics.
- Trip.
- Route selection.
- Freeway avoidance/preference.
- Problems on freeways.

Subject Characteristics

The 157 drivers ranged from 65 to 89 years of age. The mean age was 72.9 years, with a standard deviation of 5.27. Forty-eight percent were male and 52 percent were female. The subjects resided in 33 different States. Seventeen (10.8 percent) were from New York; fourteen (8.9 percent) were from Indiana; eight (5.1 percent) were from Louisiana; seven (4.5 percent) each were from Georgia, Missouri, and Texas; and six (3.8 percent) each were from Michigan, Mississippi, Ohio, and Washington. The remaining 23 States each had five (3.2 percent) or fewer drivers participating.

Trip Characteristics

During the 2-week period in September 1994, the 157 drivers logged 7,713 trips, which averages to about 3.5 trips per day. The 157 drivers covered from 28 mi (45 km) to 3,413 mi (5495 km) during the 2-week period. The mean distance traveled during the 2 weeks was 451 mi (726 km); the median value was 354 mi (570 km). The mean value results in a projected annual mileage of 11,700 mi (18 837 km). The drivers indicated the proportion of each trip that was on a freeway. In this study, the term "freeway" was used to include interstates or expressways. The category choices were: all or most, 3/4, ½, 1/4, and none. As might be expected, most of the trips (79.7 percent) involved no freeway travel. The distribution of the trips, by proportion on freeways, was as follows:

Freeway Use	Number of Trips	Percent
None	6,144	79.7
1/4	294	3.8
½	340	4.4
3/4	334	4.3
All or most	601	7.8
Total Trips	7,713	100

As also might be expected, the trips with a greater proportion of freeway travel were longer in both time and distance. As shown in table 27, the trips with no freeway use averaged 15.54 min, while those that were all or mostly on a freeway averaged 49.33 min. These trips averaged 4.83 mi (7.78 km) and 35.37 mi (56.95 km), respectively. To facilitate comparisons between freeway driving behavior and route avoidance and route selection criteria, it was decided to group the 1/4, ½, and 3/4 categories together. As is apparent in table 27, these three subgroups are quite similar in terms of time and distance, and decidedly dissimilar from the trips that are all or mostly freeway. The majority of the analyses in this section address differences between trips that were all or mostly, 1/4 to 3/4, or not at all (none) on freeways. The distribution of the basic sample is:

Freeway Use	Number of Trips	Percent
None	6,144	79.7
1/4 to 3/4	968	12.6
All or most	601	7.8
Total Trips	7,713	100

Day of Week

Older drivers tend to drive slightly more during the week than on weekends. Weekday trips varied from a high of 16.7 percent on Fridays to a low of 14.1 percent on Thursdays. Saturdays and Sundays accounted for 11.5 percent and 12.1 percent, respectively. There were no significant differences in the day of the week distribution when tabulated by portion of trip on freeway (chi-square = 12.24, df = 12).

Table 27. Trip duration as a function of freeway use—original categories.

Portion on Freeway	n	Trip Duration			
		Time, min		Length, mi*	
		Mean	SD	Mean	SD
None	6144	15.54	20.29	4.83	8.97
1/4	294	34.29	46.56	15.83	25.82
½	340	34.68	41.34	18.82	28.41
3/4	334	35.08	32.70	21.25	30.67
All or most	601	49.33	58.72	35.37	49.56
Total	7713	20.60	30.19	8.80	20.37

* 1 mi = 1.61 km

Trip Length/Speed

The trips involving no freeway use were much shorter in both time and distance than trips that were either partly (1/4 to 3/4) or all or mostly on freeways (see table 28). These differences were found to be significant (analysis of variance). The three groups are significantly different from each another. Computation of an average speed per trip from these figures indicates an 18-mi/h (29-km/h) mean speed for non-freeway trips, a 31-mi/h (50-km/h) mean speed for partly freeway trips, and a 43-mi/h (69-km/h) mean speed for all or mostly freeway trips.

Table 28. Trip duration as a function of freeway use—combined categories.

Portion on Freeway	n	Trip Duration			
		Time, min		Length, mi*	
		Mean	SD	Mean	SD
None	5919	15.54	20.29	4.74	8.33
1/4 to 3/4	939	34.70	40.31	18.14	26.67
All or most	581	49.33	58.72	35.33	49.64
Total	7439	20.60	30.19	8.80	20.37

Analysis of Variance, minutes

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob
Between groups	2	817513.67	408756.83	509.92	0.00
Within groups	7436	5960740.37	801.61		
Total	7438	6778254.04			

Group	Count	Mean	Standard Deviation	Standard Error	95% Conf. Int. for Mean
None	5919	15.54	20.29	0.26	15.03 to 16.06
1/4 to 3/4	939	34.70	40.31	1.32	32.12 to 37.28
All or most	581	49.33	58.72	2.44	44.55 to 54.11
Total	7439	20.60	30.11	0.35	19.91 to 21.29

Analysis of Variance, miles

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob
Between groups	2	606551.35	303275.68	901.94	0.00
Within groups	7679	2582039.21	336.25		
Total	7681	3188590.58			

Group	Count	Mean	Standard Deviation	Standard Error	95% Conf. Int. for Mean
None	6121	4.74	8.33	0.11	4.53 to 4.95
1/4 to 3/4	962	18.14	26.67	0.86	16.45 to 19.83
All or most	599	35.55	49.64	2.03	31.35 to 39.32
Total	7682	8.80	20.37	0.23	8.35 to 9.26

* 1 mi = 1.61 km

Origins/Destinations of Trips

Table 29 shows the distribution of the origins and destinations (combined) for trips that involved no, 1/4 to 3/4, or all or mostly freeways. The driver's own home was the most common trip origin/destination; about a third of all trips either started or ended there. The all or mostly freeway trips generally have similar origins/destinations as the no and 1/4 to 3/4 freeway trips. As might be expected, the all or mostly freeway trips involve more gas stations and rest stops (10.0 percent) and more restaurants (10.2 percent) than trips with less freeway use. It appears that older drivers use freeways as part of their normal travel patterns.

Table 29. Origin/destination as a function of freeway use.

Origin/Destination	About what part of trip was on freeway?						Total Cases	
	None		1/4 to 3/4		All or Most			
	n	%	n	%	n	%	n	%
Your own home	4440	36.2	706	36.5	366	30.4	5512	35.8
Home of family or friend	868	7.1	202	10.4	123	10.2	1193	7.7
Store, mall, grocery	2157	17.6	274	14.2	144	12.0	2575	16.7
Dr, dentist, clinic, hosp.	425	3.5	108	5.6	55	4.6	588	3.8
Place of worship	555	4.5	71	3.7	28	2.3	654	4.2
Bank, post office	520	4.2	43	2.2	14	1.2	577	3.7
Hotel or motel	35	0.3	32	1.7	47	3.9	114	0.7
Social/recreation facility	976	8.0	164	8.5	73	6.1	1213	7.9
Place of employment	313	2.6	34	1.8	14	1.2	361	2.3
Restaurant, movie	727	5.9	122	6.3	123	10.2	972	6.3
Beauty shop, barber	181	1.5	18	0.9	15	1.2	214	1.4
Gas station, rest stop	286	2.3	43	2.2	120	10.0	449	2.9
Educational facil., library	259	2.1	23	1.2	16	1.3	298	1.9
Other	512	4.2	92	4.8	62	5.2	666	4.3
Multiple stops	20	0.2	4	0.2	2	0.2	26	0.2
Total	12,274	100	1936	100	1202	100	15,412	100

Times of Travel/Accident Experience

Table 30 shows the distribution of trips by time of day. To generate this distribution, each driver's trips were aggregated by date and hour of the day so that each driver could potentially contribute 0, 1, or 2 trips to any given hour during the 2-week diary period. In this table, all trips that involved at least 1/4 or more freeway travel were included. Since some trips were longer than 1 h, the total number of trips is greater than the number of freeway trips (1,569) indicated above. The distribution clearly shows that older drivers do most of their freeway driving during the middle of the day—62.2 percent of the trips are between 9 a.m. and 3 p.m. Older drivers appear to avoid driving during times when they might experience congestion. Only 6.9 percent of the trips are between 7 a.m. and 9 a.m. and 12.9 percent are between 4 p.m. and 6 p.m. They also appear to avoid driving at night. Only 8.3 percent of the trips occurred between 9 p.m. and 6 a.m.

Also shown in table 30 is the distribution of freeway accidents for drivers over age 65. This distribution of freeway accidents is similar to the distribution of freeway trips. To quantify the relationship between accidents and trips (exposure), a hazard ratio was computed by dividing the percentage of accidents by the percentage of trips that occurred during each hour. If the percentage of accidents equals the percentage of trips, the hazard ratio is 1. If there are more accidents than trips, the hazard ratio is greater than 1. If there are fewer accidents than trips, the hazard ratio is less than 1. Most of the hazard ratios are relatively close to 1. With the single exception of the 5 a.m. time period, none of the hazard ratios exceed 2. The most hazardous time periods for older drivers are 5 a.m. (hazard ratio 4.1) and 4 p.m. (hazard ratio 1.6). The least hazardous time periods are 12 midnight, 6 a.m., 11 a.m., and 9 p.m. Each of these periods has a hazard ratio of 0.5, indicating that there were half as many accidents as would be expected, based on the degree of exposure. The accident and exposure data do not indicate any consistent trends to suggest that periods of traffic congestion or periods of darkness are especially hazardous for older drivers. It appears that older drivers restrict their driving during these time periods and thereby reduce their exposure to hazards.

Route Selection

A study objective was to determine the extent to which older drivers specifically avoid using freeways. One of the trip diary items asked the subjects to indicate, "Why did you decide to use the roads you used?" Multiple responses were allowed. The data for this item, cross tabulated by the portion of the trip involving freeway travel, are shown in table 31. The most common reason given was that the route was the short-est or fastest. About 80 percent of the routes in all three groups were chosen for this reason. The second most common response was that the route chosen was the most familiar. About 40 percent of the routes in all three groups were picked for this reason.

The next most frequently indicated response was that the route chosen was the "only route available." It is somewhat surprising that this item was not checked more often. Only 15.3 percent of the non-freeway trips and 12.7 percent of the mostly freeway

Table 30. Freeway accidents and freeway trips by time of day—hazard ratios.

Time of Day	Accidents		Trips		Hazard Ratio
	n	%	n	%	
12 m.	1	0.2	9	0.4	0.5
1 a.m.	4	1.0	1	0.04	-
2	2	0.5	6	0.3	1.7
3	3	0.7	10	0.5	1.4
4	3	0.7	12	0.5	1.4
5	12	2.9	15	0.7	4.1
6	3	0.7	29	1.3	0.5
7	13	3.2	48	2.2	1.5
8	12	2.9	105	4.7	0.6
9	26	6.3	175	7.9	0.8
10	31	7.6	206	9.3	0.8
11	21	5.1	206	9.3	0.5
12 noon	45	11.0	182	8.2	1.3
1 p.m.	35	8.5	202	9.1	0.9
2	27	6.6	205	9.3	0.7
3	36	8.8	201	9.1	1.0
4	46	11.2	151	6.8	1.6
5	29	7.1	135	6.1	1.2
6	18	4.4	97	4.4	1.0
7	10	2.4	66	3.0	0.8
8	15	3.7	54	2.4	1.5
9	5	1.2	54	2.4	0.5
10	8	2.0	30	1.4	1.4
11	4	1.0	17	0.8	1.3
Total	409	100	2216	100	1.0

Table 31. Route selection criteria by freeway use.

Why did you use the roads you used?	About what part of trip was on freeway?						Total Cases	
	None		1/4 to 3/4		All or Most			
	n	%*	n	%	n	%	n	%
Shortest, fastest	4983	82.6	742	76.9	466	77.9	6191	81.5
Most familiar	2500	41.4	424	43.9	231	38.6	3155	41.5
Better road—wider, etc.	156	2.6	150	15.5	157	26.3	463	6.1
Better facilities	60	1.0	21	2.2	29	4.8	110	1.4
Most scenic/enjoyable	134	2.2	41	4.2	19	3.2	194	2.6
Safest, avoid unsafe neighborhood	71	1.2	31	3.2	15	2.5	117	1.5
Only route available	924	15.3	59	6.1	76	12.7	1059	13.9
Avoid traffic congestion	231	3.8	101	10.5	49	8.2	381	5.0
Avoid construction	104	1.7	28	2.9	7	1.2	139	1.8
Avoid local streets	44	0.7	118	12.2	92	15.4	254	3.3
Avoid freeways	72	1.2	13	1.3	3	0.5	88	1.2
Avoid toll	6	0.1	3	0.3	-	-	9	0.1
Other	19	0.3	19	2.0	13	2.2	51	0.7
Total Respondents	6033		965		598		7596	

* Percentages do not sum to 100 because multiple responses were allowed.

trips were chosen because they were the only route available. Fewer of the 1/4 to 3/4 freeway trips were so classified (6.1 percent). The older drivers are aware of a number of route choice options and are apparently selecting trip routes for other reasons.

The biggest differences between the partly, mostly, and non-freeway trips involved the "better roads—wider, good signs, etc." response. Over a quarter (26.3 percent) of the mostly freeway routes and a sizable percentage (15.5 percent) of the partly freeway routes were selected for this reason. Only 2.6 percent of the non-freeway routes were selected because they had better roads/good signs, etc. Older drivers also select freeways because better facilities, such as food/gas, are available (4.8 percent of the mostly freeway trips). Routes were sometimes chosen because they were "more scenic or enjoyable." In 2.2 percent of the non-freeway trips, 4.2 percent of the partly freeway trips, and 3.2 percent of the mostly freeway trips, scenery was a factor. In the focus group discussions, drivers had indicated that travel on freeways was sometimes boring.

Although not a large percentage of the total, personal safety is a consideration in route selection. Subjects were asked to indicate if route selection involved safety and avoiding bad neighborhoods. While this item was selected in 1.2 percent of the local trips, it was a more important factor in trips that were partly or mostly on freeways (3.2 percent and 2.5 percent, respectively).

Older drivers also based their route selection on avoiding a variety of situations. Most often, they indicated that a route was chosen to avoid traffic congestion. While 10.5 percent of the partly freeway routes and 8.2 percent of the mostly freeway routes were chosen for this reason, only 3.8 percent of the non-freeway routes were chosen to avoid traffic congestion. It would appear from the responses in this sample that older drivers see freeways as a way to avoid traffic congestion.

Avoiding construction is also a priority. Although construction is presumably less common than congestion, avoiding it was frequently indicated as a reason for route selection. In 1.8 percent of all trips, avoiding construction was indicated as a reason for route selection.

The most prevalent avoidance behavior uncovered in the trip diary involves local streets. A surprising 15.4 percent of the mostly freeway routes and 12.2 percent of the partly freeway routes were selected "to avoid local streets/highways." By way of contrast, only 1.2 percent of the local trip routes were selected in order to avoid freeways. Also, avoiding tolls does not seem to be an older driver priority.

The responses to this item indicated that older drivers choose freeways because they are better roads—with wider lanes, better signing, and better gas and food facilities. Freeways are also seen as a way to avoid traffic congestion, as well as unsafe routes or neighborhoods. Many older drivers use freeways to avoid local streets and highways. There is no evidence in the responses to this item to indicate that older drivers avoid using freeways.

Freeway Avoidance/Preference

To determine whether they prefer or avoid freeways, older drivers were asked to indicate if they could have chosen another route that involved more freeway travel. Table 32 shows the distribution of the responses for trips that had no, some, or mostly freeway routes. For trips with no freeway travel, only 6.8 percent had alternatives that involved freeway travel. For trips that were 1/4 to 3/4 freeway, the older drivers indicated that an option with more freeways was available in 18.7 percent of the trips. For trips that were mostly freeway, it was indicated that 15.0 percent could have involved more freeway travel. The mean for all trips was 9.1 percent—older drivers could have selected another route that involved more freeway travel in less than 1 out of 10 trips.

Additional analyses were performed on the 616 trips where the driver could have selected an alternate route that involved more freeway use. This was done to see if there are any differences in either the drivers who make these choices, the times when they make these choices, the origins/destinations of the trips, or the reasons for making the choices.

Table 32. Availability of alternative route with more freeway travel, by freeway use.

Portion on Freeway	Could you have chosen another route with more freeway travel?			
	Yes		No	
	n	%	n	%
None	364	59.1	4969	80.4
1/4 to 3/4	168	27.3	732	11.4
All or most	84	13.6	477	7.7
Total	616	100	6178	100

A total of 92 different drivers were involved in the 616 trips where they could have chosen more freeway travel, but elected not to. This is more than half of the drivers in the sample. The mean age of these drivers was 72.51 years, with a standard deviation of 4.98. This is very close to the mean and standard deviation of the entire sample. Apparently, those drivers choosing not to use freeways are not any older or any younger than those who do not avoid freeways. An examination of the start and end times of these trips revealed that there are no differences between the trips where the drivers did not choose to use freeways and the trips where they did choose to use freeways. Apparently, the drivers are not avoiding freeways at specific times of the day as one might expect if the older drivers were trying to avoid freeway congestion.

The next analysis examined the reasons for selecting a particular route cross tabulated by the availability of an alternative route with more freeway travel. Results are shown in table 33. The most frequent response given for taking a route with less freeway travel was that it was the shortest or fastest (67.9 percent) or the most familiar (43.2 percent) route. Older drivers also indicated that they avoided the freeway in order to avoid traffic congestion (20.0 percent) and construction (4.4 percent). Only 7.6 percent of the routes that could have involved more freeway travel were chosen because the driver specifically wanted to avoid the freeway. As discussed in the previous paragraph, less than 10 percent of the routes taken offered an alternative route that could have involved more freeway. And, less than 10 percent of these routes were selected in order to avoid the freeway. The older drivers are using freeways when they are available; and when they choose not to use freeways, it is because other shorter, faster, more familiar, and less congested alternatives are available.

Table 33. Availability of alternative route with more freeway travel, by route selection criteria.

Why did you use the roads you used?	Could you have chosen another route with more freeway?				Total Cases	
	Yes		No			
	n	%*	n	%	n	%
Shortest, fastest	421	67.9	5066	82.4	5487	81.1
Most familiar	268	43.2	2492	40.5	2760	40.8
Better road—wider, etc.	60	9.7	362	5.9	422	6.2
Better facilities	25	4.0	80	1.3	105	1.6
Most scenic/enjoyable	59	9.5	125	2.0	184	2.7
Safest, avoid bad neighborhood	16	2.6	80	1.3	96	1.4
Only route available	2	0.3	912	14.8	914	13.5
Avoid congestion, traffic	124	20.0	237	3.9	361	5.3
Avoid construction	27	4.4	86	1.4	113	1.7
Avoid local streets	35	5.6	207	3.4	242	3.6
Avoid freeways	47	7.6	33	0.5	80	1.2
Avoid toll	6	1.0	3	0.0	9	0.1
Other	9	1.5	39	0.6	48	0.7
Total Respondents	620		6148		6768	

* Percentages do not sum to 100 because multiple responses were allowed.

Additional analyses were performed on route selection criteria (the subset of 620 trips where drivers could have used more freeway travel). Table 34 shows the route selection criteria for these trips, categorized by the portion of the trip that was on freeways. If older drivers are avoiding freeways, one would expect to find a difference in route selection criteria. Non-freeway routes were selected more often because they were the most familiar (49.2 percent vs. 34.5 percent for freeway routes). Freeway routes were selected more often because they involve better, wider roads (17.1 percent vs. 4.2 percent for non-freeway routes) and better facilities (7.5 percent vs. 1.1 percent for non-freeway routes). It is interesting that avoiding congestion was given as a reason for selecting non-freeway routes about as often (18.9 percent) as it was given as a reason for selecting routes on freeways (22.2 percent). The drivers who chose to use some freeway routes did so to avoid local streets (11.1 percent). This is comparable to the percentage of drivers who chose to use no freeway routes, saying they did so to avoid freeways (8.9 percent).

For those drivers who did not use any freeway routes vs. those who did, route familiarity and roadway quality/facilities appear to be major reasons for route selection. Freeway avoidance, as such, was not found to be a reason for route selection.

Table 34. Route selection criteria for those trips where more freeway routes could have been used, by frequency of use.

Why did you use the roads you used?	About what part of trip was on freeway?				Total Trips	
	None		1/4 to All			
	n	%*	n	%	n	%
Shortest, fastest	239	66.4	175	69.4	414	67.6
Most familiar	177	49.2	87	34.5	264	43.1
Better road—wider, etc.	15	4.2	43	17.1	58	9.5
Better facilities	4	1.1	19	7.5	23	3.8
Most scenic/enjoyable	33	9.2	25	9.9	58	9.5
Safest, avoid bad neighborhood	9	2.5	7	2.8	16	2.6
Only route available	1	0.3	1	0.4	2	0.3
Avoid congestion, traffic	68	18.9	56	22.2	124	20.3
Avoid construction	16	4.4	11	4.4	27	4.4
Avoid local streets	6	1.7	28	11.1	34	5.6
Avoid freeways	32	8.9	14	5.6	46	7.5
Avoid toll	3	0.8	3	1.2	6	1.0
Other	3	0.8	6	2.4	9	1.5
Total Respondents	360		252		612	

* Percentages do not sum to 100 because multiple responses were allowed.

Problems on Freeways

Drivers were asked to indicate if they had any problems on the freeway portion of their trip. Table 35 shows the problems encountered on trips that were partly and all or mostly on freeways. There are no differences in the types of problems encountered by degree of freeway use, so the discussion here addresses the total column that combines all freeway trips. The older drivers report that they had no problems on 87.7 percent of the trips. When problems were encountered, the most common were heavy traffic (16.3 percent), construction (5.6 percent), and bad weather (3.1 percent). Since multiple responses were allowed, the percentages total more than 100 percent. Some of the less frequently encountered problems include situations that were also identified in the focus group discussions and the AARP survey. Discourteous car drivers (1.9 percent) and discourteous truck drivers (1.3 percent) were mentioned. Glare from headlights was encountered in 1.3 percent of the trips. This is probably an underestimate of the severity of the problem since relatively few of the trips took place at night.

Table 35. Problems encountered, by freeway use.

While on interstates, any problems?	About what part of trip was on freeway?				Total Cases	
	1/4 to 3/4		All or Most			
	n	%*	n	%	n	%
No problems	793	88.2	506	86.8	1299	87.7
Heavy traffic	141	15.7	100	17.2	241	16.3
Trouble reading signs	2	0.2	1	0.2	3	0.2
Got lost/disoriented	1	0.1	2	0.3	3	0.2
Discourteous car driver	16	1.8	12	2.1	28	1.9
Discourteous truck drivers	10	1.1	10	1.7	20	1.3
Glare from headlights	8	0.9	12	2.1	20	1.3
Got tired/fatigued	1	0.1	7	1.2	8	0.5
Bad weather	27	3.0	19	3.3	46	3.1
Took wrong road	3	0.3	2	0.3	5	0.3
Construction	43	4.8	40	6.9	83	5.6
Accident/fire	1	0.1	5	0.9	6	0.4
Rough road/potholes	5	0.6	7	1.2	12	0.8
Other	4	0.4	9	1.5	13	0.9
Total Respondents	899		583		1482	

* Percentages do not sum to 100 because multiple responses were allowed.

Some of the infrequently mentioned problems are especially interesting. Although their responses amounted to only 0.5 percent, drivers on eight trips actually mentioned that they became tired or fatigued. While the drivers had trouble reading signs (0.2 percent of the trips), they also took the wrong road (0.3 percent) and got lost or disoriented (0.2 percent).

A separate analysis was conducted of the eight trips involving drivers either "getting lost/disoriented" or "taking the wrong road." Since multiple responses were allowed, it is not known if the eight trips involving these factors represented eight drivers getting lost or one driver getting lost eight times. In eight trips, three different drivers consistently checked "got lost/disoriented" whenever they checked "took wrong road," and two other drivers indicated that they took the wrong road without indicating that they got lost/disoriented. Although it was an infrequent occurrence, it is perhaps noteworthy that 2.7 percent of the older drivers got lost or disoriented, or took the wrong road on freeways at least once in the 2-week period.

SUMMARY

A sample of 157 AARP members, who ranged in age from 65 to 89 and resided in 33 different States, completed a 2-week travel diary. They took almost 8,000 trips during that time. Twenty percent of these trips involved at least 1/4 of the trip on freeways. The following summarizes the findings:

- The respondents chose the shortest/fastest route to their destination and do not avoid freeways. When they did select a route to avoid a freeway, it was to avoid congestion or construction, and not simply to avoid the freeway.

- Comparisons between the times when trips are taken and the times when accidents occur indicate that periods of congestion and darkness are hazardous for older drivers.

- The respondents indicated that they had problems on about 10 percent of their freeway trips. The most common problems involved congestion, construction, and bad weather. Less frequently encountered problems involved discourteous car drivers, discourteous truck drivers, and headlight glare. Although infrequently mentioned, potentially serious problems included fatigue, difficulty reading signs, and taking the wrong exit or getting lost.

8. FUTURE RESEARCH RECOMMENDATIONS

The final objective of this project is to recommend further research to develop guidelines for freeway countermeasures that will accommodate the needs and capabilities of older drivers. Previously described project activities included the following six studies to identify the problems that confront older drivers on freeways:

- Task Analysis of Age-Related Capabilities in Relation to Freeway Driving.
- Focus Group Discussions of Older Driver Freeway Problems.
- Computerized Accident Analysis of Older Drivers on Freeways.
- Hard-Copy Accident Analysis of Older Drivers on Freeways.
- AARP Survey of Problems Experienced by Older Drivers on Freeways.
- Travel Diary Study of Freeway Usage and Avoidance by Older Drivers.

The purpose of each study was to identify specific difficulties experienced by older drivers on freeways.

A variety of specific problem areas were identified and grouped into four general problem areas: design/geometrics, operations, environmental factors, and traffic control (signing and delineation). The specific problem areas identified by the six studies are shown in table 36. For example, the first line shows that narrow shoulders were identified as a problem during the focus group discussions. The second line shows that left exits were identified as a problem during both the focus groups and the AARP survey. The table shows only that a particular problem area was identified; it does not indicate the severity of the problem. Similarly, the fact that a problem area was identified in several studies does not indicate that the problem is more important or more severe than a problem area identified in only one study.

An examination of the identified problem areas indicates that five general types of design considerations are apparent: geometrics/highway design, operations, signing, delineation, and lighting. It is also apparent that older drivers are experiencing problems at five specific locations on freeways: mainline, ramps, work zones, toll plazas, and rest areas. Table 37 shows the relationship between the five categories of design considerations and the five specific freeway locations. The table indicates that each of the design considerations has implications at virtually all of the freeway locations. Additional research efforts to address the problems older drivers are having on freeways could be organized to target either the general design considerations (across the specific freeway locations) or the specific freeway locations (across the general design considerations). In other words, research efforts could be designed to examine the problems older drivers have at ramps. Such a project would look at geometrics, operations, signing, delineation, and lighting of freeway ramps. Or research efforts could be designed to examine a general consideration, such as delineation, and to look at the effects of delineation on older drivers at ramps, work

Table 36. Specific problem areas identified by each problem identification study.

Problem Area	Problem Identification Study					
	Task Anal.	Focus Group	Comp-uter Acc	Hard-Copy Acc	AARP Survey	Travel Diary
Design/Geometrics						
Narrow shoulders		U			U	
Left exits		U				
Combined exit/entrance lanes		U			U	
Merge lanes—too short		U				
Degree/rate of curvature		U			U	
Merging—general	U	U	U		U	
Lane changing	U		U	U		
Rest areas—frequency		U			U	
Rest areas—design		U			U	
Toll plazas—entering		U			U	
Toll plazas—exiting		U			U	
Operations						
Construction		U			U	U
Congestion		U			U	U
Trucks		U	U	U	U	U
High speeds		U		U	U	
Rudeness, dangerous/others		U			U	U
Inadequate enforcement		U				
Tailgating		U				
Environmental Factors						
Snow/icy conditions			U		U	U
Rain/icy weather		U	U		U	U
Sun glare	U	U			U	
Night driving—general	U				U	
Headlight glare	U	U			U	
Inadequate lighting		U			U	
Inadequate lighting—exits					U	

Table 36. Specific problem areas identified by each problem identification study (continued).

Problem Area	Problem Identification Study					
	Task Anal.	Focus Group	Comp-uter Acc	Hard-Copy Acc	AARP Survey	Travel Diary
Inadequate lighting—rest areas		U			U	
Driver condition—fatigue	U		U	U	U	U
Driver not familiar with area	U			U		
Driver—perception of speed	U			U		
Traffic Control						
Signing						
Visibility, day	U	U			U	U
Visibility, night	U	U			U	U
Comprehension	U	U			U	U
Position—prefer overhead		U				
Inadequate advance signing		U			U	
Directional signs—getting lost		U			U	U
Inconsistent format/placement		U				
Inadequate—gas, food, lodging		U			U	
Delineation						
Worn edge/lane lines		U			U	
Like RPMs, PMDs		U			U	
Rumble strips		U		U	U	

zones and toll plazas. It was decided that the suggested additional research would be most compatible with FHWA's research program if it were targeted to identify specific design considerations across all applicable freeway locations. Therefore, specific research studies were designed to address older driver issues related to geometrics, operations, signing, delineation, and lighting.

Table 37. Relationship between design considerations and specific freeway locations.

Design Consideration	Mainline	Ramps	Work Zones	Toll Plazas	Rest Areas
Geometrics/Design	✔	✔	✔	✔	✔
Operations	✔	✔	✔		
Signing	✔	✔	✔	✔	✔
Delineation	✔	✔	✔	✔	✔
Lighting	✔	✔	✔	✔	✔

The remainder of this section is organized into discussions of each of the problems identified, formatted as follows:

- *Problem:* A brief description of the problem experienced by older drivers on freeways—information source of the problem (i.e., focus groups, accident data).
- *Objectives:* A description of additional research needed (if any) to further define the problem or to identify potential countermeasures.
- *Scope:* A preliminary listing of countermeasures or treatments that may address the specific older driver problem.
- *Methodology:* Suggested methodologies for evaluating potential countermeasures for the specific older driver problem.
- *Variables/Measures of Effectiveness:* Suggested candidate variables and/or measures of effectiveness for evaluating the potential countermeasures.

Four general research approaches are suggested:

- Freeway Signing and the Older Driver.
- Freeway Geometrics/Design and the Older Driver.
- Freeway Delineation and the Older Driver.
- Freeway Lighting and the Older Driver.

Specific issues related to freeway operations and construction are being addressed in ongoing FHWA research and, therefore, will not be included in this discussion. In addition, during the course of this project, specific issues that merit additional consideration were uncovered. The following research studies are suggested as a result of the problem identification activities:

- Visual Acuity Study.
- Fitness for Duty Study.
- Complex Reaction Time Study.
- Speed Selection and Control Study.
- Older Driver Navigation/Wayfinding Study.
- Freeway Ramp Merging Study.
- Freeway Transition Area Study.
- Lane-Changing/Passing Behavior Study.
- Study of Speed as a Policy Issue.
- Study of Vehicle Size as a Policy Issue.
- Rest Areas—Design and Placement.
- Perception of Closing Speed.
- Divided-Attention Study.
- Contrast Sensitivity.

Freeway Signing and the Older Driver

Problem

The problem identification studies indicated that older drivers have difficulties reading signs and following routes. In addition, older drivers indicated a strong preference for illuminated overhead signs as well as a need for additional advance warning signs for exits and rest areas.

Objectives

The objective of this research would be to identify deficiencies in current signing practices and develop recommendations for making freeway signing more sensitive to the needs of the older driver.

Scope

Current signing practices for freeway guide signs, regulatory signs, warning signs, motorist service signs, recreational/cultural interest area signs, and tourist-oriented directional signs (TODS) need to be reviewed. Issues related to sign legibility, sign placement, sign frequency, and sign illumination need to be investigated.

Methodology

The first task should identify the types of signs and sign characteristics that are most problematic for older drivers. Focus groups, driver interviews, and driver surveys could be used in this problem definition phase. Once specific problems are identified, alternative sign designs, sign characteristics, and sign placements need to be developed to improve freeway sign effectiveness. The effectiveness of these alternatives should next be evaluated using driver surveys, laboratory testing, and computer simulations. Promising alternatives would be selected for field testing.

Variables/Measures of Effectiveness (MOEs)

MOEs include subjective preference, sign visibility, sign legibility, and message comprehension as a function of sign placement, sign size, day, night, weather, number of lanes, etc.

Freeway Geometrics, Design, and Operations and the Older Driver

Problem

Research has indicated that certain current highway geometric and design standards may not be sensitive to the needs of older drivers.

Objectives

Additional study is needed to determine what changes in current highway geometric and design standards will make freeways more compatible with the needs of older drivers.

Scope

Geometric and design standards for interchanges and mainline sections need to be examined. Mainline characteristics such as lane width, shoulder width, rumble strip location, glare-screen placement, and degree of curvature; and ramp characteristics such as degree of curvature, superelevation, entrance/exit lane length and width, and common merge lane length and width should be addressed. In addition, the geometric and design standards for rest areas and toll plazas need to be examined.

Methodology

The first task would be to identify specific design elements that are not responsive to older driver capabilities. This could be done by using focus groups or subject ride-alongs to identify the favorable as well as the unfavorable aspects of current freeway design. The next task would be to develop changes to existing design parameters. The changes would then be evaluated using laboratory testing, field testing, and/or computer simulation. Comparisons could be made between two similar existing facilities as well as before/after changes to a single freeway facility.

Variables/Measures of Effectiveness (MOEs)

Appropriate MOEs include subjective preference as well as changes in behavioral effectiveness, i.e., reduction in erratic maneuvers, reduction in speed variance and lateral placement variance, reduction in conflicts, etc.

Freeway Delineation and the Older Driver

Problem

Research has suggested that some of the problems older drivers experience on freeways may be reduced through changes in roadway delineation.

Objectives

Additional study is needed to identify inadequacies in current roadway delineation practices and to make roadway delineation more useful to older drivers.

Scope

Roadway delineation at interchanges, toll plazas, rest areas, and mainline sections needs to be evaluated. Delineation, including pavement markings, raised pavement markings, and post-mounted delineators, should be included.

Methodology

A number of the problems older drivers have at ramps, toll plazas, work zones, and on the freeway mainline may be reduced by changes in delineation. The first activity would be to identify those specific situations and specific locations where the problems of older drivers may be related to inadequate delineation or the lack of delineation. This could be done by using focus groups and driver surveys of older drivers. Subject ride-alongs could be used to identify the favorable, as well as the unfavorable, features of delineation at existing facilities. Alternative delineation treatments would then be developed to address the weaknesses identified in current delineation practices. These alternative designs would next be tested in the laboratory or using computer simulations. The most promising alternative delineation treatments would then be field tested. It is very difficult to realistically recreate situations as complex as toll plazas, work zones, and freeway ramps/merge areas in a test course situation. For this reason, it is suggested that the field testing take place at actual toll plazas, work zones, and freeway ramps.

Variables/Measures of Effectiveness (MOEs)

Potential measures of effectiveness include reductions in erratic maneuvers, reduction in speed variances, improvements in lane tracking, and reductions in lane-line and edge-line violations.

Freeway Lighting and the Older Driver

Problem

It was found that older drivers have problems due to inadequate lighting on freeways, especially at interchanges, toll plazas, and rest areas.

Objectives

The objective of the additional research is to identify changes to freeway lighting practices that will address the needs of older drivers.

Scope

Many older drivers restrict their nighttime freeway driving because of inadequate lighting. Those who do drive at night report problems due to inadequate lighting, especially at interchanges, toll plazas, and rest areas. The research should address the needs of those who avoid driving because of inadequate lighting, as well as the problems reported by those who still drive at night.

Methodology

A problem definition task should be the first activity. The lighting-related problems experienced by older drivers should be defined using focus groups and driver surveys. These techniques would be used to determine if the problems are due to the lack of lighting or inadequate existing lighting. In situations where the problems are associated with inadequate existing lighting, additional field studies may need to be conducted to determine optimal/acceptable luminance levels for older drivers in freeway situations. Next, candidate changes to existing lighting standards (i.e., luminare placement, spacing, and intensity) would be developed to make the standards more responsive to the older drivers' visual capabilities. Field testing or computer modeling would then be conducted to determine the effect of the candidate revised standards on older driver safety as well as comfort. Cost benefit analyses of the most promising revised standards should be performed.

Variables/Measures of Effectiveness (MOEs)

MOEs should include subjective rating and/or preference, lane tracking, erratic maneuvers, speed variance, and conflicts (especially at toll plazas).

Visual Acuity Study

Problem

Great concern over the declining visual acuity of older drivers is evidenced in many of the elements of the current project. However, given some narrow limitations, acuity problems can be remedied through the use of corrective lenses. Unfortunately, many older drivers may not have a correct current prescription. Furthermore, older drivers may not seek professional eye care on a regular basis unless they have a problem. Older drivers may also continue to use an older prescription because they cannot afford new eyeglasses.

Objectives

A study should be conducted to determine:

- If older drivers who need corrective lenses have them, and whether they use them while driving.
- If older drivers who wear corrective lenses have the proper prescription for correction to near 20/20 (Snellen) vision.
- If there are measurable safety benefits associated with having 20/20 corrected vision versus having worse than 20/20, but at least as good as required by the State(s).
- The most effective frequency for visual exams for older drivers.

Scope

Foremost, this work would provide highway safety, design, and operations professionals a true picture of the capabilities of today's driving population from a visual acuity standpoint. (Other measures, such as contrast sensitivity, should also be included in this study.) A study of this type would lead to a refinement of State department of motor vehicle (DMV) procedures regarding visual screening. This research could also provide information for older drivers, their family members, and health care professionals regarding how often visual screening is necessary so that older drivers have a prescription that is current and effective.

Methodology

Older drivers would be subject to a visual screening that would include an assessment of their current prescription and their required prescription, along with other measures of visual performance. A determination of the contrast sensitivity, static and dynamic visual acuity, and low-illumination acuity of the older driver population should be made.

Information on date of last visual screening and date of last license renewal would also provide useful data on how often screening should take place.

Variables/Measures of Effectiveness (MOEs)

Current corrective lens prescription, required corrective lens prescription, date and location (e.g., doctor's office, senior center, DMV office) of last visual screening, and date of last license renewal.

Fitness for Duty Study

Problem

The Hard-Copy Accident Analysis pointed to a problem regarding older driver fatigue/ sleepiness behind the wheel, often during daylight hours. Fatigued or sleeping drivers, or drivers who are inattentive because they are tired or sleepy present a major hazard on the highway.

Objectives

A study patterned on the recent studies conducted to assess commercial vehicle operator "fitness for duty" could identify circumstances under which older drivers experience problems with fatigue and falling asleep. A study of this type could also give older drivers better information on indicators that they might be tired or sleepy before they start out to drive and while they are driving.

Scope

Information on maximum consecutive hours of vehicle operation and cumulative hours of vehicle operation could provide guidance for the older driver. Lists of signs of fatigue could also give older drivers better tools to assess their own "fitness for duty." Information on countermeasures to combat fatigue in the older driver would also be a useful outcome of this work. All types of driving—urban/rural, congestion/slow speed, and no congestion/high speed—should be addressed.

Methodology

An in-depth review of hard-copy accident reports, along with follow-up interviews with the involved parties, may yield information on how long older drivers were operating their vehicles before being involved in a fatigue/sleep-related crash. Information on pre-trip activities (e.g., sleep patterns, prescription drug or alcohol use, etc.) for a 24-h period could provide information on activities that could lead to a fatigued/sleepy condition. Gathering this information may prove to be problematic because of State regulations related to the privacy of parties involved in accidents. Thus, there may be a need to rely on laboratory studies that take their cues from other studies of operator fitness or general studies of daily activities and how they relate to fatigue and sleepiness. Focus group discussions could be used to provide an indication of the nature of the problem and the degree to which older drivers recognize it as such.

Variables/Measures of Effectiveness (MOEs)

Information should be gathered (for the previous 24-h period) on strenuous physical activities; periods and patterns of sleep; food, beverage, and drug intake; etc. Time of day, weather conditions, and rest area should be considered.

Complex Reaction Time Study

Problem

Concern is expressed in many of the studies over the slowed reactions of older drivers. However, research on simple reaction time shows little difference between younger and older subjects. Furthermore, recent work by Lerner et al. reveals that there is little difference in the reaction times of younger and older subjects when performing tasks related to stopping sight distance and intersection sight distance maneuvers. Still, the belief persists that in complex, multitask, or attention-sharing situations, the reactions of older drivers are deficient relative to their younger counterparts.

Objectives

A study of older driver "reactions" relative to younger driver reactions is proposed. The study should place both groups into complex driving situations wherein the ability to sense, perceive, understand, and react to additional stimuli are assessed.

Scope

This work would provide highway safety, design, and operations professionals with a true picture of the capabilities of today's driving population from a complex reaction-time standpoint. A study of this type could lead to changes in the screening procedures used by State departments of motor vehicles to include some measure of complex reaction-time capabilities.

Methodology

This type of study would most likely be performed in some type of simulation environment. Subjects would be placed in complex driving situations and then confronted with some type of emergency situation related to the weather, other vehicles, or other situations of interest. The method could include the showing of slides or videos of potential hazards or stimuli requiring action—a construction flagger, a traffic signal, a pedestrian about to enter the street, a stopped vehicle on the road—and then asking subjects to identify its location (by quadrant).

Variables/Measures of Effectiveness (MOEs)

The primary variable of interest would be the measured reaction time of the older subjects relative to some control group. The ultimate objective is to identify and define a reaction-time measure that is highly correlated with accident involvement and that is a suitable screening tool for driver license testing.

Speed Selection and Control Study

Problem

Many of the project studies indicated some concern about the speed selection and control of older drivers. For example, the task analysis delineates several different task descriptions for proper speed selection and control. Many of the other studies show that speed-related issues are a concern to both the older and younger drivers on the highway. It would be useful to know how older drivers select and maintain a speed when driving on limited-access facilities.

Objectives

A task compliance study is proposed to see how well older drivers perform the task elements associated with speed selection and control.

Scope

This research could lead to the identification of coping strategies for older drivers relative to speed selection and control. There may also be some recognition of driver education or remediation techniques that could lead to better speed selection and control on the part of older drivers.

Methodology

A large sample of older drivers should be observed so that their performance of the tasks needed to practice proper speed selection and control can be assumed.

Variables/Measures of Effectiveness (MOEs)

Compliance with the tasks normally associated with speed selection and control.

Older Driver Navigation/Wayfinding Study

Problem

The AARP Survey, the Focus Group discussions, and the Travel Diary information point out that older drivers have problems navigating their vehicles in the highway environment. These difficulties may range from missing an exit from the freeway to becoming completely lost. The accident studies also point out that many collisions involving older drivers occur when they are away from areas near their homes. The issues here are related to wayfinding strategies; and the visibility of, information provided on, and placement of traffic control devices. The role of map-reading skills and the prevalence of pre-trip planning should be determined. The potential value of electronic maps to older drivers—and the problems they may have using them—needs to be evaluated.

Objectives

Research should be conducted to identify problems that older drivers have with wayfinding and vehicle navigation. The study should consider strategies used by older drivers for wayfinding and vehicle navigation, along with the optimal uses of traffic control devices for this user group.

Scope

This research could yield information on how older drivers find their way and navigate, the deficiencies associated with their wayfinding and navigation strategies, and how these deficiencies can be corrected. Improved methods for the design and placement of freeway guide signs could be products of this research.

Methodology

Any research related to this topic should begin with a thorough review of National Cooperative Highway Research Program (NCHRP) Report 123, *Development of Information Requirements and Transmission Techniques for Highway Users*, and any of the information on the Positive Guidance concept, especially as it relates to a priori and ad hoc driver expectancy. The study should attempt to find out what strategies older drivers use to wayfind and navigate, compare those strategies to what is known about wayfinding and navigation, and assess any differences to determine what changes should be made to better accommodate the older driver populations. Furthermore, laboratory and field testing of optimal design of freeway guide signing relative to information content, materials used, placement (overhead vs. roadside, as well as distance from exit), lighting, and other design issues should be done.

Variables/Measures of Effectiveness (MOEs)

Information needed, information desired, size and quantity of signs, and longitudinal and lateral placement of signs.

Freeway Ramp Merging Study

Problem

The AARP Survey and the Hard-Copy Accident Analysis pointed out the problems that older drivers have with merging into mainline traffic when entering limited-access highways. The problem could be attributed to poor driving practices by older drivers or to inadequate geometric design.

Objectives

Research should be conducted to study the behavior of older drivers on, at, or near highway entrance ramps. This study should concentrate on the driving maneuvers of older drivers, along with the geometric characteristics of the ramp and mainline facilities.

Scope

This study could result in improved guidelines for the design of highway entrance ramps, especially related to the ramp-mainline junction area, including the gore, auxiliary lane, and taper areas. This research could also lead to improved educational materials for older drivers on how to traverse the ramp and enter the mainline section of the highway.

Methodology

The behavior of older drivers as they traverse ramp-roadway and ramp-mainline junctions should be observed and categorized to see if this population is performing the driving task safely and efficiently. These observations should be conducted at a variety of highway entrance ramps so that ramps of different design (e.g., relative to ramp length, gore areas, length of auxiliary lane, and length of taper) are represented.

Variables/Measures of Effectiveness (MOEs)

Starting speed, merging speed, gap acceptance, mainline speed, speed profiles, erratic maneuvers, length of ramp, length of auxiliary lane, length of taper, and left- vs. right-lane exits/entrances.

Freeway Transition Area Study

Problem

The AARP Survey and Focus Group discussions noted that older drivers may have problems at transition areas other than freeway entrance ramps along the highway. These areas would include: exit ramps, bifurcations, and lane drops.

Objectives

Research should be conducted to find out which transition areas (other than freeway entrance ramps) present the greatest problems for older drivers. Selected problem areas should then be studied in detail to examine the behavior of older drivers when they are traversing these types of facilities. The research should also examine the geometric features of each of the facility types identified for study.

Scope

This study could result in improved guidelines for the design of highway transition areas. The research could also lead to improved educational materials for older drivers on how to traverse these types of highway features.

Methodology

The behavior of older drivers as they traverse freeway transition areas should be observed and categorized to see if this population is performing this driving task safely and efficiently. These observations should be conducted at a variety of highway transition areas so that the features of different designs (e.g., gore areas, length of weave areas, and length of tapers) are represented.

Variables/Measures of Effectiveness (MOEs)

Mainline speed, diverging speed, speed profiles, and erratic maneuvers in relation to salient highway features.

Lane-Changing/Passing Behavior Study

Problem

The AARP Survey and Hard-Copy Accident Analysis found that older drivers have problems with lane changing in general, and completing a passing maneuver in particular. The problem can be more broadly defined because these problems occur not only in situations where the older driver is changing lanes to gain an operational advantage in trying to actively pass a slower vehicle, but also when changing lanes to avoid a difficult situation or being passed by another vehicle.

Objectives

The study should identify situations in which older drivers experience difficulties or discomfort when changing lanes or passing.

Scope

This work could lead to the development of improved education or training information that will allow older drivers to make these types of maneuvers more easily and safely. This research could also form the basis of an intelligent transportation system study of other driver information needs for decision aids for these types of maneuvers.

Methodology

Observe lane changing and passing from both inside and outside the vehicle to see how older drivers perform in terms of driver behavior and positioning the vehicle. These actions could be compared to the task analyses of these maneuvers to see if the older driver group performs as expected.

Variables/Measures of Effectiveness (MOEs)

Compliance with the tasks normally associated with lane changing and passing.

Speed as a Policy Issue Study

Problem

Many of the problem identification studies cited speed as an issue. This includes the speed at which older drivers travel, as well as the speeds of other vehicles on this highway. Older drivers appear to be law-abiding or law-bending (0-10 mi/h [0-16 km/h] over the speed limit) citizens, who fear the actions of other drivers traveling at excessive speeds. Both the Federal and State governments continue to pursue policies that set lower speed limits without actually enforcing them. The time has come to reassess all policies related to highway travel speeds and let all drivers know where they stand relative to a safe, yet rational, travel speed policy for the country.

Objectives

A comprehensive study should be conducted to formulate a safe, rational highway speed policy so that when all users are on our Nation's highway facilities, they will know what to expect in terms of speeds allowed by various conditions. They will also be confident that any disregard of this policy will be met with swift, consistent enforcement actions.

Scope

All rural and urban freeways should be included.

Methodology

It is generally accepted that speed variance is inversely related to safety. The very recent elimination of the National Speed Limit will undoubtedly result in an increase in speed variance. Travel speeds should be monitored so that the age of the driver can also be determined. If older drivers are found to be disproportionately responsible for the increased speed variance, corrective action may be appropriate.

Variables/Measures of Effectiveness (MOEs)

Vehicle speeds and speed variance.

Vehicle Size as a Policy Issue Study

Problem

The focus group discussions and AARP Survey point out the concern that older drivers have about sharing the highways with motorcycles, trucks, and other oversize vehicles. Many of the comments about tailgating, excessive speeds, and passing maneuvers have been echoed in other studies. Most drivers, not just older drivers, are concerned about the disparate size and performance characteristics of vehicles on our highways. The concern carries over to highway administrators, who are constantly faced with the problem of fairly allocating the costs of highway construction, maintenance, and administration among the different users of the highway system.

Objectives

A comprehensive policy study should be conducted to address the problems of having different vehicle types (each with its own set of unique operating characteristics and operator types) share the same roadway. This study should consider the safety, operational efficiency, and cost-allocation implications of having different vehicles share the same roadway.

Scope

The safety and operational effects of truck lane restrictions and commercial vehicle prohibitions should be included.

Methodology

Before/after evaluation of existing lane restrictions could be used to determine any effect on older driver accidents. Unfortunately, the exposure data to compute accident rates by age are not available.

Variables/Measures of Effectiveness (MOEs)

Accident rate by age category, perceived comfort.

Rest Areas—Design and Placement

Problem

Fatigue, falling asleep, effects of medication, and the general physical condition of the driver may be more serious issues for older drivers. The AARP Survey, Hard-Copy Accident Analysis, and focus group discussions indicate that this is true. When asked how far they drive on long trips, older drivers said 300 to 500 mi (480 to 800 km) per day. When asked how close they'd like to have rest areas, older drivers indicated a range of 68 to 100 mi (110 or 160 km) or every 2 h. Of the 1,392 survey respondents, 40 percent indicated that more rest areas are needed on interstate highways.

An interstate system that is more driver-friendly would include more/better rest facilities. There is also a need for rest areas for drivers of commercial vehicles.

Objectives

- Research should be conducted to better pinpoint current use and older driver needs and desired rest stops.
- Identify/develop a "wish list" of various facilities at rest areas to include toilets, picnic tables, maps, attendants.
- Study the feasibility of adding better lighting and guards where necessary.

Scope

- Develop a usage scale that can be a tool for implementing various levels of rest stops throughout the interstate system, for example:

    Type A: full service (relief facilities plus lighting, security, gas, and food).
    Type B: some service.
    Type C: limited service (toilet/sink only).

- Determine the need for more advance signing of upcoming rest areas with distance indicated.

Methodology

- Survey older drivers' needs and preferences at several locations, including rest areas, AARP, senior centers, Department of Motor Vehicle (DMV) offices.
- Conduct state-of-the-practice interviews with the States regarding their plans, current locations, and general protocol for building and maintaining rest areas.

- Conduct onsite observation of rest areas and observe use of all aspects of the location—people counts, time of day.

Variables/Measures of Effectiveness (MOEs)

Determine effect of rest area spacing, rest area characteristics (service level, lighting, security, etc.), and rest area alternatives (service stations and restaurants) on rest area use.

Perception of Closing Speed

Problem

Data from this project indicated that 24 percent of older driver accidents involved striking slow or stopped vehicles. The primary cue to accurate closing speed is motion-in-depth, which is dependent largely on the rate of change of the size of the image in the eye. One of the few visual abilities that relates to accidents is perception of motion-in-depth. This correlation is greater for older drivers.

Objectives

A study of older drivers' ability to judge closing speed would provide a better understanding of why rear-end collisions occur so frequently with older drivers.

Scope

Information from such work could be useful in educating older drivers about this limitation, of which they are generally unaware. It would also be useful in determining cutoff points for design of in-vehicle collision warning systems in future Intelligent Vehicle-Highway System (IVHS)-type equipment.

Methodology

Drivers would be required to approach lead vehicles that were traveling at different speeds or were stopped, and would then be required to indicate the distance from which they knew that they were closing in on the other vehicle. This would be done in a roadway situation, both during the day and at night.

Variables/Measures of Effectiveness (MOEs)

Measures of perception of motion-in-depth and detection of closing speed.

Divided-Attention Study

Problem

It is known that older drivers have greater-than-average problems with dividing their attention and avoiding distraction. In-depth accident research has suggested that difficulties with attention and distraction could account for a significant proportion of traffic accidents. Inattention and distraction (paying attention to an appropriate stimulus) could be causative elements in many of the older driver accident scenarios discussed.

Objectives

The extent to which older drivers have difficulties in attending to the driving task (including problems with divided attention, attention switching, and distraction) while on a freeway require study.

Scope

The information gained would be helpful in educating and re-educating older drivers as well as in guiding designers in reducing information overload at decision points on freeways. There would also be implications for encouraging older drivers to rely more heavily on passengers to navigate in complex situations.

Methodology

A simulation requiring drivers to merge with other traffic, including large trucks, and to find the assigned exit and complete the exit maneuver should be carried out under heavy traffic conditions.

Variables/Measures of Effectiveness (MOEs)

Measures of divided attention, such as the useful field of vision (UFOV) procedure, as well as the adequacy of lane keeping and sign reading. Drivers would also be debriefed concerning the difficulties they had.

Contrast Sensitivity Study

Problem

Reported difficulties reading shoulder-mounted signs and the preference for overhead-mounted illuminated signs suggest that some problems of older drivers may be the result of reduced contrast sensitivity. Sensitivity differences in visual contrast reduces dramatically with age. It has been suggested that the contrast between a target and its background (e.g., a pedestrian on the road at night, letters on a traffic sign) must be increased by a factor of three for a 65-year-old driver to see the target as well as a 20-year-old driver.

Objectives

Research is needed to examine more fully the effects of low-contrast sensitivity on the performance of freeway driving at night. The results may also have implications for changes in driver licensing testing standards.

Scope

The research would provide a better understanding of older driver perception under low-illumination conditions and would have implications for drivers in detecting roadway hazards and reading traffic signs, as well as for increased illumination of freeway interchanges, and for the need to reflectorize certain roadside hazards.

Methodology

Laboratory research under different levels of illumination is needed to relate difficulties encountered with low-contrast sensitivity to problems in detecting and identifying roadway hazards and reading signs with different color-legend combinations.

Variables/Measures of Effectiveness (MOEs)

Contrast sensitivity as measured by standard procedures, detectability of low-contrast targets, and legibility of traffic signs with different levels of contrast.

9. SUMMARY AND CONCLUSIONS

INTRODUCTION

This report described research conducted to investigate the needs and capabilities of older drivers on freeways and limited-access highways. The objectives of the study were to: (1) identify the characteristics of older drivers that affect their ability to drive on freeways; (2) identify the characteristics of freeway driving that cause the greatest difficulties for older drivers; (3) conduct problem identification research to define the problems experienced by older drivers on freeways; and (4) recommend further research to develop guidelines for countermeasures to accommodate the needs and capabilities of older drivers.

The study defined the problem of older driver mobility and safety on freeways. First, a thorough review of the literature was necessary to guide future research addressing freeway-related behavioral characteristics of the older driver population.

Problem identification methodologies were designed to confirm and expand upon literature review findings and to supplement information gaps discovered in the literature review. These activities were conducted to determine the ability of freeways to provide a safe, convenient environment for use by the older driving public.

Specific issues addressed included the compatibility of older driver capabilities with freeway system elements, including design features, operational requirements, and traffic control devices.

To achieve the study objectives, six problem identification activities were performed:

- Task Analysis/Literature Review.
- Focus Group Discussions.
- Computerized Accident Analysis.
- Hard-Copy Accident Analysis.
- AARP Survey.
- Travel Diary Study.

TASK ANALYSIS/LITERATURE REVIEW

Age-related characteristics of older drivers that may adversely affect the ability of these individuals to safely and efficiently drive on freeways were examined. Because of the lack of empirical information on age-diminished capabilities related to freeway driving, the task analysis was necessarily analytical as opposed to empirical. The results of the analysis were therefore in the form of hypotheses concerning specific aspects of freeway driving that may be vulnerable to age-diminished capabilities. Three specific topics were addressed.

The first section summarized the analysis of the freeway driving task and age-diminished capabilities. Obviously, each age-diminished capability may affect a number of capabilities. The following topics were addressed: basic driving tasks, maneuvering, abnormal conditions, emergencies, driver readiness, and vehicle readiness.

The second section includes an inventory of the various tasks involved in driving on freeways and identifies those specific tasks that are potentially vulnerable to the effects of age-diminished capabilities. Through the process of formal analysis, potential effects of age-related changes in driving ability on freeway driving are hypothesized. The task analysis thus provides a framework for identifying potential problems. Potential interactions between age-diminished capabilities and various aspects of the driving task are described.

The last section describes relevant research that has addressed the characteristics of drivers that influence vehicle operations and that may change with increased age. General abilities discussed include visual aspects (acuity, dynamic acuity, visual field, night vision, contrast sensitivity); other sensory abilities (hearing, olfaction); perceptual-cognitive abilities (attention sharing, information processing, choice reaction time, problem solving, short-term memory, spatial perception, field dependence, motion detection, parafoveal attention); motor abilities; and physical abilities. Driving-specific characteristics discussed include: performance, knowledge, skill, and attitude.

FOCUS GROUP DISCUSSIONS

Eight focus groups were held in four cities: Washington, DC; San Diego, CA; Tampa, FL; and Phoenix, AZ. The 8 groups involved 44 men and 44 women who ranged in age from 65 to 88, with a median age of 70. Participants indicated that their driving performance was better on city streets and country roads, and on freeways when traffic was light, than it was at night, in poor weather, or on freeways when traffic is heavy. There was no evidence to suggest that these older drivers avoid driving on freeways. The most disliked aspects of driving on freeways included: the rudeness and dangerous actions of other drivers, large trucks, and high travel speeds. Participants were most concerned about: congestion, inconsistent signing format and placement, inconsistent speed limits, too few police, short entrance ramps, construction zones, and inadequate rest areas. When driving at night, they preferred freeways with good lighting; they indicated problems with glare from oncoming headlights and problems seeing edge lines and lane markings.

Problems with signage include: unclear messages, inadequate advance notice, too much information (especially California), difficulty seeing shoulder-mounted signs (prefer well-lit overhead signs, especially with arrows specifying lane destinations), and inadequate advance notice for right-turn only and exit-only lanes.

Design issues include the need for larger, more gradual exit/entrance ramps and longer acceleration/merge lanes; the increased use of concrete medians to promote safety and reduce glare; and rumble strips and/or speed bumps to keep drivers alert. Although the older drivers like cloverleaf interchanges because they are predictable and allow for reentry if the driver makes a wrong turn, they do dislike the combination exit/entrance ramps, i.e., weaving sections, found at cloverleafs.

While half of the older drivers did not have a problem with trucks, the other half of the participants felt that trucks were one of the biggest problems. These participants reported problems with speeding and tailgating trucks, and they supported truck lane restrictions and truck time-of-day restrictions.

The older drivers would like to see more well-lit, safe rest areas. They indicated a need for more advance notice of rest areas and for more signs showing the distance to the next rest area.

COMPUTERIZED ACCIDENT ANALYSIS

Accident databases from five States (Illinois, Michigan, Minnesota, North Carolina, and Utah) over a 3- to 4-year period were included in the analysis. Comparisons were made between 4,155 crashes involving drivers over age 65 and 36,142 crashes involving drivers ages 31 to 45. The first series of analyses used all freeway accidents. The following were found:

- No differences in involvement in multivehicle, as opposed to single-vehicle, accidents.
- Older drivers are somewhat more involved in rural as opposed to urban accidents, possibly because they avoid freeways during periods of heavy congestion.
- Older drivers are slightly underinvolved during adverse conditions (dark, wet, ice/snow).
- Older drivers are overinvolved in single-vehicle run-off-road accidents, possibly from effects of fatigue.

A second series of analyses involved a paired-vehicle comparison of accidents involving one older and one younger driver.

- Older drivers are more likely to be cited for failure to yield, improper lane use/passing, or speed violations.
- Older drivers are more likely to be merging or changing lanes just prior to the accident.

HARD-COPY ACCIDENT ANALYSIS

The hard-copy accident analysis involved more than 900 accident reports from four States: Arizona, Florida, Illinois, and Maryland. Hard-copy accident reports were manually coded to identify causative and descriptive factors. Comparisons were made between accidents involving drivers 50 to 55 years of age and drivers more than 65 years of age occurring on the same segments of rural and urban interstates. About one-quarter of the accidents involved single-vehicle accidents. The analysis of the single-vehicle accidents revealed the following:

- Older drivers are more involved in accidents occurring from 10 a.m. to 3 p.m. and less involved in accidents occurring from 11 p.m. to 6 a.m.
- Older drivers are less involved in accidents when the road is wet and snow- or ice-covered.
- Older drivers are more involved in accidents on two-lane freeways than on freeways with three or more lanes.
- Almost one-quarter of the older drivers in single-vehicle accidents were found to be fatigued or asleep.

About three-quarters of the crashes involved two or more vehicles.

- As with the single-vehicle accidents, most multivehicle accidents occurred between 10 a.m. and 3 p.m. and on two-lane freeways.
- The older drivers are struck by vehicles that are traveling faster.
- Unlike single-vehicle accidents, fatigue/falling asleep was not a factor in the multivehicle accidents.
- There were no differences in lighting condition, road surface condition, vehicle type, vehicle speed, and involvement scenario.

The narrative and collision diagram of the hard-copy accident reports were reviewed to quantify some of the more subjective aspects of the crash.

- Older drivers were more likely to:
  - Exhibit careless driving.
  - Be fatigued or asleep.
  - Make improper turns.
- Older drivers were less likely to be driving too fast for conditions.
- There were no differences between the older drivers and the 50- to 56-year-old control group in terms of:
  - Contributory cause.
  - Unsafe lane change.
  - Following too closely.
  - Failure to yield.
  - Reckless driving.

- The older drivers were more likely to be found "at fault."

- In single-vehicle accidents, the older drivers more frequently ran off the road with no prior loss of control than did the younger drivers.

- In single-vehicle accidents, the older drivers were less likely to hit a non-moving object/animal on the roadway.

- In multivehicle accidents, the older drivers were as likely to hit the other vehicle as they were to be hit by the other vehicle. However, they were more likely to be hit by the other vehicle while changing lanes and while going slower than were the younger drivers.

AARP SURVEY

Almost 1,400 members of the American Association of Retired Persons (AARP) were surveyed. Members in 39 States completed an 8-page survey form in order to identify some of the specific problems or difficulties experienced by older drivers on freeways. Multiple responses were allowed. Respondents ranged in age from 50 to 97, with a mean age of 72.2. To identify age-related driver characteristics, the sample was divided into two groups: "younger" old drivers (age 72 or less) and "older" old drivers (age 73 or more). There were 683 "young-old" drivers and 657 "old-old" drivers. Chi-square comparisons were made between the young-old drivers and the old-old drivers.

- About one-quarter of the drivers indicated that they avoided freeways. There were no differences between the younger and the older drivers. The most common reasons for avoiding freeways included heavy traffic, high travel speeds, trucks, difficulties merging or changing lanes, and preference for a more leisurely/scenic route.

- Reasons for preferring freeways included: faster/quicker, no signals/avoid towns, safer/easier/less stressful, traffic moves better, most direct route.

- About one-quarter of the drivers indicated difficulty judging distances on freeways at night, specifically in construction zones, merge lanes, and entrance lanes. Fewer drivers reported problems judging distances relative to other vehicles and to the side of the road.

- Over half of the respondents indicated that they drive less at night, during rush hour, and in snowy and foggy weather.

- About one-third of the sample indicated that they drive less on freeways than they used to. Most (56 percent) indicated that this is because they drive less in general. Other reasons included: it is stressful and dangerous and they are not as confident as they once were, congestion, high speed limit, and the recklessness and speed of other drivers.

- About one-quarter of the sample indicated that they changed their driving habits because of changes in their vision. Most frequently these drivers said they drove less at night. They also mentioned that they were more cautious, had problems with glare, and avoided bad weather and unfamiliar roads.

- When asked about the adequacy of the signing on freeways, 11 percent indicated that signs were too small and 20 percent said they were not bright enough. The older drivers were not significantly more likely to indicate these problems.

- About half of the drivers indicated that sign messages (words and symbols) were either "sometimes" or "often" confusing.

- Three-quarters of the drivers indicated a preference for overhead signs as opposed to shoulder-mounted signs. They also prefer signs that indicate distances to several (as opposed to one) upcoming exits.

- About one-third feel that there are not enough advance signs for exits, gas, food, and lodging.

- Lane changing is difficult for older drivers. They indicated that they sometimes (60 percent) and frequently (17 percent) slow down and follow a slower vehicle rather than pass it. They also never (17 percent) or almost never (23 percent) pass a slow-moving vehicle in the fast lane.

- Lane preference revealed some interesting trends. Although relatively few drivers indicated they preferred the left-most lane, nearly half said they liked the center lane. Reasons for this preference included: allows access to both right and left exits (14 percent), safest (13 percent), allows others to pass (11 percent), and allows others to exit or enter (11 percent). Reasons given for using another lane included: passing (60 percent) and turning off/exiting (55 percent).

- Almost half of the drivers indicated that they either occasionally (45 percent) or often (3 percent) became fatigued while driving. When they become tired or fatigued, they typically stop at a rest area, take a walk, or simply stop driving.

- The older drivers indicated that they sometimes (42 percent) or often (32 percent) use rest areas. Rest areas would be used more often if they offered more services, and had better lighting and security guards. Almost three-quarters of the older drivers would like more advance notice of the next rest area. They also like signs that list distances to the next several rest areas.

- Toll plazas create difficulties for some older drivers. They indicated that they sometimes or often had problems: knowing that a toll plaza is coming (15 percent), knowing which booths are open (21 percent), merging with other vehicles to get into line (33 percent), getting money ready (20 percent), depositing money (16 percent), and merging with other vehicles leaving the plaza (27 percent).

- Problems driving under specific conditions were frequently reported at night (38 percent), in foggy weather (24 percent), in bright sunlight (17 percent), in the rain (18 percent), and in snowy weather (8 percent). Headlight glare from oncoming and following vehicles cause problems for half of the drivers.

- About a fifth of the drivers reported problems with construction zones. The most common problems mentioned included congestion (25 percent), not enough warning (16 percent), other drivers (15 percent), too narrow (11 percent), lane shifts (9 percent), and unclear/obstructions (8 percent).

- Lane-line visibility is not a problem during the day. However, it is a problem during snowy weather (82 percent), fog (71 percent), rain (40 percent), and at night (40 percent).

- The drivers reported that they had problems staying in their lane because of worn or faded lane markings (56 percent), barriers or construction (25 percent), and large trucks (24 percent).

- Almost three-quarters of the drivers indicated that more lighting is needed on freeways; specific locations included exit ramps (45 percent), rest stops (37 percent), construction areas (31 percent), and interchanges (26 percent).

- The drivers indicated that many highway features "help a lot," including painted lane lines (90 percent), RPMs (78 percent), guardrails (68 percent), post-mounted reflectors (68 percent), and rumble strips (50 percent).

- The drivers have difficulties entering and exiting freeways. While 17 percent have trouble finding a suitable gap, 30 percent wish entrance ramps were longer and 25 percent said they actually stop before merging into traffic. Only 13 percent wish exit ramps were longer, but 52 percent slow down before reaching the exit lane. Thirty percent said they had more problems with interchanges with shared exit/entrance lanes.

- While one-third of the drivers would take a different route to avoid construction, more than half would do so to avoid congestion.

TRAVEL DIARY STUDY

A subset of the AARP Survey participants was recruited to keep a 2-week written account of their driving trips. The participants recorded date, time, odometer readings, origin/ destination routes used, reasons for route selection, and problems encountered. The final sample indicated 7,896 trips by 157 drivers who ranged in age from 65 to 89, with a mean age of 72.9. They represented 33 different States. The most frequent origins/destinations included: stores, social/recreational facilities, home of family/friend, restaurant/movie, church, doctor's office, and bank/post office.

As expected, most (80 percent) of the trips involved no freeway and relatively few (8 percent) were all or mostly freeway. The analysis focused on the 20 percent of the trips that involved at least one-quarter or more freeways.

- Comparisons between the time of day of travel and the time of day of accident involvement revealed that the distribution of freeway accidents is very similar to the distribution of freeway trips. Apparently, older drivers successfully schedule their trips to avoid periods of heavy congestion and higher accident risk.

- The older drivers indicated that they typically selected their route because it was shorter/faster or because they were more familiar with the chosen route. They were more likely to choose their route to avoid local streets and traffic congestion than to avoid freeways.

- Less than 10 percent of the routes selected involved trips that could have included more freeways. In most cases, drivers chose less freeway because it was shorter or faster to do so or because they were familiar with the non-freeway route. Only 8 percent of the routes were chosen because the driver specifically wanted to avoid the freeway.

- The drivers indicated the problems they encountered on their freeway trips. The most frequently encountered problems were: congestion (16 percent), construction (6 percent), and bad weather (3 percent). Less frequently encountered problems included: discourteous car drivers (1.9 percent), discourteous truck drivers (1.3 percent), and headlight glare (1.3 percent).

- Although rarely mentioned, several potentially serious problems were reported by the drivers: got tired/fatigued (0.5 percent), took wrong road (0.3 percent), had trouble reading signs (0.2 percent), and got lost/disoriented (0.2 percent).

RESEARCH RECOMMENDATIONS

The ultimate purpose of this project was to identify the problems experienced by older drivers on freeways and to identify additional research to address these problems. The preceding project activities identified a wide range of different problems that older drivers have on freeways. The listing of specific problems was examined and grouped into four general areas: design/geometrics, operations, environmental factors, and traffic control (signing and delineation). Further examination of the identified problems revealed that many of them were specific to certain locations. The problem locations identified included mainline, ramps, work zones, toll plazas, and rest areas. A cross tabulation of general problem area (design/operations/traffic control, etc.) by location revealed that most specific locations experience a variety of different problems.
In order to systematically address the wide variety of problems identified, it was decided to organize the future research recommendations by general problem area. Thus, the issues associated with one general problem area (i.e., design) will consider all potential locations (i.e., ramps, mainline, etc.).

Descriptions of the recommended future research were formatted as follows:

- *Problem:* A brief description of the problem experienced by older drivers on freeways—information source of the problem (i.e., focus groups, accident data).

- *Objectives:* A description of additional research needed (if any) to further define the problem or to identify potential countermeasures.

- *Scope:* A preliminary listing of countermeasures or treatments that may address the specific older driver problem.

- *Methodology:* Suggested methodologies for evaluating potential countermeasures for the specific older driver problem.

- *Variables/Measures of Effectiveness:* Suggested candidate variables and/or measures of effectiveness for evaluating the potential countermeasures.

The recommended research involved 4 general approaches and 14 more specific research studies that target very specific issues that were identified during the course of the project. The four general research approaches include:

- Freeway Signing and the Older Driver.
- Freeway Geometrics/Design and the Older Driver.
- Freeway Delineation and the Older Driver.
- Freeway Lighting and the Older Driver.

These four studies describe research directed at improving the signing, design, delineation, and lighting at ramps, toll plazas, rest areas, and on the freeway mainline. The 14 specific research approaches that address very specific problem areas are:

- Visual Acuity Study.
- Fitness for Duty Study.
- Complex Reaction-Time Study.
- Speed Selection and Control Study.
- Older Driver Navigation/Wayfinding Study.
- Freeway Ramp Merging Study.
- Freeway Transition Area Study.
- Lane-Changing/Passing Behavior Study.
- Study of Speed as a Policy Issue.
- Study of Vehicle Size as a Policy Issue.
- Rest Areas—Design and Placement.
- Perception of Closing Speed.
- Divided-Attention Study.
- Contrast Sensitivity.

Table 38 provides a brief description of some of these problem areas and a brief description of the research needed to address these problems.

Table 38. Recommended research.

Research Area	Problem(s)	Needed Research
Roadway Signing	Strong preference for overhead signing and for listing multiple exits on advance warning systems. Difficulties navigating. Overinvolvement in accidents far from home.	Determine readability, legibility advantages and disadvantages of overhead vs. shoulder-mounted signing. Determine optimal message content (length and format) of advance exit signing.
Freeway Geometrics/Design	Merging onto mainline from ramps. Exit ramps, bifurcations, and lane drops.	Identify ramp geometrics and mainline characteristics that contribute to the problem. Develop and test alternative designs. Identify geometric features and traffic control devices to minimize problems in transition areas.
Roadway Delineation	Heavy reliance on delineation, RPMs, and post-mounted delineators. Run-off-roadway and lane-changing accidents may be related to poor delineation.	Determine optimal delineation width and reflectance. RPM and post-mounted delineator spacing, etc. Wet/nighttime performance is especially critical.
Illumination Requirements	Nighttime driving. Reduced driving at night.	Identify critical factors associated with highway lighting, i.e., placement, amount of lighting.
Construction Areas	Major concern to older drivers. Reason for avoiding freeways.	Identify characteristics of construction areas that are troublesome to older drivers. Develop and test treatments to improve older driver performance in construction zones.
Speed/Lane Selection	Inappropriate lane selection. Inappropriate speed selection.	Identify relevant design parameters: horizontal/ vertical curvature; lane, roadway, and shoulder width; median type and proximity; guardrail type and proximity.
Fatigue/Medication	Fatigue is a major factor in single-vehicle accidents. Many survey respondents indicated they were often fatigued while driving.	Identify roadway characteristics (geometrics, delineation, lighting) associated with fatigue and fatigue-related crashes.
Lane-Changing/Passing Behavior	Lane-changing-related crashes. Problems reported with passing/lane changing.	Conduct detailed behavioral analysis of lane-changing and passing behavior. Determine adequacy of exit signing and advanced exit signing relative to time needed to complete passing maneuver and/or change lanes to exit.
Rest Areas	Older drivers use existing rest areas and would like more of them. Fatigue-related accidents might be reduced if more rest areas were provided.	Determine optimal rest area spacing and characteristics (services, lighting, security, etc.).
Toll Plaza Design	Merging with other vehicles to get in line and merging with other vehicles leaving the plaza.	Determine factors that affect merging behavior when approaching and leaving toll booths (delineation, signing, illumination, etc.). Optimize the most salient factors for older drivers.
Congestion-Related Accidents	Twenty-four percent of the older driver multiple-vehicle accidents involve striking stopped or slowing vehicles.	Determine effect of both active and passive advance warning signs for "congestion ahead" situations. Determine optimal type, placement, and wording.
Glare	Glare from oncoming vehicles, following vehicles, and roadway lighting.	Identify nature of glare problems. Evaluate effect of median barriers, glare screens, and overhead lighting (placement and intensity) on older drivers.

APPENDIX A. AARP SURVEY FORM WITH RESPONSE DISTRIBUTIONS

The following pages contain a copy of the survey that was completed by the American Association of Retired Persons (AARP) members throughout the United States. After the survey was scored, respondents were divided into two groups: young-old (age 72 and under) and old-old (age 73 and older). The results of the survey, in many cases, will show two different numbers or percentages. The first number represents the results of the younger group and the second number represents the results of the older group of drivers. Where only one number is given, no significant difference was found between the two age groups.

DRIVING ON FREEWAYS AND INTERSTATES AARP SURVEY

We are conducting this survey to find out what kinds of problems older drivers have on freeways and interstates. **THIS IS NOT A TEST**. Your experiences and opinions will help us find ways to make driving on interstates easier and safer. Please answer the questions frankly. Remember that we are interested in freeways and interstates. Your answers will not affect your driving record. All information is strictly confidential. You do not need to sign your name.

IF YOU NO LONGER DRIVE, PLEASE COMPLETE THE SURVEY BASED ON WHEN YOU LAST DROVE. THANK YOU VERY MUCH FOR YOUR TIME AND THOUGHTS.

N = 683 ≤ 72 657 >72

Age **$\bar{x}$ = 72.2 Years** Sex **35%**M **65%** F

AARP Chapter **N = 57** City and State ________

If you no longer drive, when did you stop driving? **N = 12**

Why did you stop driving? ________________

If you have not driven a car in the last two weeks, when was the last time you drove?
All 12 Subjects 7 months or less

How many years have/had you been a licensed driver? **$\bar{x}$ = 45/54years**

About how many miles do or did you drive a year?

(1)________ none
(2)**23%/34%** 1,000 to 4,999
(3)**32%/35%** 5,000 to 9,999
(4)**27%/22%** 10,000 to 14,999
(5)**11%/5%** 15,000 to 19,999
(6)**7%/3%** 20,000 or more

In a normal month's time, about how many trips of the following type do you make?

Short trips, including errands, that last less than 2 hours one way on freeways or interstates. **$\bar{x}$ = 11.8**

Short trips, including errands, that last less than 2 hours one way on other roads. **$\bar{x}$ = 25.6**

During the last year, about how many trips of the following type did you make?

Long trips that last more than 2 hours one way on freeways or interstates. **$\bar{x}$ = 8.0/5.1**

Long trips that last more than 2 hours one way on <u>other roads</u>. $\bar{x}$ = **8.2/4.1**

Do you AVOID freeways/interstates for any reason? Yes **24%** No **76%**
If "Yes", explain why. ____________________

Do you PREFER freeways/interstates for any reason? Yes **67%/59%** No **33%/41%**
If "Yes", explain why. ____________________

Do you ever drive a recreational vehicle (RV)? Yes **10%** No **90%**

Do you ever tow a trailer? Yes **12%** No **88%**

Have you taken any type of a driving safety refresher course such as AARP's 55 Alive or GEICO's Program? Yes **47%/58%** No **53%/42%**

Are there enough rest areas on the interstate road system? Yes **60%** No **40%**

How often do you misjudge distances at night? (**circle one**)

Never	Rarely	Occasionally	Often
20%	**52%**	**24%**	**4%**

Indicate the kind of distances you might misjudge on freeways at night. (**check all that apply**)

30%	Exits
9%	Vehicles in front of me
7%	Vehicles next to me
21%	Construction areas
12%	Vehicles on side of road
26%/20%	Length of merge or entrance lanes
2%	Other ______________
16%/35%	Don't drive at night

Listed below are things that some drivers dislike about freeway and interstate driving. **Please check those things that you <u>dislike</u>.**

36%/45%	High speed of travel
38%/32%	Difficulty merging onto the freeway/interstate
55%	Large trucks

20%/15% Getting lost
48%/43% Signs that are confusing or difficult to see
12% Exiting from the freeway/interstate
64%/57% Rudeness or dangerous actions of other drivers
16%/11% Boring view, nothing to look at
11% Difficulty of maneuvering in traffic
21%/26% Things happening too quickly

Do you drive less at night than you used to? Yes 66%/80% No 34%/20%
If "Yes", explain why. ____________________

Do you drive less during rush hour than you used to? Yes 59%/65% No 41%/35%
If "Yes", explain why. ____________________

Do you drive less on freeways/interstates than you used to? Yes 33%/49% No 67%/51% If "Yes", explain why. ____________________

Do you drive less in snowy weather than you used to? Yes 60%/68% No 40%/31%
If "Yes", explain why. ____________________

Do you drive less in rain than you used to? Yes 29% No 71%
If "Yes", explain why. ____________________

Do you drive less when it is foggy? Yes 46%/58% No 54%/42%
If "Yes", explain why. ____________________

Have you changed anything about your driving because of your vision?
Yes 25%/31% No 75%/69%
If "Yes", in what ways? ____________________

Have you changed anything about your driving because of your hearing?
Yes 1%/3% No 99%/97%
If "Yes", in what ways? ____________________

What are mileposts or mile markers for? (**check all that apply**)

43% Distance to next major city
64% Distance to the state line or end of an interstate
8% For Highway Department use only
32% Matches the exit number in some states
4% For snowplows to check the road edge
12% Don't know

SIGNS ON FREEWAYS AND INTERSTATES

In general, signs are: (**check one**)

11%	Too small
89%	About right
0%	Too large

In general, signs are: (**check one**)

20%	Not bright enough
79%	About right
0%	Too bright

In general, the words on signs are: (**check one**)

15%	Not easy to read
73%	About right
12%	Easy to read

Are messages on signs confusing or hard to understand? (**circle one**)

Rarely	Sometimes	Often
44%	**53%**	**4%**

Are symbols on signs confusing or hard to understand? (**circle one**)

Rarely	Sometimes	Often
54%	**43%**	**3%**

Do directional signs/guide signs give you the information you need?
If "No", explain why. ____________________ Yes 90% No 10%

Do you prefer: (**check one**)

74%	Overhead signs
26%	Signs to the side of the road

Do you prefer signs that: (**check one**)

26%/39%	Indicate distance to only the next upcoming exit
74%/61%	Indicate several upcoming exits and their distance

Are there enough signs in advance of exits, gas, food, lodging? (**circle one**)

Yes	Sometimes	No
57%/66%	**33%/28%**	**10%/6%**

Changing lanes to pass a slower vehicle is sometimes risky. How often do you slow down and follow the slower vehicle rather than pass it? (**circle one**)

Never	Almost never	Sometimes	Frequently
4%	**19%**	**60%**	**17%**

How often do you pass slow-moving vehicles that are in the slow lane? (**circle one**)

Never	Almost never	Sometimes	Frequently
1%/2%	**5%/5%**	**38%/51%**	**56%/41%**

How often do you pass slow-moving vehicles that are in the fast lane? (**circle one**)

Never	Almost never	Sometimes	Frequently
17%	**23%**	**44%**	**15%**

How do you check your blind spot? _______________

Do you try to stay out of the other driver's blind spot? (**circle one**)

Yes	No	Don't know
75%	**4%**	**21%**

How do you let other drivers know that you intend to change lanes?________________

In what lane do you usually drive? (**circle one**)

Far left lane	Center lane	Far right lane
6%/4%	**52%/41%**	**42%/54%**

Why do you use that lane?____________________

Why would you drive in other lanes? _______________

Do you ever get tired or fatigued while driving? (**circle one**)

Never	Almost never	Sometimes	Frequently
10%/16%	**38%/40%**	**47%/43%**	**4%/2%**

While driving, how do you know when you are tired or fatigued?____________________

What do you do when you become tired or fatigued while driving?________________

At toll plazas, how often do you have difficulties with the following? (**circle one choice for each**)

	Never	Rarely	Sometimes	Often
Knowing that a toll plaza is coming up:	**49%**	**37%**	**13%**	**2%**
Telling which booths are open:	**41%**	**38%**	**18%**	**3%**
Merging with other vehicles to get into line:	**49%**	**37%**	**13%**	**2%**
Getting money ready:	**45%**	**36%**	**15%**	**5%**
Depositing money/getting ticket:	**47%**	**38%**	**13%**	**3%**
Merging with other vehicles leaving plaza:	**32%**	**42%**	**24%**	**3%**

REST AREAS:

How often do you use rest areas on freeways and interstates?

Never	Rarely	Sometimes	Often
6%/11%	**16%/20%**	**42%/42%**	**36%/27%**

Would you use them more often if they: (**check all that apply**)

35%/24%	Offered more services
36%/24%	Had better lighting
44%	Had security guards on duty
9%	Had more parking
7%	Large trucks were not allowed to use

About how many miles apart would you like rest areas to be located? **$\bar{x}$ = 68.3** mi. apart.

Would you like more advance notice of the next rest area? Yes **71%** No **29%**

If signs were provided on freeways/interstates listing the next few rest areas, how helpful would that be: (**circle one**)

Not helpful	Helpful	Very helpful
4%/6%	**52%/66%**	**44%/29%**

Please tell us about any problems that you may have driving in each of the conditions listed below:

At night ____**38%**____

In foggy weather ____**24%**____

In bright sunlight ____**17%**____

In rain ____**8%**____

Does headlight glare from oncoming vehicles cause you any problems?
Yes **58%/69%** No **42%/31%**

Does headlight glare from vehicles behind you cause any problems?
Yes **48%** No **52%**

Do you feel comfortable driving at speeds of 55-65 mph? Yes **95%/88%** No **5%/12%**
If "No", explain why. ____________________

Do you have any difficulty seeing any of the controls in your car such as the speedometer or the heater? (**circle one**)

Yes	Sometimes	No
2%/5%	**7%/14%**	**91%/81%**

Do you have any difficulty using any of the controls in your car? (**circle one**)

Yes	Sometimes	No
1%	**4%**	**95%**

Why? ______________________________

Do you ever have any problems with work zones/construction areas on interstates?
Yes 21% No 79%

What kinds of problems? ____________________

How could work zones/construction areas be improved to make driving through them easier? ______________________

Let us know how you feel about driving near large trucks. (**circle one choice for each**)

Truck drivers tailgate my car:

Never	Rarely	Sometimes	Often
8%	**27%**	**51%**	**14%**

Truck drivers cut me off when they change lanes:

Never	Rarely	Sometimes	Often
14%	**43%**	**37%**	**6%**

On roads I travel, truck drivers drive too fast:

Never	Rarely	Sometimes	Often
4%	**15%**	**43%**	**39%**

I have problems keeping my car in my lane when trucks pass me or I pass them:

Never	Rarely	Sometimes	Often
38%	**41%**	**20%**	**1%**

Truck headlights bother me:

Never	Rarely	Sometimes	Often
19%	**38%**	**34%**	**9%**

Are painted lines that divide the lanes and mark the road edge visible enough under the following conditions: (**check one each**)

Daylight	Yes	94%	No	6%
Rain	Yes	60%	No	40%
Night	Yes	61%	No	39%
Fog	Yes	29%	No	71%

Snow Yes **18%** No **82%**

Do any of the following make it difficult for you to stay in your lane? (**check all that apply**)

7%	Vehicles on my right
2%/6%	Vehicles on my left
24%	Large trucks
56%	Worn/faded lane meetings
25%	Barriers or construction on my right
22%	Barriers or construction on my left

Is more lighting needed on freeways/interstates? Yes **70%** No **30%**

If "yes", where? (**check all that apply**)

37%	Rest stops	45%	Exit ramps
26%	Interchanges	31%	Construction areas
8%	Toll plazas	23%	Rural interstates
11%	Urban interstates	3%	Other _____

When driving on freeways and interstates, which of the following do you find helpful? (**circle one choice for each**)

Painted lane lines:	Not very helpful **1%**	Help some **9%**	Help a lot **90%**
Lane marking reflectors:	Not very helpful **2%**	Help some **20%**	Help a lot **78%**
Guardrails:	Not very helpful **3%**	Help some **30%**	Help a lot **68%**
Post-mounted reflectors on the shoulder:	Not very helpful **3%**	Help some **29%**	Help a lot **68%**
Rumble strips:	Not very helpful **13%**	Help some **37%**	Help a lot **50%**

About how far ahead of you do you look when driving? (**answer in <u>either</u> feet, car lengths, or part of a mile**)

$\bar{x}$ = **370** feet $\bar{x}$ = **5.2** car lengths $\bar{x}$ = **.039** of a mile

How do you choose what speed to drive? _____________

Does your car have cruise control? Yes 76% No 24%

If you have cruise control, do you use it? **(circle one)**

Yes	Sometimes	No
52%	**31%**	**17%**

If "No", explain why. ____________________

Do you have difficulty maintaining your speed without cruise control?
Yes 11% No 89%

If "Yes", explain why. ____________________

When entering a freeway/interstate, do you: **(check all that apply)**

90%	Use your turn signal
17%	Have trouble finding a big enough gap in traffic
25%	Stop before merging into traffic
81%	Use your mirrors
34%/26%	Wish that entrance lanes were longer

Sometimes a freeway entrance lane also serves as the exit lane. Do you have more problems with these entrance/exit lanes than you do with a regular entrance lane?

Yes 39%/27% No 61%/74%

Why? ____________________________

When exiting a freeway/interstate, do you: **(check all that apply)**

96%/91%	Use your turn signal
86%/79%	Use your mirrors
13%	Wish that exit lanes were longer
4%/1%	Take the wrong exit
52%	Slow down before reaching the exit lane
60%	Slow down after entering the exit lane

Sometimes a freeway exit lane also serves as the entrance lane. Doyou have more problems with exit/entrance lanes than you do with a regular exit lane?

Yes 34%/27% No 66%/74%

Why? ______________________________

When you notice road construction, do you usually try to take a different route or get off the interstate? Yes 34% No 66%

When you notice heavy traffic congestion, do you usually try to take a different route or get off the interstate? Yes Yes 51% No 49%

In the last three years have you:

Received a traffic warning?	Yes 3%	No 97%
Received a traffic ticket other than for parking?	Yes 4%	No 96%
Been involved in a traffic accident?	Yes 9%	No 91%

If you checked "Yes" to any of the three questions above, please explain.

____

____

Please tell us about any freeway/interstate driving problems you have that we haven't asked you about.

____

____

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