Title

Investigation of Elderly Driver Safety and Comfort: In-Vehicle Intersection “Gap Acceptance Advisor” and Identifying Older Driver Needs

Authors
Bougler, Benedicte
Cody, Delphine
Geyer, Judy
et al.

Publication Date
2005-11-01

CALIFORNIA PATH PROGRAM
INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY

Investigation of Elderly Driver Safety and Comfort: In-Vehicle Intersection "Gap Acceptance Advisor" and Identifying Older Driver Needs

Benedicte Bougler et al.

California PATH Research Report
UCB-ITS-PRR-2005-36

This work was performed as part of the California PATH Program of the University of California, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation, and the United States Department of Transportation, Federal Highway Administration.

Final Report for Toyota GapAdvise

November 2005

ISSN 1055-1425

Toyota GapAdvise:

INVESTIGATION OF ELDERLY DRIVER SAFETY AND COMFORT:

In-Vehicle Intersection "Gap Acceptance Advisor" and Identifying Older Driver Needs

FINAL REPORT

Benedicte Bougler
Delphine Cody
Judy Geyer
Jedidiah H. Horne
James A. Misener
Christopher Nowakowski
Caroline J. Rodier, Ph.D.
David Ragland, Ph.D, MPH
Susan A. Shaheen, Ph.D.

University of California PATH Program
1357 S. 46th Street Bldg 452; Richmond, CA 94804-4648

Joy Caguimbaga
Bevin Daniels
Kathryn Hamel, PhD

Movement Analysis Laboratory, Department of Physical Therapy and Rehabilitation Science
University of California San Francisco, Box 0625; San Francisco, CA 94143

March 28, 2005

ACKNOWLEDGMENTS

The authors would like to thank Toyota Motor Corporation for their generous contributions to this older driver research.

We would also like to express appreciation to our older driver research partners who supported our focus group research, particularly: Albert Austria of Toyota Technical Center, USA; Sharon Smith of the Rossmoor Senior Adult Community in Walnut Creek;

California PATH and Institute of Transportation Studies, Berkeley faculty, staff, and students also deserve special credit for their assistance with this project, including: Dr. Samer Madanat, Steven Campbell, Rachel Finson, Linda Novick, Cynthia McCormick, Amanda Eaken, and Joanna Mui. Additionally, thanks go to members of the PATH "Intersection Decision Support" team who prepared experimental software, drove vehicles and served as flaggers. Particular thanks in this regard go to Susan Dickey, Ashkan Sharafsaleh, Joel VanderWerf and our flagger Tracy Shaw.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Our work in Toyota GapAdvise is comprised of two interrelated elements: identify driving task challenges, and a pilot study on one particular class of decision support system, an intersection gap advisor. From these elements, we have recommended countermeasures and potential design guidelines for the elderly driving population in the United States.

We performed our work in the following sequence of technical tasks, each corresponding to a section heading in this final report:

> <u>Determine Extent of Problem (Task 1)</u>. From crash databases and demographic data, we have determined the projected extent of the problem, extending from past work. From our synthesis and interpretation of data and publications, we have ranked causal factors.
>
> <u>Conduct Focus Group and Observational Analysis of Elderly Drivers (Task 2)</u>. Through focus groups and observing elderly drivers in their own vehicles, we have developed an understanding of the problems faced by elderly drivers.
>
> <u>Conduct Driving Experiments (Task 3)</u>. Using PATH instrumented vehicle and test intersection at the University of California, Berkeley's Richmond Field Station facility, we have performed in-vehicle experiments to characterize driver behaviors.
>
> <u>Recommend In-Vehicle Design (Task 4)</u>. From Tasks 1 – 3, we provide integrated recommendations, to include engineering constraints and design principles, from Tasks 1 – 3.

<u>Determine Extent of Problem (Task 1)</u>

The growing number of older drivers presents a special challenge and opportunity for health professionals and the motor vehicle industry. Over the next few decades, the number of persons over age sixty-five will increase at least 240%, and the number of persons over eighty-five will increase by at least 466%. In the meantime, the percent of seniors licensed to drive is increasing steadily. Also, today's older adults entering into retirement are driving more miles per year than current retirees, as today's adults are more accustomed to longer commuting, shopping, and recreation trips than current retirees experienced in their younger adulthood.

The number of licensed drivers and the average annual miles driven are projected to increase for all age groups. Older adults deserve special attention by health care professionals and the motor vehicle industry because driving performance tends to decline with age. Adults age sixty-five and over have higher collision rates both per mile driven and per licensed driver than adults age twenty-five to sixty-four. Seniors are also overrepresented in certain crash types, such as crossing path collisions and those involving right-of-way violations.

Our work outlines the projected growth in the number of older adults, older adult drivers, and the differences in collision outcomes between adults and older adults. Unless otherwise noted, all data describe the United States population, its drivers, and their collision rates. Data sources and analysis methods are explained.

Conduct Focus Group and Observational Analysis of Elderly Drivers (Task 2)

Impediments and potential solutions to safely extend driving for older travelers were explored in four focus groups conducted in the summer and fall of 2004 at the Rossmoor Senior Adult Community in Walnut Creek, California. In total, 20 women and 16 men participated in the four focus groups, and their ages ranged from 70 to 85 years (mean age of 78). Driving alone was the most frequently used travel mode among participants, and they owned vehicles that ranged from small compact cars to luxury sedans.

The focus group research method allows for detailed, in-depth exploration of relatively new research areas, but its small, non-random sample limits generalizations to the larger population. As a result, it is important to interpret the results of the focus group findings in the context of the demographic and attitudinal profiles of the participants. These were assessed using questionnaires administered before the start of each focus group. The survey results indicate that participants in this study were most likely to:

- Have begun driving at 18.5 year of age;
- Be married;
- Live in a household with 1.5 people, 1.5 drivers, and 1.4 autos;
- Have a Bachelor's degree; and
- Have a household income ranging from $20,000 to $49,000.

In addition, the typical focus group participant expressed the following attitudes related to auto use:

- Enjoyed and was satisfied with his/her personal vehicle;
- Did not find operation and maintenance of a personal vehicle to be onerous; and
- Neither inclined nor disinclined to experiment with new things.

During the focus group discussion, several key problem areas were identified. In approximate order of importance, these included:

- Blind spots while merging and changing lanes, often exacerbated by the difficulty drivers experienced turning their necks;
- Problems reversing and parallel parking, again caused by blind spots and difficulty looking backwards;
- Items placed in the trunk not staying in place while driving;
- Seats too low for drivers to see above the dashboard and/or reach the pedals;
- Difficulty with vehicle ingress and egress, particularly for taller drivers and those with physical disabilities, and often worsened by poor seating design;
- Problems adjusting or reading knobs, dials, and displays, particularly dim displays and clocks set into the dashboard at a hard-to-see angle;
- Concern about glare and the speed of oncoming drivers at night or in the rain; and
- Travel to unfamiliar or long-distance destinations.

Participants also identified potential solutions to their specific difficulties. Numbers one through three in parentheses indicate increasing levels of solution complexity.

- Blind spots while merging and changing lanes and concern about the speed of other vehicles: (1) "wink" mirrors, redesigned convex right hand side mirrors; (2) redesigned window pillars; and (3) automated blind spot detection.
- Problems gauging when to safely make left-hand turns at unprotected intersections: (3) intelligent intersections.
- Concern for hitting other cars, the curb, or pedestrians when parallel parking and reversing: (1) reverse beepers (to avoid hitting other cars or pedestrians), "curb feelers" (to avoid hitting the curb); and (3) automated parking technology.
- Items not staying in place when placed in the trunk and difficulty lifting items from the trunk when loading or unloading: (1) netting, bungee cords, Velcro; and (2) "flat" trunks without additional lip, compartmentalization.
- Seats too low for drivers to see above the dashboard and/or reach the pedals: (1) manual up/down adjustments on vehicles; and (2) electric-adjust memory seat settings, adjustable pedals.
- Difficulty reading displays and using knobs: (2) increased brightness, knobs on steering wheel, remote for radio.
- Physical discomfort or difficulty during access and egress due to limited range of motion or physical impairment: (1) handles above door, running boards, mechanical door check to avoid slamming; and (2) ergonomic design for taller drivers, adjustable steering wheels, sliding front doors.
- Decreased visual acuity when driving at night or during rain: (2) automatic-dimming headlights for incoming glare, faster automatic lights for night driving.
- Traveling to unfamiliar locations increases anxiety: (1) digital compasses; and (3) GPS-enabled in-vehicle navigation systems (can also mitigate short-term memory loss).
- Sun glare: (1) wider or adjustable visors; and (2) tinted windshields.
- Problems remembering when to turn off turn signals: (1) volume setting, timeout function.

An important element of this was to observe and analyze older adults during “in-vehicle” performance on an open road course and also during ingress/egress tasks, as it was hypothesized that problems faced by older drivers would be clearly observed through analysis of “in-vehicle” performance. It was also hypothesized that the problems detected in this study would direct future research on specific intervention strategies to address these problems. Future motor vehicle modifications, along with medical and behavioral intervention strategies should be targeted at keeping older drivers safe on the road, despite functional declines. Three components were a Rossmoor driving section, a Walnut Creek driving section and observation of ingress/egress.

Key results from the Rossmoor section include:

- 75% of those drivers who reversed out of the starting parking space did not fully look through rear window before backing out
- 100% of those who pulled forward out of the parking space made no scanning errors
- Many errors were made during turn out of Rossmoor parking lot:
    - 90% did not fully stop before turning
    - 43% did not scan the surrounding area adequately
    - 20% failed to slow
    - 23% failed to signal
- 40% of drivers made head turning errors at stop sign controlled intersections
- 67% of drivers made head turning errors during lane changes
- 17% of drivers made head turning errors during yield
- 13% of drivers made signaling errors at intersections
- 23% of drivers made signaling errors during lane changes
- 57% of drivers did not fully stop at stop sign controlled intersections
- 13% of drivers did not follow prescribed route
- 30% of drivers did not adequately scan
- 37% of drivers sped
- 17% of drivers made critical errors

Key points from Walnut Creek section include:

- 73% of drivers made head turning errors at intersections
- 77% of drivers made head turning errors during lane changes
- 20% drivers made head turning errors while parking
- 63% of drivers turned too wide
- 17% of drivers failed to signal at intersections
- 17% of drivers failed to signal before changing lanes
- 23% of drivers failed to signal during parking/pulling out
- 20% of drivers rolled through stop signs
- 43% of drivers inadequately scanned during drive
- 17% of drivers sped during drive
- 17% failed to have two hands on wheel during all of drive
- One driver performed a self-distracting activity while driving (looking at map, misses light turning green)
- 10% of drivers committed critical errors

Key results from ingress/egress observations include:

<u>Suitcase Loading</u>

- 70% placed the suitcase in the trunk
- 21% placed the suitcase on backseat floor
- 9% placed the suitcase on backseat

<u>Grocery Bag Loading</u>

- 64% placed the groceries in the trunk
- 21% placed the groceries on the backseat floor
- 15% placed the groceries on backseat

<u>Ingress</u>

- 28% had difficulties getting into the driver seat
- 67% had difficulties getting out of the driver seat

- 65% had difficulties getting into rear passenger seat
- 91% had difficulties getting out of rear passenger seat
- Required the use of one arm/hand during ingress - driver seat = 12%, backseat = 32%
- Required the use of one arm/hand during egress - driver seat = 24%, backseat = 23%
- Required the use of two arms/hands during ingress - driver seat = one person, backseat = 9%
- Required the use of two arms/hands during egress - driver seat = 9%, back seat = 14%

Conduct Driving Experiments (Task 3)

We experiment with an in-vehicle message for a left turn across path / opposite direction (LTAP/OD) gap advisor, judging its effectiveness with older drivers (versus younger drivers). This work leverages research conducted under the Intersection Decision Support (IDS) project and upcoming with the Cooperative Intersection Collision Avoidance System (CICAS). This gives rise to the LTAP/OD display used for *Toyota GapAdvise.*

This experiment is as follows: the subject vehicle (SV) – or the vehicle equipped with the *Toyota GapAdvise* LTAP/OD warning system – approaches the intersection. It has a (permissive) green signal, but there is no left turn arrow or protected cycle, so the driver slows down to a stop to check if it is safe to make a left turn onto at the intersection. The SV driver may be older or otherwise not able to easily judge the speed or location of this approaching traffic, making it hard to decide whether or not to turn. While the SV driver is trying to determine whether the left turn is safe, other vehicles ("Principal Other Vehicles" – POV) are approaching the intersection with the intent of proceeding straight. Therefore, intermittent gaps, some safe and some not save may be present.

In exploring the concept of an in-vehicle gap advice system, this study addressed the following four research questions on 20 subjects:

1. What is considered an unsafe gap?

2. When should you give the warning to be effective in influencing the drivers' decisions?
3. How should the warning be given?
4. How effective might the system be in reducing the number of unsafe turns?

We are also able to distinguish between the effectiveness of in-vehicle systems versus an analogous roadside-mounted system, since we are conducting parallel roadside warning experiments under the IDS project.

<u>Recommend In-Vehicle Design (Task 4)</u>

We suggest specific solutions that focus on redesign of vehicle components or on changes that are already available in some models, such as improved mirrors, minor adjustments to displays or radios, and mechanical seat adjustments and checks on doors. Participant focus group results also suggest improvements involving more complicated electronics or major structural changes to vehicle design fall into the second category, and these include redesign for blind spots, flat trunks, and automated or electronically adjustable features, among other recommendations. We also provide a set of solutions which integrate enhanced driver information into automatic vehicle navigation or alert systems.

Although our sample population of older drivers was relatively robust and most likely higher functioning than the average population of older adults, most drivers in the study made several driving errors which could affect safety. Our observational analysis of driving performance confirm the findings from the focus groups which suggest that blind spots, difficulties changing lanes, and concerns about hitting objects such as a curb or pedestrian were among the most important problem areas mentioned by our participants. Recommendations for vehicle modifications include that might address the reduced neck and torso mobility include: mirror redesign, increased visibility through pillar and window reconfiguration, back-up beepers and cameras, and potentially a warning system of some sort to remind individuals to scan appropriately at intersections and during lane changing.

We were surprised to find that 60% of the individuals in our study had deficits in working memory given that they all easily passed the cognitive screening test. This suggests that navigation could be beneficial in this population; however this idea must be tempered by the fact that the majority of participants had mild deficits in directed visual search and half had mild deficits in divided attention.

From a usability standpoint, we observed that those with mobility problems and taller individuals had the most difficulty getting into and out of the vehicle, particularly for the rear passenger seat. Additionally, the smallest women in the study tended to be positioned too close to the steering wheel and sometimes forced into a more flexed, or forward leaning posture. Greater seat adjustment capability (particularly for the height of the seat) might address some of these limitations. Greater space in the back seat, along with some form of adjustment might improve an older adult's ability to perform ingress and egress more easily.

The drivers' comments on the overall concept of a gap advice system were positive. Almost all of the drivers commented that such a system could be useful and come in handy at times. However, unsurprisingly, almost all of the drivers also agreed that the interface would need much more study and work before being accepted as an in-vehicle system.

The head-down display used for the visual component of the warning was reported as being too low to be seen, even though it was mounted as high as possible for a head-down display. When asked to comment on the graphical components of the display, such as the looming no-left-turn sign or the oncoming vehicle distance to intersection countdown bar, all 20 drivers reported that they did not glance to the display during their turning maneuver, rather they simply listened for the warning beep. A few of the drivers expounded on this, stating that their eyes and attention were focused on the oncoming vehicle throughout its approach, and they did not feel comfortable taking their eyes off the road.

These and other comments spawn potential design considerations:

1. Integrated DVI design, with specific auditory and visual meaning to intersection left turn conflicts.

2. Recognition that the infrastructure mounted active sign, in the scanning direction of SV

drivers, had particular appeal. This may translate into design guidance of head up, not head down, display location. More specifically, when making left turns drivers tend to scan the upper left quadrant of the windshield, in the vicinity of the left side A-pillar.[1] This presents a visual design placement challenge, perhaps resolved by relying on another channel, e.g., auditory.

We recommend that future research include the design and possible deployment of prototype vehicles incorporating different level solutions for field tests with older drivers. Because of the high cost and uncertain demand for some technologies, it is possible that the marginal benefits of component level solutions may be the most cost effective for older drivers. Because many drivers also had difficulty with merging, another area that deserves future study is merging and turning behavior, perhaps through a merge assist study with technology development and interface assessment.

We feel that specific GapAdvise driver interfaces be designed for more comprehensive studies in the future. Some of the studies, both general observational and with intersections, should be comprehensively designed. For example, the older adult could also be studied driving during twilight or night hours. Another interesting study would be to evaluate a prototype vehicle using the same subjects tested in this study to evaluate how their performance changes in a new vehicle targeted to older adults.

[1] Nowakowski, C. (2004). *Intermediate summary of IDS (intersection decision support) field test results.* Presented at the IDS Quarterly Meeting 9/26-9/29 in Minneapolis, MN. Berkeley, CA: California PATH.

1.0 INTRODUCTION

This work was undertaken in recognition that with the growing numbers of elderly drivers, particularly with the impending retirement of the bow wave of the "baby boom" generation, most living in relatively low density suburban environments, the mobility challenges will increase greatly in coming years. The emerging challenge for millions of older adults will be to maintain driving mobility in the face of functional decline.

This report describes our work, which includes a multi-disciplinary systems-oriented approach to develop a pilot study on one particular class of decision support system, an intersection gap advisor, *Toyota GapAdvise*. Our work also identified driving task challenges, from we which suggest countermeasures for the elderly driving population by means of interpretation of focus groups and observations. From these elements, we have recommended countermeasures and potential design guidelines.

In short, we have performed the following sequence of technical tasks, each corresponding to a section heading in this final report:

> <u>Determine Extent of Problem (Task 1)</u>. From crash databases and demographic data, we have determined the projected extent of the problem, extending from past work. From our synthesis and interpretation of data and publications, we have ranked causal factors.
>
> <u>Conduct Focus Group and Observational Analysis of Elderly Drivers (Task 2)</u>. Through focus groups and observing elderly drivers in their own vehicles, we have developed an understanding of the problems faced by elderly drivers. In areas as: ingress/egress, and seating/control adjustments.
>
> <u>Conduct Driving Experiments (Task 3)</u>. Using PATH instrumented vehicle and test intersection at the University of California, Berkeley's Richmond Field Station facility,

we have performed in-vehicle experiments to characterize driver behaviors. We note that we have significantly leveraged our Federal- and Caltrans-sponsored Intersection Decision Support (IDS) project to focus on gap acceptance (versus collision warning) advisor for older drivers[2]. This has allowed us to add to the Toyota-sponsored segment, additional observations on driver acceptance of left turn warnings provided from the infrastructure versus those provided from a driver-vehicle interface (DVI).

Recommend In-Vehicle Design (Task 4). From Tasks 1 – 3 , we provided integrated recommendations, to include engineering constraints and design principles, from Tasks 1 – 3.

2.0 DETERMINE EXTENT OF PROBLEM

2.1 A Growing Senior Population

Traffic safety is an important issue for all segments of the population. Population changes affect the both the number of motor vehicle passengers and licensed drivers. Also, an increase in population leads to an increase in motor vehicle injuries and fatalities. The general population is expected to grow 157% from 1990 to 2040 (Table 2-1). These projections, published by the U.S. Census Bureau, are based on the 2000 Census.[3]

Table 2-1. Projection of U.S. Population

	Total Population
1990	249,622,814
2000	282,125,000
2010	308,936,000
2020	335,805,000
2030	363,584,000
2040	391,946,000

The number of older adults in the United States is accelerating not only due to overall

[2] The clear distinction is that our approach for *Toyota GapAdvise* focuses on an in-vehicle gap advisor and elderly drivers, whereas our Federal IDS project does not address in-vehicle systems, nor does it particularly focus on elderly drivers.
[3] U.S. Interim Population Projections, Based on Census 2000. U.S. Census Bureau, Population Division, Population Projections Branch. March 18, 2004. http://www.census.gov/ipc/www/usinterimproj/

population growth, but also because of the aging "Baby Boom" generation and an increasing life expectancy. In 1990, 12.5% of the population was sixty-five years old and older. This percentage is expected to increase to 20.4% by the year 2040. Therefore, the senior population will not only increase, but it will become a more visible demographic group. Seniors eight-five years and older, a demographic group especially influencing the demands on health and care facilities, is projected to grow from 1.1% of the population in 1990, to 3.9% of the population in 2040.

Table 2-2. Projection of U.S. Senior Population

	65+	85+
1990	31,242,000	2,830,000
2000	35,061,000	4,267,000
2010	40,243,000	6,123,000
2020	54,632,000	7,269,000
2030	71,453,000	9,603,000
2040	80,049,000	15,409,000

The ratio of males to females changes drastically as a function of age, and this change is important to understanding the needs of the average older driver and passenger. In 1990, 59.8% of the population over the age of sixty-five was female and 72.1% of the population eighty-five and over was female. Population projections published by the U.S. Census illustrate an expectation that the average life-span of males and females will increase. Females may still have longer life-expectancies, but the percent of the 65+ and 85+ populations that are female will decrease slightly because both men and women are expected to live longer. Figures 2-1 and 2-2 illustrate this expectation:

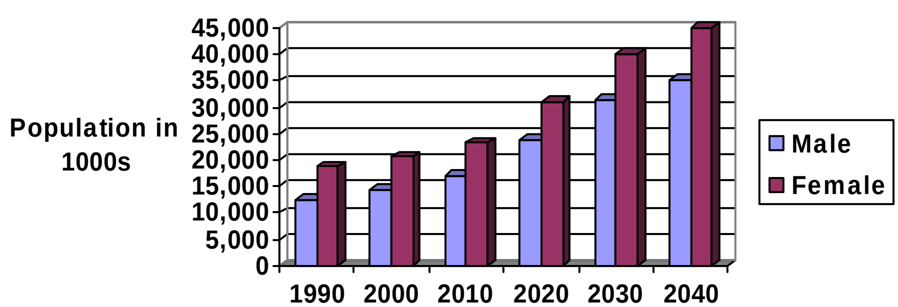


Figure 2-1. U.S. Population Projections, Age 65 and Over

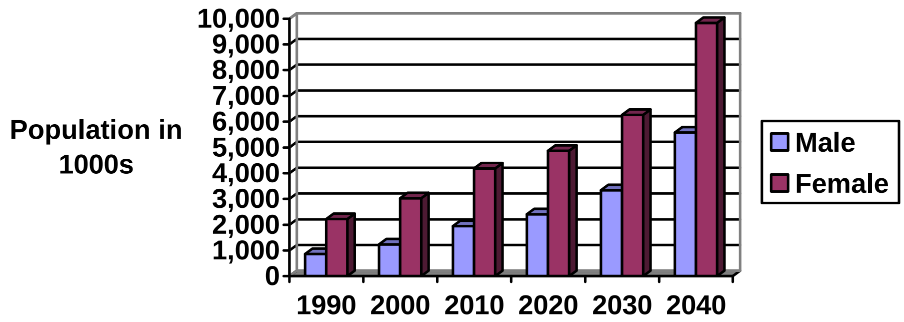


Figure 2-2. U.S. Population Projections, Age 85 and Over*

The large increase in the elderly population will bring a substantial increase in demand for safe mobility for seniors. Currently, middle-aged adults drive more than the current elderly did when they were younger. Now, adults drive farther distances to work, for errands, and for recreational purposes than any other generation of adults. The transportation infrastructure and urban design will not change drastically in the next forty years, so we can expect private motor vehicle travel to continue to be the most popular form of travel.

Implications for GapAdvise

The very substantial increase in older adults (over 65 and over 85) will mean dramatic increases in need for mobility. A very substantial proportion of this mobility will be delivered by the private automobile. Automobile design will need to be modified to meet the demand for safety and comfort for this elderly population, whether they are drivers or occupants.

2.2 Senior Driver Population

An increase in the senior population will lead to an increase in the number of elderly drivers. In 1991, 43% of males eight-five and over had a driver's license. By 2000, 78% in this age group had a license. Similarly, the percentage of females eighty-five and over who had licenses increased from 13.5% in 1991 to 36.3% in 2000. Also, the driving patterns of seniors have changed dramatically in the last 15 years, and will probably continue to change.[4]

To our knowledge, there are no published projections of the number of licensed drivers. The Bureau of Transportation Statistics (BTS) provides the number of total number of licensed drivers nationwide by gender and five-year age categories from 1990 to 2001. We can conclude fairly confidently that the percent of seniors who are licensed drivers will continue to increase. First, there has been a steady and substantial increase in percent of seniors who are licensed drivers over at least over the past decade. Second, younger drivers who will be seniors over the next few decades are more likely to be licensed, and to have driven more, compared to current seniors when they were younger. However, we do not know the magnitude and pace of the expected increase. Likewise, we do not know when and if this increase will level off, aside from the fact that the percent of those licensed in any particular age group will most likely not exceed the current level of that group.

To produce a projection of the percentage of licensed drivers at each age group in future years, we have used data on the percentage of licensed seniors from 1990 to 2001 and created projection models to estimate how this percentage might change between 1990 and 2040. To

[4] Rosenbloom, Sandra. The Mobility Needs of Older Americans: Implications for Transportation Reauthorization. Brookings Institute Series on Transportation Reform. July, 2003.
http://www.brookings.org/dybdocroot/es/urban/publications/20030807_Rosenbloom.pdf
Accessed 2/20/04

satisfy the expectation that the percentage will increase and then level off, we have used a logarithmic regression function to approximate the growth and ultimate leveling-off of the percentage of licensed drivers. This approach is purely a projection, and the actual percentage of licensed drivers in each age group will depend on a number of factors, including future changes in licensing policies, mobility needs based on housing and transportation trends and policy, and vehicle and highway design. As an example, our projection model for female licensed drivers age 70 and over is shown in Figure 2-3.

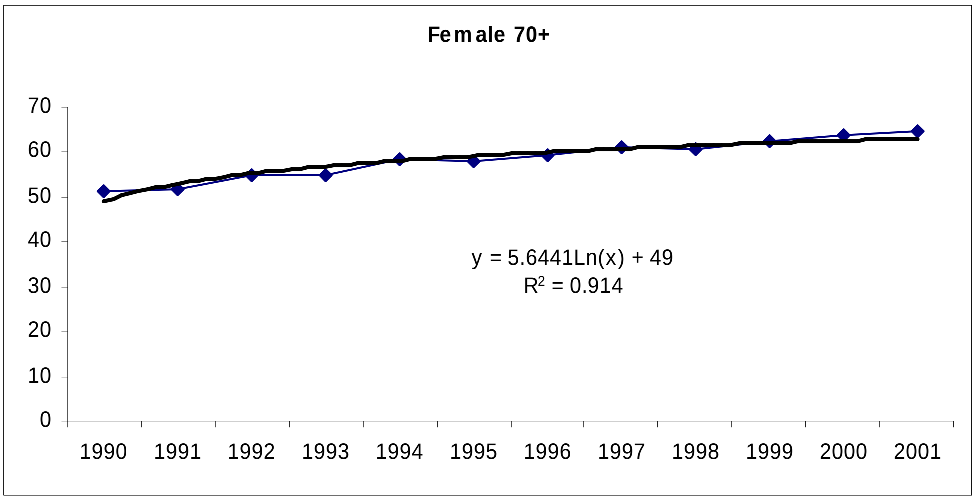


Figure 2-3. Projection Model for Number of Female Licensed Drivers Age 70+*

*Based on the 2000 Census and BTS Licensed Drivers 1990-2001.

We then multiplied the projected percentage of licensed drivers by the projected population to obtain the projected number of licensed drivers. Our projections rely on the total population projections from the 2000 Census. The following two figures (2-4 and 2-5) show the expected number of licensed drivers over the age of 70 and 85.

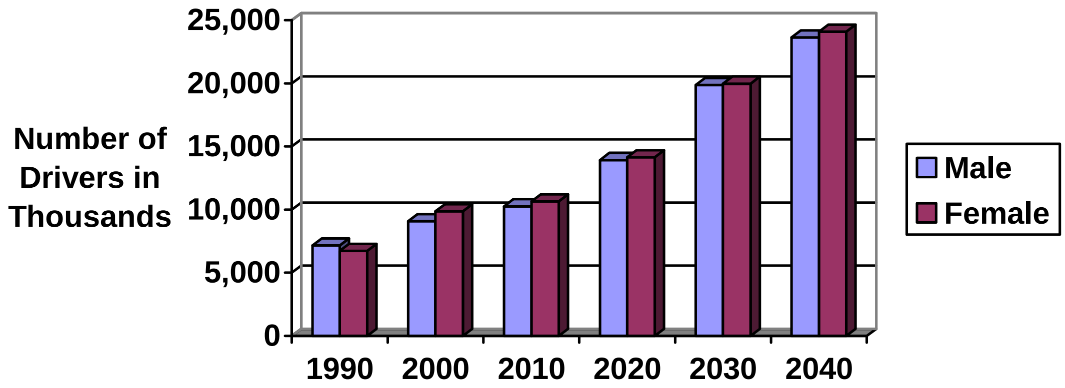


Figure 2-4. Number of Licensed Drivers Age 70 and Over*

*Based on the 2000 Census and BTS Licensed Drivers 1990-2001.

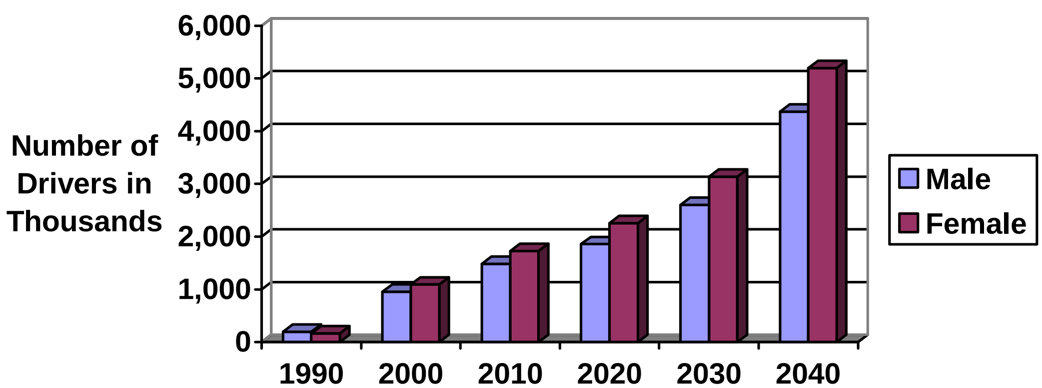


Figure 2-5. Number of Licensed Drivers Age 85 and Over*

*Based on the 2000 Census and BTS Licensed Drivers 1990-2001.

Both figures above illustrate that the number of licensed senior drivers will increase rapidly, at an even faster rate than the expected increase in the elderly population. Indeed, figures 2-4 and 2-5 show a large expected increase from 2000 to 2040 in the number of licensed drivers; the number of drivers age 70+ and 85+ will increase 252% and 466%, respectfully.

Implications for GapAdvise

The increase in the number of older drivers, whether defined 70 and older, or 85 and older, in conjunction with well established declining function with age, will mean a very substantial increase in the number of drivers on the nation's highways with reduced capacity for driving.

There will be a very high, and increasing, demand for altered vehicle design to facilitate safe and comfortable driving for older drivers.

2.3 Elderly Drivers and Increased Motor Vehicle Injury

Motor vehicle fatality or injury rates are presented in many different ways. Often, a simple number of injuries are reported. Other times, reports calculate the rate of fatality or injury per population size, per licensed drivers, or per miles driven. Each method carries different implications, and they are each discussed here.

The first data analysis method is to study the total number of fatal crashes by age and gender. These data is often used to provide medical facilities planners and emergency responders information about the number of crashes, and therefore their agency's expenditures. The elderly are involved in far fewer motor vehicle crashes than teenagers and adults, and as a consequence they suffer fewer injuries and fatalities as a result of motor vehicle crashes. In 2001, seniors age 85 and over suffered only a tenth of the number of fatalities that teenagers and young adults (20-24) experienced (see Figure 2-6). This fact reflects smaller population in the elderly as well as reduced driving.

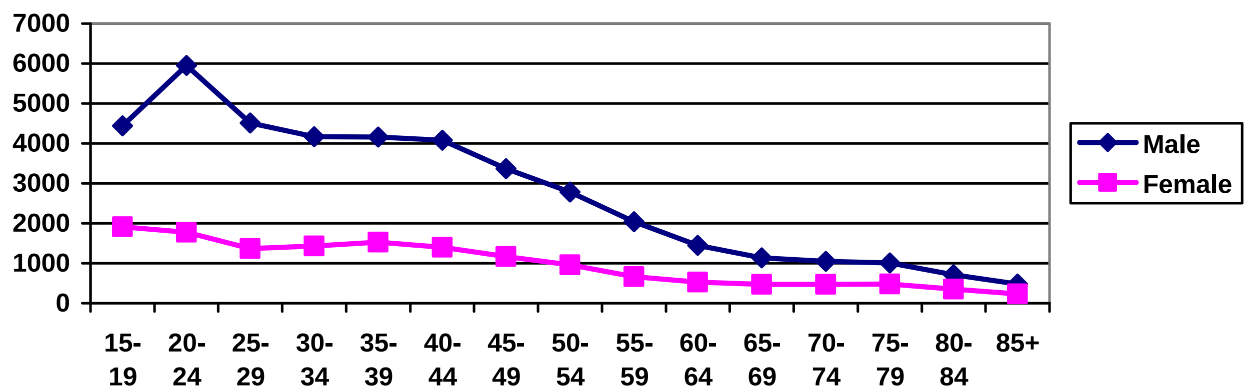


Figure 2-6. Number of Fatal Crashes by Age and Gender, 2001

* For consistency this graph is based 2001 data from the Fatal Analysis Reporting System (FARS). FARS 2002 is available, but Figure 7 and Figure 8 refer data sources that were most recently updated in 2001.

Although the absolute number of fatal crashes is lower for the elderly, this does not indicate that older drivers are safer drivers. After controlling for the number of drivers in each category, we actually conclude that older drivers have higher fatal crash rates than other adults. This second data analysis method interests insurance companies and the Departments of Motor Vehicles because it represents the risk that each driver will be involved in a collision. Figure 2-7 shows that the average fatal crash rates per 10,000 licensed drivers is highest for teenagers, decreases with age until about age 50, and then increases steadily starting at age 65.

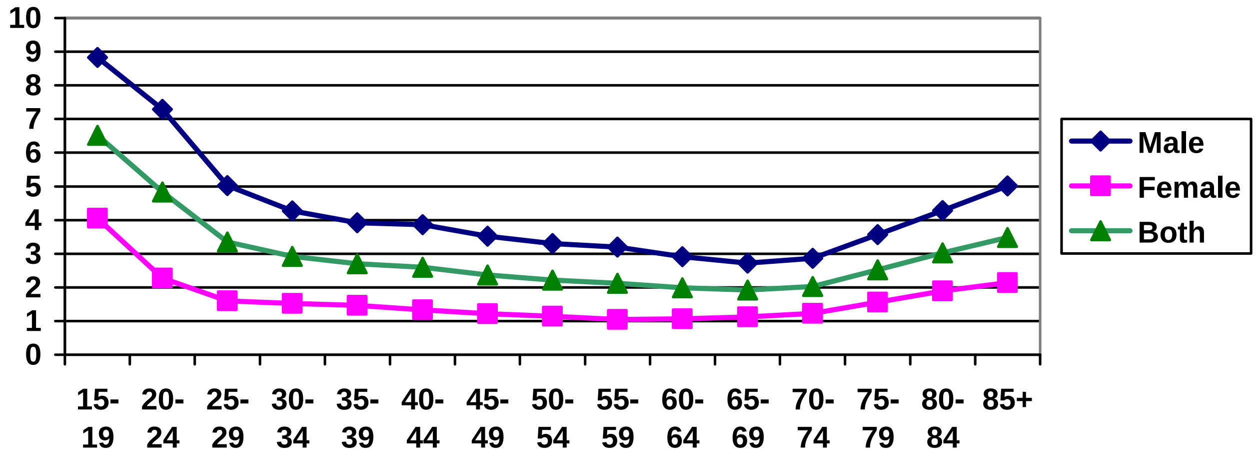


Figure 2-7. Number of Fatal Crashes per 10,000 Licensed Drivers, 2001

*Based on the FARS 2001 and the BTS Licensed Driver 2001 database. BTS 2001 is the latest available national survey of the number of licensed drivers.

Yet another method of analyzing crash involvement is to control for the annual miles driven by persons in each age category. The number of collisions per mile driven represents "actual" risk to the driver, and implies that the more miles he drives, the more likely he will experience a crash. This method reveals an even starker difference in fatality rates between older adults and the younger population. Figure 2-8 shows that adults age 85 and over are involved in *more* fatal crashes per mile than any other age group, including teenagers. If this fact remains true in the coming years, motor vehicle fatalities will be one of the top concerns for elderly drivers and injury specialists as the elderly increase as a percentage of the whole population and drive more than previous elderly populations.

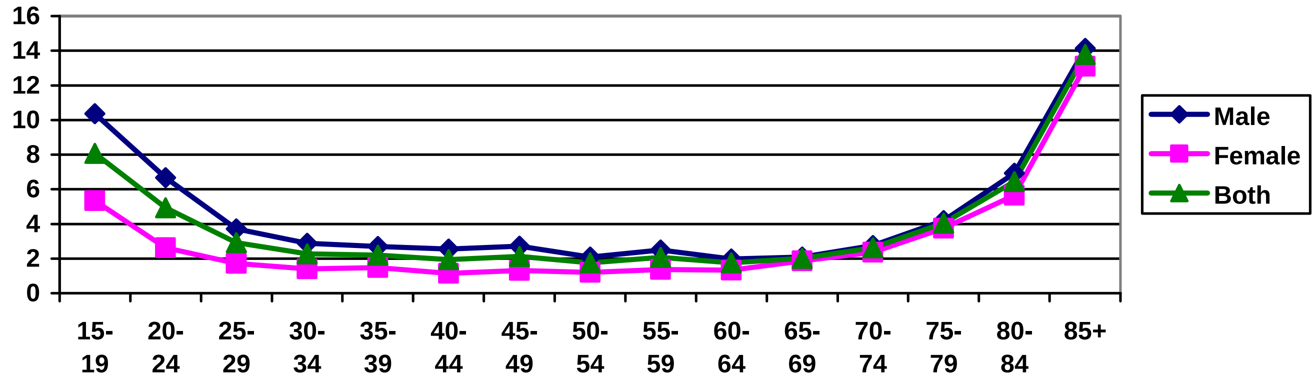


Figure 2-8. Number of Fatal Crashes Per 100 Million Miles Driven, 2001

*Based on the FARS 2001 and the National Household Transportation Survey (NHTS) 2001. NHTS 2001 is the latest available national survey on annual miles driven.

Elderly drivers might have very high fatality rates per miles driven, but that does not necessarily mean that elderly drivers are involved in more forcefully violent crashes than other drivers. Although poor driver performance may contribute to the fatality rates, older adults also are far more fragile than younger adults, and are more easily injured and are less likely to recover from injury than younger adult bodies. Controlling for the mechanical forces in a crash, older drivers are more likely to die in a crash than younger drivers.[5] Figure 2-9 illustrates recent driver fragility as a function of age; these data illustrate the fatality rates per 1000 crashes is eight times higher for adults 85+ than for teenagers.

[5] Evans, L. *Traffic Safety and the Driver*. 1991

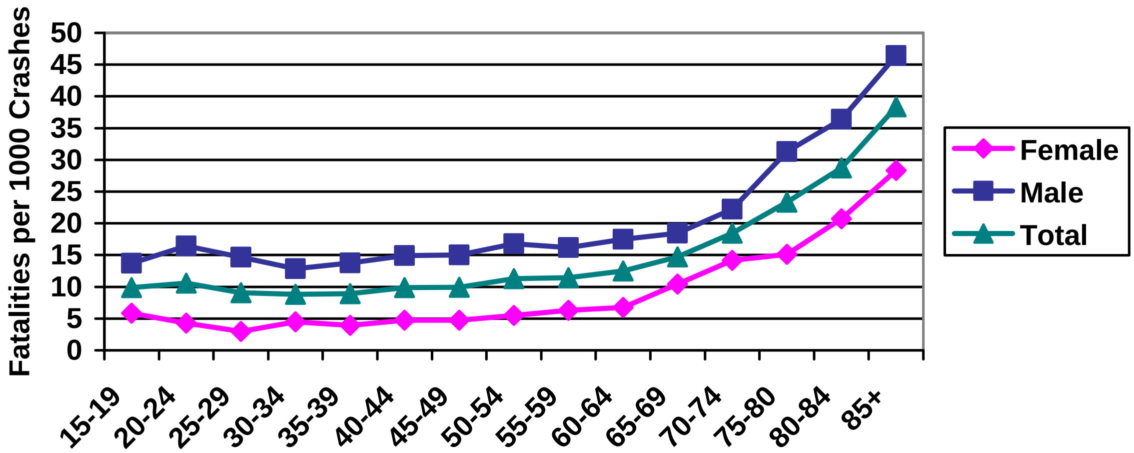


Figure 2-9. Driver Fragility: Fatalities Per 1000 Crashes*

*Based on the California Statewide Integrated Traffic Records System (SWITRS), all crashes from 1999 to 2002 (inclusive).

Figure 2-9 illustrates a stark difference in fragility rates for males and females. Note that this difference may be misleading, because this analysis did not control for the physical impact of a crash. Males are more often cited for speeding violations than females, and therefore may experience more fatal or serious collisions (as a percentage of all of their fatal and non-fatal collisions) than females.

Although seniors are more susceptible to motor vehicle fatalities due to increased fragility, fragility is not the sole factor for an increase in fatal crashes per mile driven. Figure 2-10 shows that even non-fatal crash rates per million miles driven increases with age.

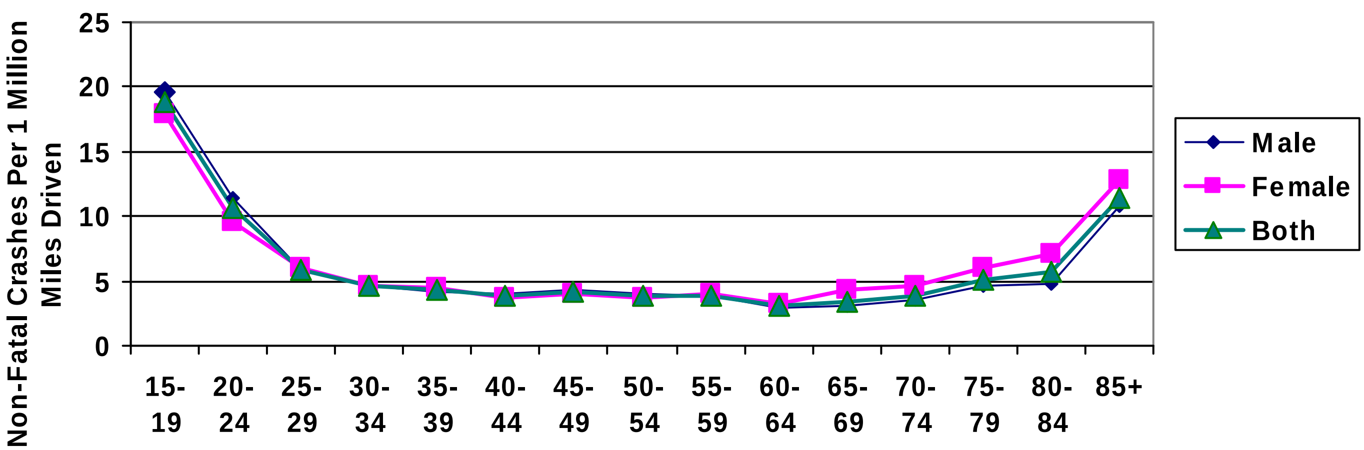


Figure 2-10. Non-Fatal Crashes Per Million Miles Driven, 2001*

*Based on the 2001 General Estimates System and the 2001 National Household Transportation Survey.

To further examine the causes of high motor vehicle injury rates in the elderly, we turn from fragility and injury rates to specific collision types and traffic violation citations.

Implications for GapAdvise

The increase in both fatal and non-fatal crash risk with increasing age after about the age of 65 means that there will be a very high demand for vehicle and highway design to mitigate this increasing risk of crashes.

The very sharp increase in fatality (per crash) with increasing age means that there will be a very high demand for improved vehicle and occupant restraint design to accommodate and increasingly fragile population.

2.4 Elderly Drivers and Collision Factors

In order to address the problem of high fatality rates in older drivers, we begin by examining the kinds of crashes most prominent among older drivers. Collision factors, as well as crash rates, vary with age. For all drivers, the most common traffic violation attributed to causing a collision is failure to yield right-of-way. Adults age 70 and over are charged with more than twice as many right-of-way violations per mile driven than adults age 30 to 60. The second most common violation for older drivers is failure to obey a traffic signal or stop sign. The number of traffic violations shown in Figure 2-11 was obtained from the General Estimates System, and the rate was computed based on annual miles driven from the National Household Transportation Survey. Although informative, these data do not detail the primary collision factors and probably ignore the primary cause of fault of any driver who died in a crash.

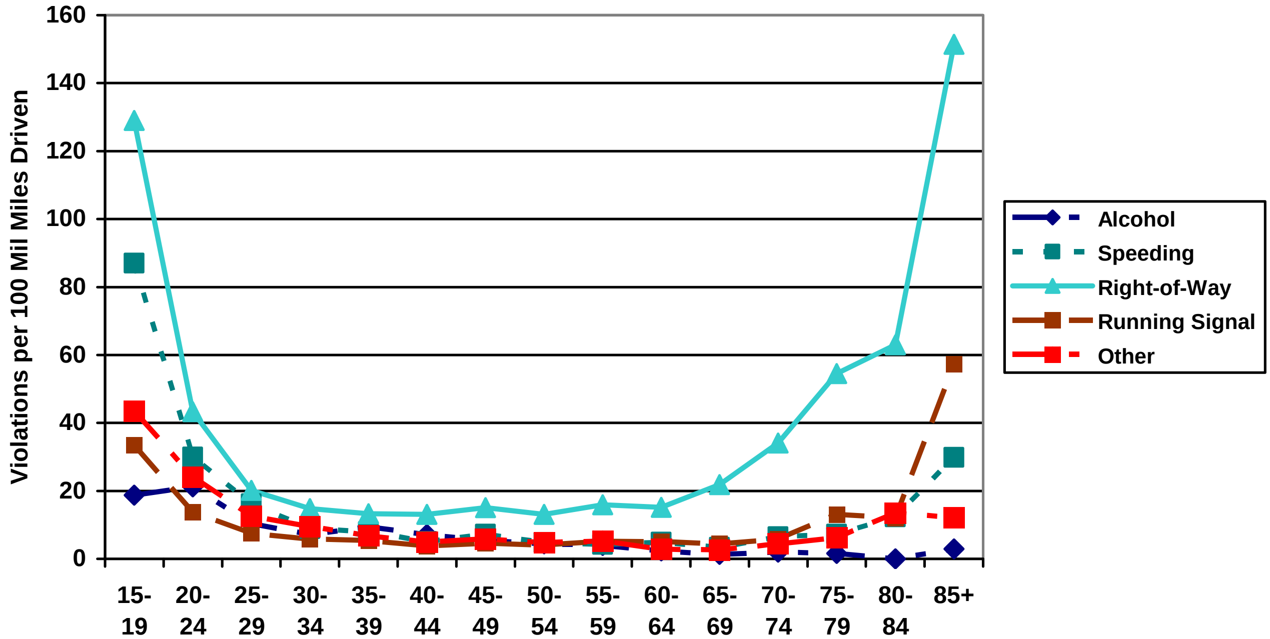


Figure 2-11. Rate of Traffic Violations Contributing to a Crash, 2001*

*Based on the 2001 General Estimates System and the 2001 National Household Transportation Survey.

A more detailed look at the two most common violations of older drivers, right-of-way and traffic signal or stop sign collisions, highlights intersection crashes. Older drivers are over-represented in intersection crashes, and, within these, in crossing path crashes. We analyzed the following crossing-path crash types[6]:

1. Left Turn Across Path - Opposite Direction Conflict (LTAP/OD)
2. Left Turn Across Path - Lateral Direction Conflict (LTAP/LD)
3. Left Turn Into Path - Merge Conflict (LTIP)
4. Right Turn Into Path - Merge Conflict (RTIP)
5. Straight Crossing Paths (SCP)

[6] Smith DL, Najm WG. Analysis of Crossing Path Crashes for Intelligent Vehicle Applications. 8th WorldITS Congress.

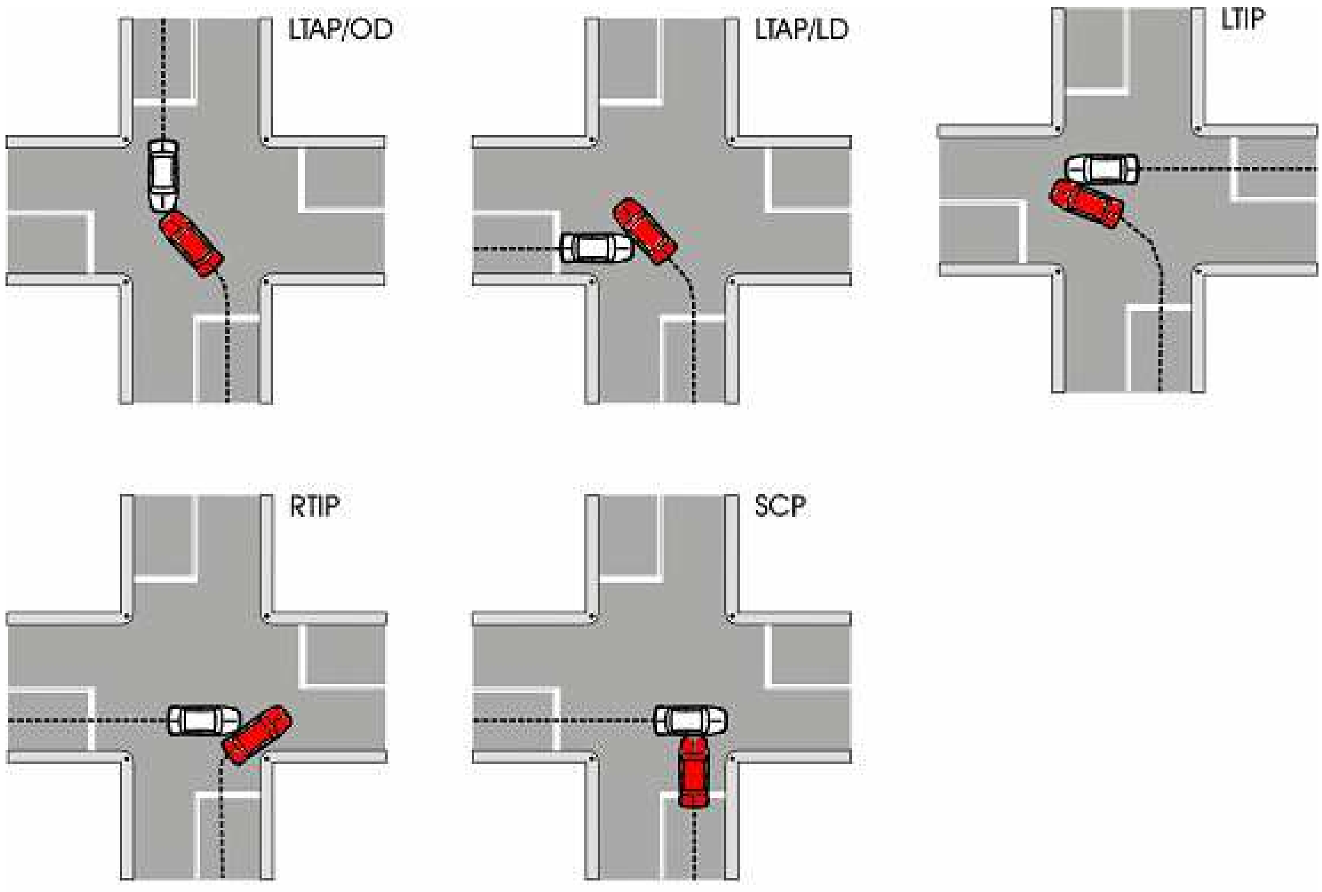


Figure 2-12. Intersection Cross-Path Collision Types

Figure 2-12 shows the distribution of crossing path pre-crash scenarios for driver under and over age 65. The shaded (red) vehicle represents the “subject vehicle” (usually the turning vehicle and at-fault vehicle); the other (white) vehicle represents the “principle other vehicle”.

First, we will examine the distribution of crossing path pre-crash scenarios (Figure 2-13). This graph shows the percentage of collision-path scenarios for crossing path collisions. For example, if a driver under 65 is involved in a crossing path collision, it is most likely a straight crossing path collision because the majority (32%) of all crossing path collisions for adults under 65 is SCP. Similarly, the majority of crossing path collisions for drivers 65 and over is LTAP/OD (30%). For all drivers, the most common cross-path collision types are SCP, LTAP/OD, and LTAP/LD. For drivers 65 and over, left turns make up 57% of all crossing path collisions. Of all crossing path collisions, drivers 65+ experience slightly more

LTAP/OD, RTIP, and LTIP collisions than drivers under age 65. (Other crossing path collisions – CP OTHER – could be collisions between pedestrians and motor vehicles, a vehicle making a wrong-way turn onto a one-way street, and other scenarios.)

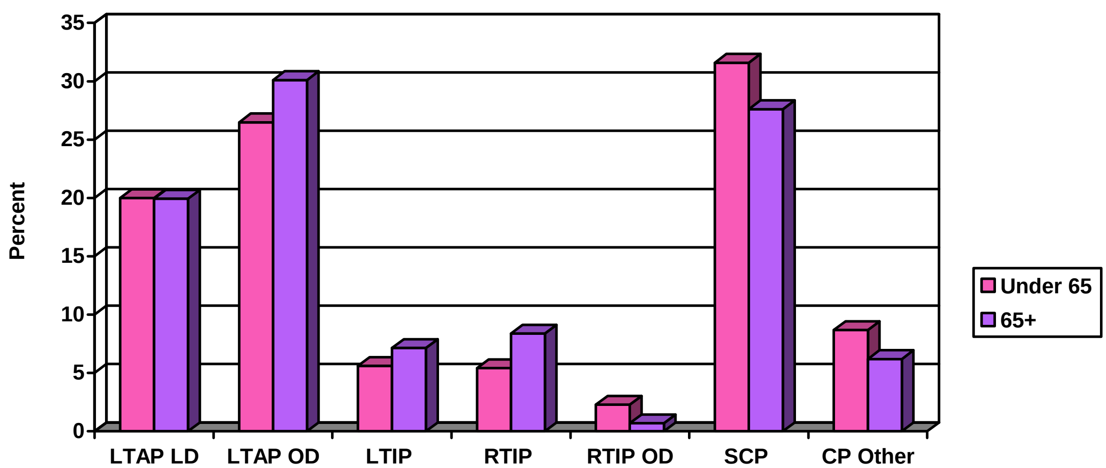


Figure 2-13. Distribution of Crossing Path Pre-Crash Scenarios, 2002*

*Based on the General Estimates System, data from 2002.

Figure 2-13 describes the distribution of crossing path pre-crash scenarios, not the actual number of collisions. Older drivers are actually involved in fewer collisions than younger drivers. Of all of the collisions in the United States, an older driver is at fault only 7.5% of the time, and 92.5% of the time, the at-fault driver is less than 65 years old (from 2002 GES collision data). However, in the event that an older driver is a collision, they are more likely to be in a left-turn collision rather than a straight crossing path collision.

The previous paragraph mentions that older drivers make up 7.5% of the at-fault drivers of all collisions in the United States. However, this percent changes if we look at specific collision types. For example, of all rear-end collision in the United States in 2002, only 5.7% of the at-fault drivers were over the age of 65. However, for LTAP-OD collisions, 13.7% of the at-fault drivers were over the age of 65. These two numbers show that older drivers cause a small percentage of rear-end collisions, and cause a relatively larger percentage of LTAP/OD collisions. These data, as well as other collision types, are summarized in Table 2-3.

("OTHER" non-crossing path collisions could be side-swipe collisions, head-on collisions with fixed objects, and others.)

Table 2-3. Percent of Drivers 65+, by Pre-Crash Scenario, 2002*

	% Over 65
LTAP OD	13.73
LTAP LD	12.25
LTIP	15.12
RTIP	17.82
SCP	10.90
CP OTHER	9.08
REAR END	5.73
OTHER	6.02
TOTAL	7.51

*Based on the General Estimates System, data from 2002

Elderly drivers cause a relatively high percentage of crossing-path collisions. This fact is not the result of elderly drivers driving through more intersections than other drivers. To prove this, we compare the number of "subject vehicles" and "primary other" vehicles at intersection collisions. For cross-path collisions, drivers age 65 and over more likely to be at fault, or the "subject vehicle", than otherwise ("principle other vehicle"). Figure 2-14 shows the percentage of drivers who are older drivers in different crash types. If all drivers were involved in the same about of collision type-crashes and were equally likely to be at fault or not at fault, the graph's bars would all be the same height. Figure 2-14 shows that in crossing path collisions, the at-fault driver is more likely to be older, i.e., over 65 years. This could be result of different factors. For example, it is possible that older drivers are more likely to drive locally, and therefore make more turns at intersections than drivers charting a longer distance and hence more often driving straight through intersections. Regardless of the absence of an exposure measure, this graph shows a significant difference in at-fault drivers versus "principle other" drivers. For all cross-path collision types, drivers over the age of 65 are more likely to be the subject vehicle rather than the principle other vehicle. Therefore, older drivers are more often at-fault in cross-path collisions than other drivers.

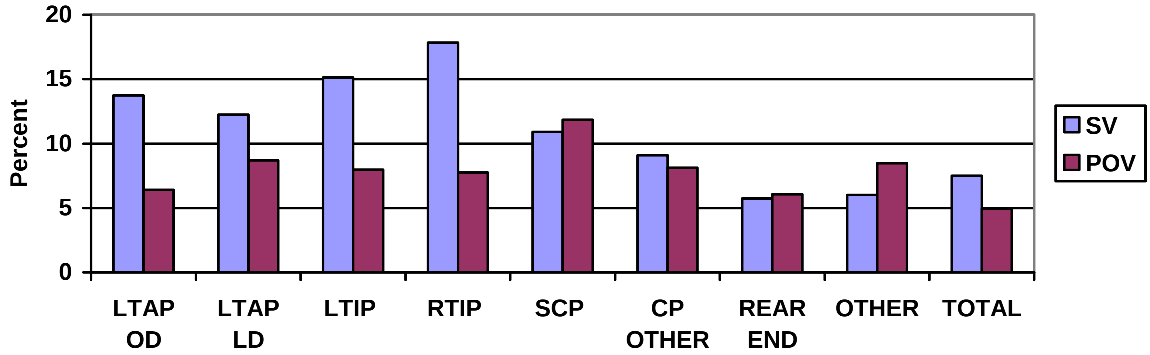


Figure 2-14. Percent Drivers 65+ By Type of Crash and Role in Crash, 2002*

*Based on the General Estimates System, data from 2002.

Not only does the General Estimate Systems data reveal the over-representation of older drivers as the "subject vehicle" operator in cross-path collisions, but the data also show that older drivers are cited for more violations in cross-path collisions (per mile driven) than adults. Figure 2-15 shows the number of violations, resulting from a cross-path collision, cited per 1 billion miles.

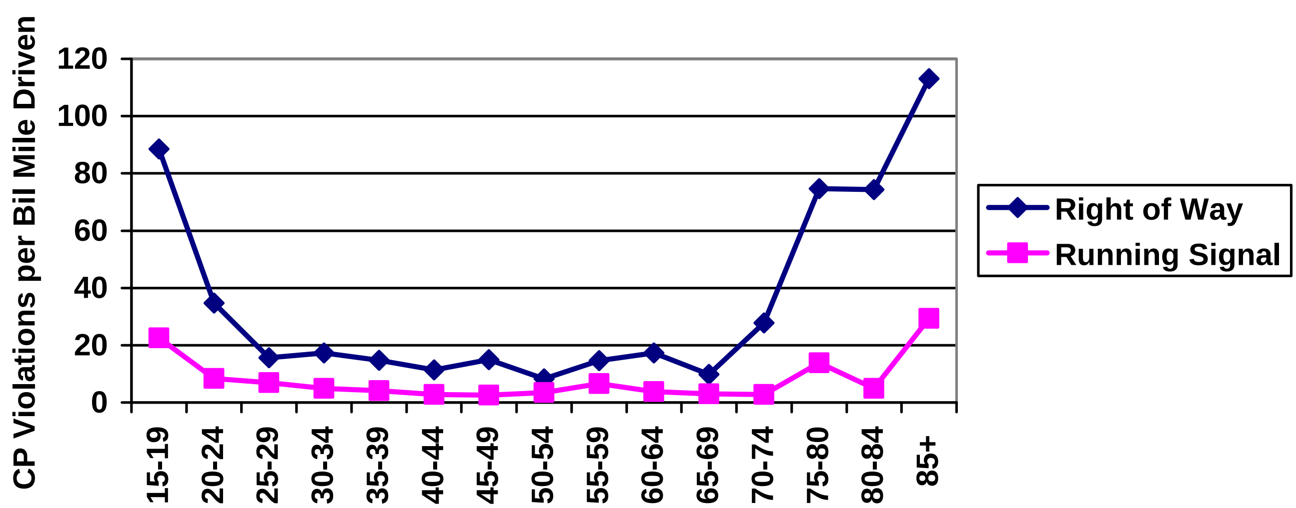


Figure 2-15. Rate of Violations in Cross-Path Collisions, 2001*

*Based on the 2001 General Estimates System and the 2001 National Household

Transportation Survey.

Implications for GapAdvise

The increase in both right-of-way violations and running-a-stop-signal violations will lead to a high demand to increase driver on-road and intersection awareness through vehicular and roadway instrumentation.

As older drivers are over-represented in intersection collisions, there will also be a high demand to introduce instrumentation that augments the driver's ability to make safe decisions about when to enter an intersection.

2.5 Causal Factors

Understanding and describing driver behavior becomes a challenge when one tries to identify driver errors in determining crash causal factors and countermeasures. Access to data related to crashes is usually based on crash statistics and restricted to general characteristics of the involved drivers, such as gender, age, type of vehicle driven. Very rarely are the actions and maneuvers that led to a crash addressed. This section briefly highlights some previous research that focuses on the causal factors of older drivers' crash rates.

The investigation of pre-crash actions and maneuvers usually relies on either focus groups involving officers who respond to crashes or drivers involved in crashes.[7] They therefore rely on subjective sources. Another approach adopted for understanding why crashes occur consists of linking general characteristics with known issues of specific group, such as age linked with perceptive and cognitive deficits.[8]

Staplin and Fisk investigated older drivers' difficulties with intersections.[9] The underlying

[7] Wierville W. W. Hanowski R. J. Hankey J.M Kieliszewski C. A. Lee S.E., Medina A. Keisler A.S and Dingus T. A. (2002) Identification and evaluation of driver errors: overview and recommendations FHWA-RD-02-003.

[8] Hakamies-Blomqvist, L. (1996) Research on older drivers: a review. *IATSS*, **20**(1), pp. 91-101.

[9] Staplin L., Fisk A. D., (1991) A cognitive engineering approach to improving signalized left turn intersections Human Factors 33 (5) 559-571

causes were identified to be perceptive and cognitive problems. “Perceptive” can be defined in terms of visual acuity and contrast sensitivity lost. “Cognitive” relates to working memory and information processing. Also, the assumption that presenting information in advance would aid older drivers was not shown true, as this did not help older drivers to make a faster decision in the end.

The importance of both perception and cognition in driving tasks arises in other studies as well. Larsen and Kines reported on an extensive investigation of crashes in Denmark.[10] The main problems they identified for left turning drivers are attention errors and misjudgment of the time available to complete the maneuver. None of the cases they investigated was due to a driver who misunderstood the right of way.

Hancock and Caird focused on the assessment of the appropriate time to turn left with variable oncoming traffic speed and time gap size.[11] They concluded that decisions do not depend only on velocity or gap size but on some cue extrinsic to these parameters. Older drivers seem to be more conservative than young. Both young and old drivers do not initiate turns upon oncoming velocities, gap size or distance; rather, they use higher order information extracted from these parameters, like time to arrival or rate of frontal expansion.

Implications for GapAdvise

Focus groups, observational studies, and driving experiments (as used by other researchers) are the best means of measuring driver decision making and behavior at intersections.

Future instrumentation to augment drivers’ decisions at intersections should address attention errors and gap misjudgment.

---

[10] Larsen L. and Kines P. (2002) Multidisciplinary in-depth investigations of head-on and left-turn road collisions in Accident Analysis and Prevention (34) 367-380

[11] Caird J. K. and Hancock P.A. (2002) Chapter 19: Left turn and gap acceptance crashes in R.E. Dewar & P. Olson (Eds) Human factors in Traffic Safety 736 p

3.0 CONDUCT FOCUS GROUP AND OBSERVATIONAL ANALYSIS OF ELDERLY DRIVERS

3.1 Focus Group Research

Safe older driving was explored in four focus groups conducted in July, August, and September of 2004 at the Rossmoor Senior Adult Community in Walnut Creek, California (see Appendix A for detailed summaries of each focus group, the focus group protocol). The 20 women and 16 men who participated in the focus group were Rossmoor residents who drove, were between the ages of 70 and 85, and passed a screening test of physical and cognitive acuity (see Appendix A). This summary describes the general findings from all four focus groups.

3.1.1 Demographic and Attitudinal Profiles

At the beginning of each focus group a questionnaire was administered that explored the demographic attributes of focus group participants, their travel patterns, and their attitudes toward various transportation modes (see Appendix A). The results for all participants in the four focus groups are examined here.

In Table 3-1, below, data on vehicle type by gender and age are presented. Participants drove a range of vehicles, from small compacts to luxury sedans, manufactured by a variety of automakers.

Table 3-1. Vehicle Type by Age, Gender and Focus Group

Focus Group	Gender	Age (Years)	Car Make/Model
1	F	72	Hyundai Elantra
1	F	74	2001 Hyundai Elantra
1	F	78	1994 Toyota Tercel
1	F	79	Do not drive household car – don’t know make/model of vehicle
1	F	83	1995 Buick Century
1	F	83	1998 Chevy Malibu
1	M	71	1996 Dodge Intrepid
1	M	73	1998 Toyota Corrolla
1	M	78	1993 Dodge Shadow
1	M	81	1994 Mercedes E420
2	F	76	2000 Dodge Durango

2	F	76	2001 BMW 325i
2	F	77	1996 Toyota Camry
2	M	70	2002 Toyota Camry
2	M	77	2001 Ford VXZ Escort
2	M	78	2004 Lexus RX330
2	M	81	2000 Dodge Caravan
2	M	83	1993 Lexus ES300
3	F	71	1998 Toyota Camry XLE
3	F	75	1995 Saturn Wagon
3	F	76	Do not drive household car – don't know make/model of vehicle
3	F	81	2003 Toyota Corolla
3	F	84	1998 Honda Accord LX
3	F	85	2002 Honda Accord
3	M	73	1999 Acura Integra
3	M	82	2000 Lexus 300 ES
3	M	83	1991 Toyota Corolla
3	M	84	1996 Toyota Camry
4	F	74	1998 Lexus sedan
4	F	79	Do not drive household car– 2004 Honda Civic
4	F	80	2004 Hyundai Sonata
4	F	81	2002 Mercedes C240
4	F	83	1988 Toyota Camry
4	M	74	Buick LeSabre
4	M	74	1996 Volvo 850
4	M	79	1996 Mercury Sable

M=male and F=Female
Note: Kathryn Hamel, Ph.D., provided the data in this table.

Aggregate demographic attributes of all participants in the four focus groups are provided in Table 3-2 (below). The average focus group participant:

- Was 78 years old and married;
- Had a Bachelor's degree and an income between $20,000 to $49,000;
- Lived in a household with 1.5 people, 1.5 drivers, and 1.4 autos; and
- Had been driving since s/he was 18.5 years old.

Table 3-2. Demographic Attributes

	Mean (N=36)
Age	78
Household Size	1.5
Household Drivers	1.5
Household Autos	1.4
License Age	18.5
	Distribution
Income	
< $10,000	6%
$10,000-$19,000	3%
$20,000-$49,000	33%
$50,000-$79,000	14%
>$110,000	14%
Declined to Respond	31%
Marital Status	
Single	8%
Married	58%
Divorced	8%
Widowed	25%
Education	
High School	9%
Associate's Degree	17%
Bachelor's Degree	50%
Graduate Degree	14%

The travel modes used more than two times per week by focus group participants are presented in Table 3-3 (below). Driving alone was the most frequent travel mode, followed by walking, and the Bay Area Rapid Transit (BART) District transit system.

Table 3-3. Frequently Used Travel Modes

	Percentage
Drive Alone	97%
Carpool	6%
Bus	6%
BART	11%
Walk	47%

Note that the total sums to more than 100 percent because respondents indicate use of more than one mode.

The types of services and devices used by focus group participant are presented in Table 3-4 (below). Most participants used both cellular phones and the Internet.

Table 3-4. Devices and Services Used by Participants

	Percentage
Cellular Phone	3.1%
Internet	25.0%
Both	71.9%

The survey instrument also explored participants' travel-related attitudes, with results shown in Table 3-5. Questions examined participants' perception of vehicle hassle, experimentation, vehicle enjoyment, and overall vehicle satisfaction. Vehicle enjoyment is a different criterion than vehicle satisfaction; many participants claimed to enjoy driving as a recreational activity (enjoyment), others, to be satisfied with it as a means of mobility (satisfaction). The focus group participants generally agreed or strongly agreed that they enjoyed and were satisfied with their vehicle. In addition, they were generally neutral towards vehicle hassle (e.g., costs and frustrations associated with vehicle ownership and maintenance, including taking cars in for repairs and finding parking) and experimentation (i.e., attitudes towards trying new things, such as advanced technologies).

Table 3-5. Attitudinal Factors

	Factor Score
Vehicle Hassle	3.2
Experimentation	3.3
Vehicle Enjoyment	4.1
Satisfaction	4.5

Scale: 1=strongly disagree, 2=disagree, 3=neutral,
4=agree, 5=agree strongly

Finally, the survey explored the frequency with which the participants used transit, currently and in the past, as well as barriers to driving and transit use that may have influenced their choices. These results are summarized in Table 3-6 (below). For some questions, the sample size was smaller because less than half (15) of the participants used transit more than occasionally. The results indicate that:

- In the past, 42 percent of participants regularly used transit at some time in their life before moving to Rossmoor;
- Currently, only 14 percent always or usually use transit, but 31 percent sometimes use the service;
- Few participants indicated difficulties with physical barriers to transit use (e.g., stairs, stepping off the bus, and purchasing tickets);
- Sixty percent or more of the participants sometimes chose to take transit when the alternative was to drive in bad weather, heavy traffic, or unfamiliar areas; and
- Insensitivity to transit cost and travel time was expressed by many participants

Table 3-6: Factors Influencing Frequency of Transit Use

	N=36
Previous Regular Transit Use	42%
Current Frequency of Transit Use	N=36
Never/rarely	53%
Sometimes	31%
Always/usually	14%
Physical Barriers	N=15
Stepping Off Bus or Train	7%
Station Stairs	13%
Purchasing Tickets/Paying Fee	7%
Take Transit (At Least Sometimes) To Avoid…	N=15
Driving at Night	20%
Left Turns	47%
Bad Weather	67%
High Traffic Roads	60%
Unfamiliar Areas	60%
Avoid Transit (At Least Sometimes) If It…	N=15
Costs More	27%
Takes Longer	40%
New Schedule	33%
Transfer	33%
Involves a New Transit Station or Stop	20%

Note: N=15 excludes participants who never or rarely use transit.

3.1.2 Synthesis of Focus Group Discussions

Introductory Comments on General Travel

Although participants in all four groups were aware of their limitations as older drivers, they expressed an overwhelming preference for travel by automobile and most used transit infrequently. Some were concerned about driving at night and during bad weather, but most had little difficulty with congestion. Residents reported very little difference between their travel behavior on weekends and weekdays despite heavier weekday traffic. Congestion was cited, however, as a reason for using the Bay Area Rapid Transit (BART) system for travel to San Francisco, and some participants avoided peak-hour traffic. Overall, however, their mobility was not limited by adverse driving conditions.

Accessing Vehicles

During the focus group discussions, participants discussed different aspects of getting in and out of their car, including their use of remote keyless entry, difficulties loading packages into the trunk or back seat, and their use of seat adjustments (both manual and automatic).

Remote Keyless Entry**.** More than half of the participants had keyless entry devices for their automobiles, and those who did described a variety of benefits of their use, including locating their parked vehicles and locking/unlocking their car doors when unloading or loading packages. Feelings about the alarm feature installed with the device were mixed, and some residents reported disarming the feature because it was too easy to activate accidentally. Some had malfunctioning devices or had difficulty learning how to use them correctly, but it appeared that once residents became familiar with their use these concerns were outweighed by the technology advantages.

Loading and Unloading Vehicles. Several participants noted the advantage of using the trunk over the back seat for transporting packages (i.e., additional privacy and more space for large items). However, nearly all used the floor or back seat at least occasionally because they felt that items in the trunk were likely to slide out of place during driving. Suggestions made for resolving this problem focused on low-technology, cost-effective solutions that many residents had already installed in their vehicles, including netting, bungee cords, foam mattresses, and removable partitions.

Others found that high trunk lips in the back of their vehicles made lifting heavy items into the trunk difficult. Although sport utility vehicles and station wagons already have flat trunks that make loading easier, most residents drove sedans or other automobiles without this feature.

Seats and Seat Adjustments. Taller residents and those with disabilities often had difficulty getting in and out of their cars, and all felt that adjustable seats made the maneuver easier. Seat adjustment, however, did pose some additional difficulties. Residents, particularly those who shared their cars with a spouse or partner, disliked having to move the seat back after it had been adjusted by another driver. There was an overwhelming preference for cars with preset adjustments for multiple users.

Petite residents, who often had to raise their seats to see over the dashboard, were concerned about being too close to the steering wheel during a crash and felt that airbags should be redesigned for safe deployment.

Seat type was another concern for many drivers. Some had difficulty getting into cars with low bucket seats, and others had difficulty adjusting them. Overall, however, there was no consensus about which seat type was most comfortable.

Other Concerns and Recommendations. Doors were also a concern for several participants, who felt that they often did not open widely enough. Others complained about doors that closed unintentionally while they were getting in or loading packages; several suggested that door stops would make access easier. One resident drove a car with an adjustable steering wheel and found that this helped with getting in and out of the vehicle.

Driving

Focus group participants described a variety of difficulties operating their vehicles. For older drivers, neck turning can often be physically difficult, and many residents expressed concern with blind spots and gauging distances in their side-view mirrors. As a result, the primary problems the drivers experienced were with difficult maneuvers that require a broader field of vision, including parallel parking, reversing, merging, and making left-hand turns. Night driving was also mentioned as problematic.

Parking and Reversing. Several residents expressed frustration with parallel parking. In particular, most had difficulty seeing behind them while reversing because of blind spots, and there was general agreement that "wink" mirrors, which provide a broader field of vision, were preferable. Other car enhancements that were viewed favorably included a remote-adjustable rear-view mirror and a global positioning system (GPS)-enabled camera that allows drivers to see behind them while fitting into a tight space.

In general, participants felt that reversing was dangerous and suggested that their vehicles be equipped with beepers or other devices to signal their presence to pedestrians or other vehicles.

Merging and Left-hand Turns. Although it was initially assumed that drivers would be principally concerned with making difficult left-hand turns, focus group participants instead expressed a much greater concern for both merging onto the freeway and changing lanes. In both cases, however, the causes of this concern were the same: difficulty gauging distances of oncoming traffic using convex mirrors and trouble seeing other cars because of blind spots—particularly prevalent among drivers who had difficulty turning their necks. In particular, pillars in the back seat windows were identified as obstructions to the view behind the vehicle. Several participants felt that other drivers were reluctant to slow down at high-speed merge points.

Some drivers went out of their way to avoid left-hand turns, citing a similar set of concerns and a lack of left-hand turn lanes in certain localities. Because of this sense of perceived control (i.e., it is possible to make three right turns to avoid making a left one) left-hand turns were not identified as being as serious a difficulty as merging into a right hand lane or as other maneuvers, which are often unavoidable.

Participants also noted that many drivers leave their turn signals on longer than necessary and suggested that manufacturers install devices that automatically shut them off after a specified period of time or make the audio alerts louder for the hearing-impaired.

Night-Time Driving. Several drivers complained about glare from incoming headlights and inquired whether cars could be equipped with automatic dimmers to lessen this problem. Another driver spoke highly of a vehicle he had once driven that had headlights that pivoted with the wheels, improving visibility while turning. The specific vehicle model was not identified, however.

Vehicle Use

Residents also had difficulty with features on their cars that were not directly related to driving, including display panels, knobs, and dials. Participants also expressed their opinions on the use of navigation aids and cell phones.

Dashboard Displays. Participants noted a variety of difficulties with their dashboard displays. Some had trouble reading the LED displays because they were not bright enough or too similar to the background panel color. One resident was unable to read the digital clock in his vehicle because of the angle of the dashboard. Another complained that the steering wheel obstructed his view of the dashboard. In general, participants expressed support for digital compasses mounted in their dashboards.

Radios and Radio Adjustments. Several participants had difficulty adjusting their radios and rarely used them or only used them in light traffic. Suggestions included using push buttons rather than more-difficult-to-operate knobs, which could assist with dexterity difficulties and provide pre-set access to favorite radio stations. Participants also thought that installing controls near the steering wheel for easier access, and providing remote controls might be helpful, but they did not have direct experience with these features.

Cell Phones. Most of the participants had cell phones but few admitted to using them while driving. When asked, there was widespread support for laws against in-vehicle use of mobile phones.

Maps and Guides. Residents were often familiar with the online service MapQuest™, but several found that the routes provided were occasionally circuitous. Several participants only used traditional paper maps. In general, participants were reluctant to identify cognitive difficulty with receiving directions or reading maps, but they were enthusiastic about readily accessible, in-vehicle information such as GPS or on-board compasses.

In-Vehicle Navigation. Those participants who had in-vehicle navigation systems spoke favorably of them. Some were concerned about the distraction of a GPS screen, but the primary concern of most residents was system cost.

3.1.3 Study Limitations

The focus group research methodology allows for detailed, in-depth exploration of relatively new research areas, but its small, non-random sample limits generalizations to the larger population. As a result, it is important to interpret the results of the focus group findings in the context of the demographic and attitudinal profiles of the participants, as described in detail above. More specifically, the sample was drawn from residents of the Rossmoor Senior Adult Community (Walnut Creek, CA) who are, on average, wealthier than members of a random sample of older drivers drawn from the larger population. In addition, participants were screened for physical and cognitive acuity (a requirement of the University of California Human Subjects Review of the study - see Appendix A). Thus, participants in this study do not represent the frailest or most impaired drivers.

Researchers also made two observations about the hesitation among participants to discuss their driving impediments. The first was that male participants were often less forthcoming with their physical and cognitive challenges than were females. The second was that participants appeared less willing to talk about cognitive difficulties with driving (e.g., getting lost or merging/turning decisions) than they were about physical ones (e.g., difficulty turning their necks). Because cognitive challenges are more difficult to observe in biometric tests, the relationship between cognitive disability and safe driving should be studied in more detail than was possible here.

3.2 Observational Research

The link between specific impairments and "in-vehicle" performance has been previously investigated using laboratory settings, instrumented cars, and closed-road circuits, which involve driving a set course without other vehicles present. Additionally, these studies have primarily used in-vehicle testers to assess impairments and infractions. Past studies have not established an association between functional assessment tests and "in-vehicle" performance in an open-road scenario using the subject's own vehicle.

Porter and Whitton (2002)[12] established the use of the Global Positioning System (GPS) and "in-vehicle" video technology to detect age-related differences during driving performance in the subject's own vehicle. This system allows the driver to perform in a less imposing test environment in comparison to other methods used in the past. Porter and Whitton also recorded the driving scene with video technology, but did not record the driver during performance. While the analysis of the driving performance can be blinded with this set-up, crucial knowledge of the driver's physical activity is lost. Studies that analyze the interaction between the driver's abilities and the driver's performance within his/her own vehicle, provide crucial information to the public and the motor vehicle industry.

Once specific impairments of older adults are factored into the equation to predict "in-vehicle" performance, research regarding possible intervention strategies can be addressed. Physical, cognitive, and visual medical intervention, as well as motor vehicle modifications could be

[12] Porter, M.M. and M.J. Whitton, Assessment of driving with the global positioning system and video technology in young, middle-aged, and older drivers. J Gerontol A Biol Sci Med Sci, 2002. **57**(9): p.

used to address the problem of elderly driver safety. Research indicates there is a need to explore modifications of private vehicles and the use of technology to enhance the performance of older drivers[13]. Use of GPS and video technology, combined with assessment of the driver, vehicle, and the driver's concerns regarding their vehicle, could lead to a safer driving experience on all roads.

The specific aims of this subtask were to observe and analyze older adults during "in-vehicle" performance on an open road course and also during ingress/egress tasks. Additionally, we sought to document the effectiveness of GPS and video technology to assess "in-vehicle" performance of older drivers. It was hypothesized that problems faced by older drivers would be clearly observed through analysis of "in-vehicle" performance. It was also hypothesized that the problems detected in this study would direct future research on specific intervention strategies to address these problems. Future motor vehicle modifications, along with medical and behavioral intervention strategies should be targeted at keeping older drivers safe on the road, despite functional declines.

3.2.1 Methods

Subject Population

Sixteen men (average age = 77± 5 yrs; range = 70-84 yrs) and twenty women (average age = 78 ± 4 yrs; range = 71-85 yrs) were recruited to take part in an observational video analysis of vehicle use and a focus group (reported in Section 3.1.1) on extending safe driving years for older adults. The study received Institutional Review Board approval through UCSF and UC Berkeley. Subjects were recruited from the Rossmoor community in Walnut Creek, CA, which consisted of 6,700 residential units, including co-operatives, condominiums, and single-family home developments. In order to reside in Rossmoor, one resident per dwelling must be at least 55 years of age and all residents must be able to live independently. Further information on the Rossmoor community can be found at www.Rossmoor.com. Subjects were

[13] Shaheen, S., Niemeier, DA, *Integrating vehicle design and human factors: minimizing elderly driving constraints.* Transportation part C, 2001. **9**: p. 155-174.

recruited through flyers posted throughout common areas in Rossmoor and an article in the Rossmoor News. Exclusion criteria for the study included:

1. Having a history of neurological disease likely to affect neuromuscular function including a stroke (Cerebral Vascular Accident), seizure disorder, or Parkinson's.
2. Having a diagnosis of dementia or Mini-Mental Status Examination score < 24.
3. Standard visual acuity worse than 20/40.
4. Having a history of any other previous illness or surgery, such as a vestibular disorder, significant visual disorder, arthritis, or cardiovascular disease, which might, in the opinion of the investigator, interfere with normal driving behavior.
5. Currently taking any medications that might interfere with driving.
6. Did not currently hold a valid California driver's license.
7. Did not currently drive at least 3 days per week.
8. Did not own/lease their own vehicle.
9. Had been involved in a motor vehicle accident or DUI within the last 2 years.
10. California car license and registration were not valid and current
11. Proof of liability insurance did not meet the minimum liability requirements of $50,000 for death or injury of any one person, any one accident; $100,000 for all persons in any one accident; and $25,000 property damage for any one accident (California DMV registration requirements are $15,000/$30,000/$5,000).

<u>Specific Procedures</u>

Pre-screening, included the Telephone Interview for Cognitive Status (TICS), which is similar in content to the Mini-Mental Status Examination. Questionnaires on general health, driving activity, and driving confidence were sent out to subjects (Appendix B), completed at home, and subsequently brought in by each subject on the day of testing. All participants voluntarily consented to take part in the study. Participants reviewed and signed a consent form acknowledging awareness of the study purpose and risks associated with participation. Subjects were paid $25 for the driving session as compensation for costs of vehicle use and time and received an additional $75 after participating in the focus group.

Intake Examination

After completing the informed consent process, physical, visual and cognitive function of each participant was assessed with a 2-hour battery of measurements listed Table 3-7. The subject was required to complete the intake tests before participating in the driving portion of the study. If information attained from the medical history questionnaire or intake assessment led the investigators to think a condition or impairment could interfere with normal driving, the subject was not allowed to perform the on road portion of the testing. If excluded, the participant was still allowed to take part in the focus group.

Package Loading and Ingress/Egress

After completion of intake examination measures, subjects were asked to perform the task of putting a bag of groceries and suitcase into their vehicle "as they normally would." Each item weighed 10 pounds. Subjects were videotaped during the loading of packages and during ingress and egress from the driver's seat and the rear passenger seat (rear passenger seat evaluation was added to the test battery after the first 9 subjects had completed the study). Package loading was evaluated from the video and scored on placement (backseat, floor of backseat and trunk) and difficulty. Ingress and egress were evaluated for difficulty compared to a young healthy adult performing the same tasks (see scoring criteria in Appendix B).

Table 3-7: Intake Examination

Physical Range of Motion	Instrument
Cervical Spine Active Range of Motion (AROM): Rotation	CROM: head mounted goniometer
Gross Upper Body AROM	Driving Health Inventory: Head-neck-thoracic spine rotation test: requires the participant to turn their whole body to see an object on a computer screen 10 feet behind their chair
Lower Extremity AROM: Ankle, knee and hip motion	Hand-held goniometer: available motion at the ankle, knee and hip was assessed as the participant actively flexed or extended each joint

Vision	Instrument
Visual scanning	PC-Based version of the Trails A and B tests (Driving Health Inventory): Asks participant to connect numbers, or letters and numbers, in a sequential order while they are being timed
Visual closure	Motor-Free Visual Perception Test (Visual Closure subtest; Driving Health Inventory): Asks participants to determine which “unfinished” figure accurately resembles the “finished” figure
High and low contrast acuity	Scan Chart test (Driving Health Inventory): examined the participants visual acuity during high and low contrast conditions and at levels of 20/40 and 20/80
Stereoscopic vision (Depth Perception)	Frisby Stereopsis Test: Asks participants to determine which of four figures has a “circle in depth” on a series of plastic cards and a different viewing distances
Divided attention; Visual processing	UFOV-Useful Field of View: The area from which one can extract visual information in a brief glance without head or eye movement. The limits of this area are reduced by poor vision, difficulty dividing attention and/or ignoring distraction, and slower processing ability.
Low contrast vision	Pelli-Robson Contrast Sensitivity: Participants are asked to identify letters at decreasing levels of contrast

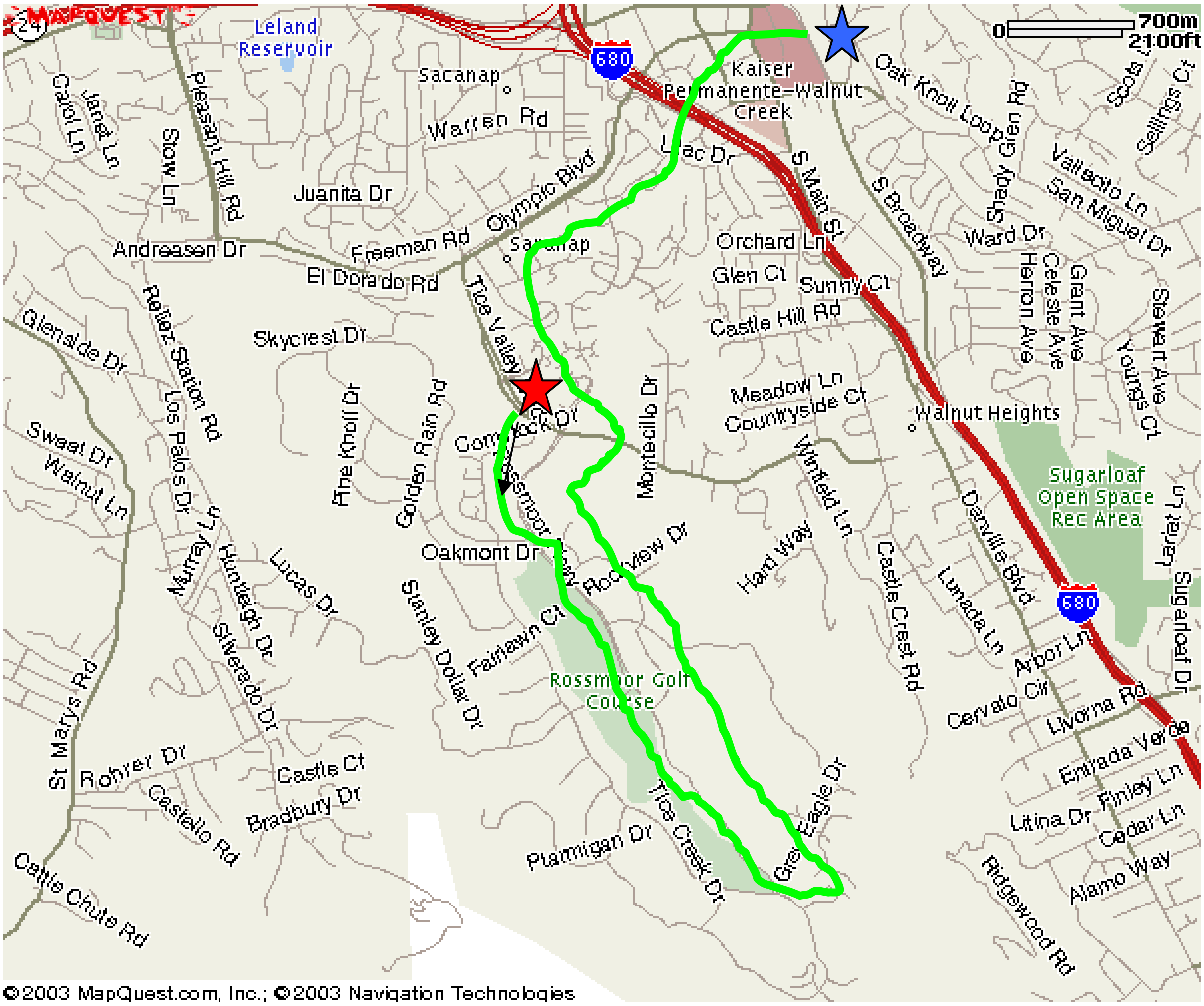
Strength	Instrument
Grip	Hand held dynamometer (force measuring device)
Plantarflexion (calf muscle)	Repeated single leg toe raises up to 25 on each leg
Dorsiflexion (ankle muscle), Knee Extension (Quadriceps – thigh muscle)	Hand-held dynamometer
Sit-to-Stand Time	Time it took each participant to complete 5 sit-to-stand-to-sit trials as fast as they could (could not use their hands and arms to help)

Balance	Instrument
	Longest time the participant could stand on one leg

Cognition	Instrument
Working Memory	Delayed Recall test (Driving Health Inventory): Asked participant to remember and recall three words at a latter point during testing

Driving Performance

Following the assessment of package loading and ingress/egress, subjects were asked to drive a pre-determined loop within Rossmoor followed by an approximately 5-mile course to downtown Walnut Creek, CA, "as they normally would" (see Figure 3-1). The course, which began and ended at the Rossmoor clubhouse parking lot, allowed the subject to choose their route to and from the downtown area once they left the Rossmoor gates (and after following the prescribed route inside of Rossmoor). Subjects were asked to park in any downtown parking space (within a pre-defined area shown to them on a map) and promptly return. Subjects were told to return without parking if they are unable to locate a space within 10 minutes. The driving course began with subjects backing out of a parking space and included numerous turns and lane changes. Driving performance for the Rossmoor course and the section from the gates to downtown Walnut Creek was analyzed for infractions based on a more detailed modification of the California Department of Motor Vehicles Road Test (scoring criteria located in Appendix B).



= Rossmoor clubhouse   = Downtown Walnut Creek, CA

Figure 3-1. Rossmoor driving route and location of downtown Walnut Creek, CA

A global positioning system was temporarily mounted to the vehicle to monitor driving speed and location of the vehicle. Additionally, investigators utilized a four-camera "surveillance" system integrated with a computer to monitor each subject's automobile use before, during, and after completing the driving course (see Figure 3-2). The cameras were attached to the subject's own vehicle using various clamps and suction cups. The subject drove alone in the vehicle without anyone else present. Video data were analyzed at a later time for driving infractions and physical movements of the driver. Infractions were judged simultaneously by two investigators using scoring criteria developed for use in the study (Appendix B).

Figure 3-2. Camera views during driving assessment

3.2.2 Equipment

A mobile digital video recorder (Model 5308; March Networks, Ottawa, Canada) was used to collect video data from 4 cameras and position and speed data from WAAS-enabled differential GPS (Model NCT-2030M; Navcom Technologies). The video data were sampled at 15 Hz per camera. For the first half of the study, we attempted to collect GPS data sampled at 5 Hz, with a positional accuracy of 0.5 m. The position and speed of the vehicle were automatically integrated and synchronized with the video data and “time stamped” on the video output. Unfortunately, due to the location of Rossmoor in Walnut Creek, CA (within a valley) and the position of the available satellites over Walnut Creek during the daytime hours of the summer of 2004, we were unable to collect accurate and reliable GPS data. Therefore, we used the camera that originally faced the rear of the vehicle (see Figure 3-2) and we mounted it to clearly view the speedometer so that we could collect information on the speed of the vehicle.

3.2.3 Data Analysis

This is a descriptive, observational and correlational study of a group of older adult subjects. Descriptive statistics were used to describe the performance of the participants.

A correlation matrix was created to examine the relationships between dependent (intake examinations measures) and independent (driving performance) variables. The Spearman rank correlation coefficient was used for all comparisons.

3.2.4 Description of Participants

The participants in this study were on average, 78 years old and 64% were retired at the time of the study. Most participants drove at least 6 out of 7 days of the week and typically drove about 120 miles during the course of one week. Additional demographics can be found in Table 3-8 and in the Focus Group Report.

Table 3-8. Demographics of participants

	Mean ± Standard Deviation
Average Number of Days Per Week Driven	5.9 ± 1.6 days
Average Number of Miles Per Week Driven	118 ± 71 miles
Number of Years the Participants Had Been Driving	58.8 ± 7.8 years
Number of Years the Participants Had Lived in Rossmoor	8.7 ± 6.5 years
Number of Years the Participants Had Lived in Walnut Creek, CA	17.3 ± 15.4 years

The percentage of participants reporting specific health conditions can be found in Figure 3-3. Of particular note was the percentage of participants with arthritic conditions such as osteoarthritis and rheumatoid arthritis (40%) which might limit their ability to get into and out of a car and manipulate controls in the vehicle. Nearly all participants wore some type of glasses (35/36) and 45% required the use of hearing aids. Although as whole, the participants in this study were a relatively robust and high functioning group, they still presented with many typical age-related disorders and diseases.

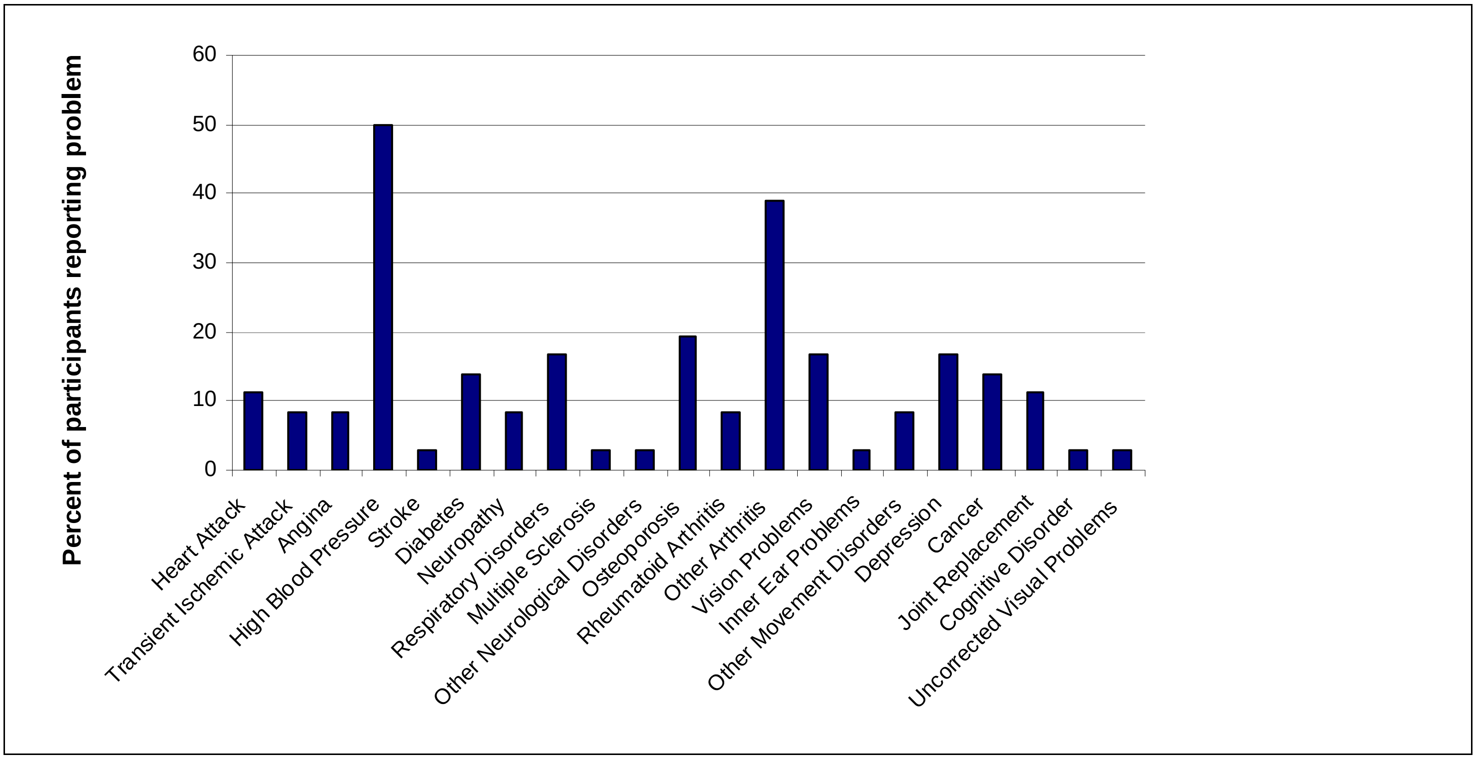


Figure 3-3. Health status among participants

<u>Driving Confidence and Avoidance Questionnaires</u>

A surprising number of participants reported some level of driving avoidance behavior (see Figure 3-4). Driving at night, in bad weather and in unfamiliar situations were the situations that the participants reported avoiding most frequently. Results included:

- 43% of participants reported that they sometimes or usually avoid driving at night
- 28% of participants reported that they sometimes or usually avoid making left turns across traffic
- 38% of participants reported that they sometimes or usually avoid driving in bad weather

- 25% of participants reported that they sometimes, usually or always avoid driving on high traffic roads
- 39% of participants reported that they sometimes, usually or always avoid driving in unfamiliar areas
- 14% of participants reported that they sometimes or usually pass up opportunities because of concerns about driving

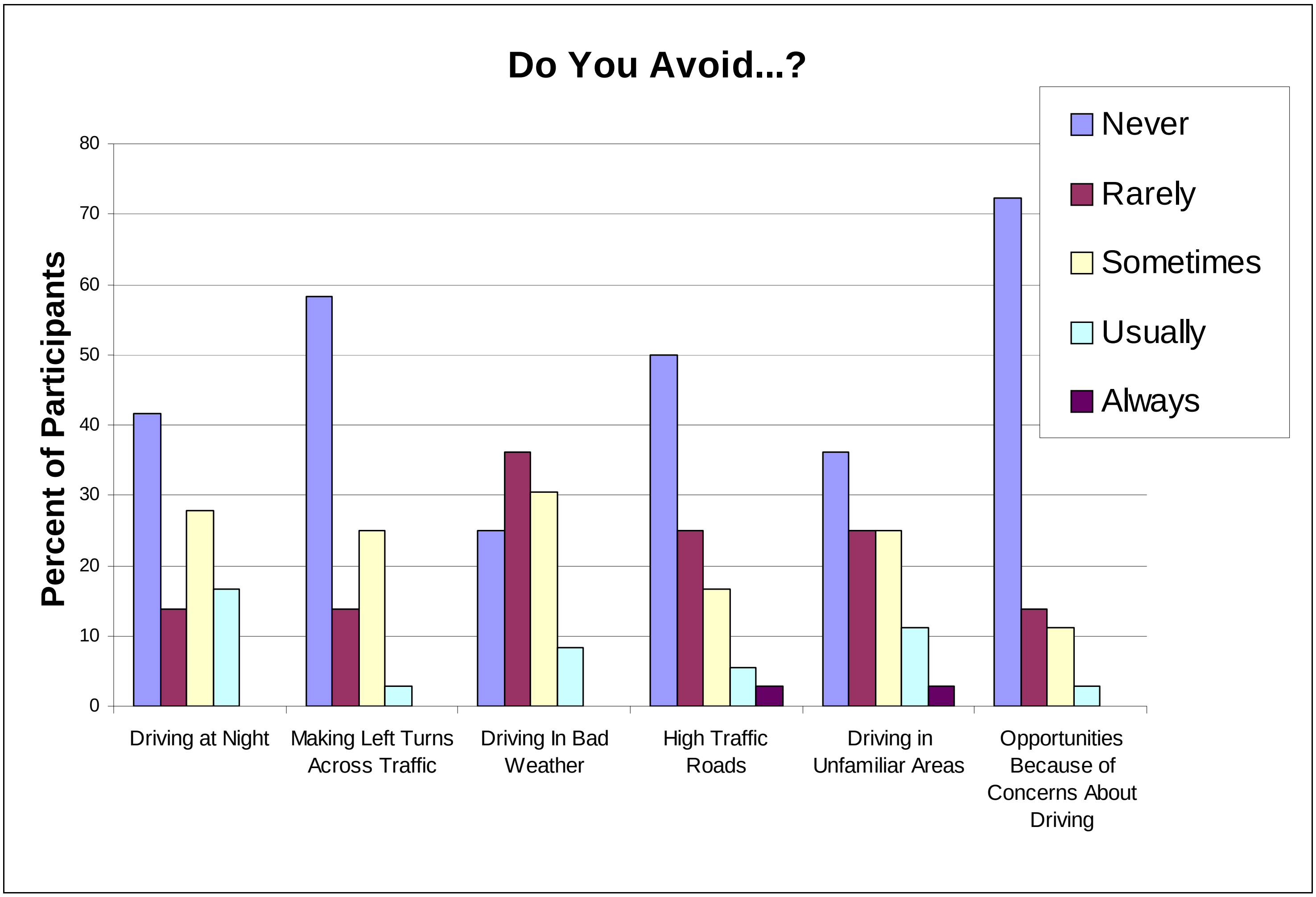


Figure 3-4. Participant responses when asked which type of driving activities they avoid and how often they avoid them.

Women reported less confidence in their driving ability when compared to the men (Average for men = 93/100 (Range = 81-100); Average for women = 75/100 (Range = 37-100); t-test: p = 0.001) (See Table 3-9).

Table 3-9. Participants confidence levels in their ability to perform certain driving tasks

Driving Task	Median Score	Score Range
Driving at night	Men = 10 Women = 8	Men = 3-10 Women = 2-10
Driving in bad weather	Men = 9 Women = 7.5	Men = 5-10 Women = 3-10
Driving in rush hour or heavy traffic	Men = 10 Women = 8.5	Men = 7-10 Women = 1-10
Highway driving	Men = 10 Women = 9	Men = 9-10 Women = 2-10
Driving during long trips	Men = 10 Women = 9	Men = 9-10 Women = 0-10
Changing lanes on busy streets	Men = 10 Women = 8	Men = 7-10 Women = 4-10
Reacting quickly	Men = 9 Women = 8.5	Men = 6-10 Women = 3-10
Pulling into traffic from a stop	Men = 10 Women = 8	Men = 7-10 Women = 5-10
Making a left turn across traffic	Men = 10 Women = 9	Men = 7-10 Women = 4-10
Parallel parking or backing into space between cars	Men = 10 Women = 8	Men = 7-10 Women = 2-10

Physical/Musculoskeletal Function Status

The older adults in this study had decreased range of motion in their hips, knees, neck and spine when compared to the norms for younger adults:

- Participants had approximately 10° less hip flexion compared to adults under the age of 60
- Participants had approximately 16° less knee flexion compared to adults under the age of 60
- 50% of participants were unable to turn far enough to see directly behind themselves while sitting
    - limited cervical and thoracic spine range of motion

Women had only 40% of the grip strength of men (Men = 32 ± 6 lbs; Women = 13 ± 5 lbs) and 60% of the thigh (quadriceps) muscle strength of men (Men = 62.5 ± 15 lbs; Women =

39.5 ± 9 lbs).

Cognitive Status

All participants were screened for cognitive ability before the start of the study and scored at least 4 points above the minimum cut-off level on the cognitive screening test (TICS). Although the participants all passed the screening exam, 30% of participants had mild deficits in working memory and 30% had serious deficits in working memory.

Visual Function Status

A surprising number of participants had deficits in divided and selective attention and directed visual search tasks. Additional deficits in low contrast visual acuity and visualization of missing information were also noted:

- 27% of participants had mild or serious deficits in low contrast visual acuity
- 22% had mild deficits and 14% has serious deficits in visualization of missing information
- 78% had mild deficits and 6% had serious deficits in directed visual search
- 51% had difficulty with divided attention on the Useful Field of View Test
- 32% had difficulty with selective attention on the Useful Field of View Test

Driving Performance

The driving performance of 30 out of 36 participants was evaluated for this report. Three participants were not allowed to drive in the study based on very low intake scores or other disqualifying criteria. Three other participants could not be scored because of equipment malfunction that impaired the ability of the investigators to accurately score driving performance. Make, model and year of each participant vehicle are listed in Table 3-1. The results of the remaining 30 participants are described in detail below.

3.4.5 Results: Rossmoor

Overall, participants made more frequent errors in the Rossmoor section of the course than they did once outside the gates of Rossmoor. This was a surprising finding considering that most participants complained about "other drivers" in Rossmoor, but seemed unaware of their own poor driving behavior. Five participants made critical errors during the Rossmoor section of the course. These errors, if made during a DMV examination, would have constituted a failed road test and immediate termination of the exam. All critical errors occurred at three- or four-way stops. The errors included failing to stop, failing to yield right of way and driving straight through an intersection from a turning lane.

Four participants did not follow the prescribed route in Rossmoor. When examining the four participant's working memory scores and cognitive screening test scores, nothing of note stood out from other participants.

Of particular note in both Rossmoor and in Walnut Creek were head turning errors. Upon leaving the staring parking space in the clubhouse parking lot, the majority of participants did not fully scan behind their car before backing out. The turn out of the Rossmoor parking lot onto the road is uncontrolled and there were often numerous pedestrians in the immediate vicinity. However, most participants made at least one error leaving the parking lot.

Key results from the Rossmoor section include:

- 75% of those drivers who reversed out of the starting parking space did not fully look through rear window before backing out
- 100% of those who pulled forward out of the parking space made no scanning errors
- Many errors were made during turn out of Rossmoor parking lot:
    - 90% did not fully stop before turning
    - 43% did not scan the surrounding area adequately

- 20% failed to slow
- 23% failed to signal

- 40% of drivers made head turning errors at stop sign controlled intersections
- 67% of drivers made head turning errors during lane changes
- 17% of drivers made head turning errors during yield
- 13% of drivers made signaling errors at intersections
- 23% of drivers made signaling errors during lane changes
- 57% of drivers did not fully stop at stop sign controlled intersections
- 13% of drivers did not follow prescribed route
- 30% of drivers did not adequately scan
- 37% of drivers sped
- 17% of drivers made critical errors

3.4.6 Results: Open Road to Walnut Creek

Three individuals made critical errors during the Walnut Creek portion of the test. Two of the three individuals only made critical errors in the Walnut Creek section, while one participant made critical errors in both Rossmoor and Walnut Creek. Two of the three errors were failing to stop the vehicle at a stop sign before making a right hand turn. Both drivers failed to slow the vehicle, come to a complete stop behind the crosswalk, yield the right of way, or scan appropriately at the intersection. Both drivers never slowed down to below approximately 20 mph before making the turn.

The third critical error was by far the most dangerous of the entire study. This driver ran a red light in downtown Walnut Creek and was completely unaware that he had done so. The light had turned red well before the driver approached the intersection. Examination of the video focused on the driver's face showed absolutely no hesitation or awareness that the driver had just driven through the red light.

The majority of non-critical errors made by most drivers mimicked those observed during the

Rossmoor section of the course. Head turning errors (not turning head appropriately to scan and/or not checking blind spot) were the most frequent, particularly at intersections and during lane changes. A little less than half of the drivers demonstrated generally inadequate scanning behavior during the Walnut Creek section of the course. Another type of error made frequently was turning too wide at an intersection. Once the driver had turned, they often did not stay in the appropriate lane (they often turned and "drifted over" into the other lane).

Key points from Walnut Creek section include:

- 73% of drivers made head turning errors at intersections
- 77% of drivers made head turning errors during lane changes
- 20% drivers made head turning errors while parking
- 63% of drivers turned too wide
- 17% of drivers failed to signal at intersections
- 17% of drivers failed to signal before changing lanes
- 23% of drivers failed to signal during parking/pulling out
- 20% of drivers rolled through stop signs
- 43% of drivers inadequately scanned during drive
- 17% of drivers sped during drive
- 17% failed to have two hands on wheel during all of drive
- One driver performed a self-distracting activity while driving (looking at map, misses light turning green)
- 10% of drivers committed critical errors

3.4.7 Results: Overall Driving

Overall, seven participants would have failed a DMV road test because they made critical errors in Rossmoor and/or Walnut Creek. Additionally, our driving performance evaluators scored those seven participants as well as one additional participant as "people they would not ride with in a vehicle" due to unsafe driving behaviors.

Two interesting observations were made in a number of participants with respect to usability issues. First, 20% of participants rested their hands during driving on the central steering wheel spokes instead of gripping the wheel itself. This seemed like an odd hand placement, and potentially unsafe if the airbag were to deploy. Additionally, hand placement on the spokes would increase the force required to actually turn the wheel. The second observation of note was that several participants (20%) frequently utilized tissues during the course of driving. This was sometimes a distracting activity because they would have to reach for the tissues and did not seem to have an adequate place to store and dispose of the tissues.

The most frequent errors that were made by nearly all drivers were related to head turning and scanning activities. This was not surprising, given the number of participants with limited neck and torso flexibility and decreased visual search and divided attention abilities. A logistic regression model was used to determine which intake examination measures were associated with head turning errors. The main predictor of head turning errors at intersections was failing the seated head turning task during the intake examination. Those drivers who could not identify an object within five seconds on a computer screen placed ten feet away directly behind them, had a 5.6-fold increased risk of making head turning errors at intersections. Those drivers who failed to look fully through their rear window before backing out of the parking space, had significantly less neck range of motion compared to those who did look appropriately (Mean neck rotation available for those who turned appropriately = 64°; Mean neck rotation available for those who did not turn appropriately = 56°; $p = 0.046$).

3.4.8 Results: Ingress/Egress and Loading of Packages

Individual ingress/egress performance and loading of packages for all drivers is compiled in Appendix B. The majority of participants loaded both the suitcase and the grocery bag into the trunk. The drivers who did not use the trunk typically placed the items on the floor of the backseat. No one used the front passenger side to load packages.

Participants had the least difficulty getting into the driver seat. Getting out of the driver seat and into the rear passenger seat were the next most difficult ingress/egress tasks. Nearly all participants had some difficulty or used altered strategies compared to young adults when getting out of the rear passenger seat (91%).

Key results include:

Suitcase Loading

- 70% placed the suitcase in the trunk
- 21% placed the suitcase on backseat floor
- 9% placed the suitcase on backseat

Grocery Bag Loading

- 64% placed the groceries in the trunk
- 21% placed the groceries on the backseat floor
- 15% placed the groceries on backseat

Ingress

- 28% had difficulties getting into the driver seat
- 67% had difficulties getting out of the driver seat
- 65% had difficulties getting into rear passenger seat
- 91% had difficulties getting out of rear passenger seat
- Required the use of one arm/hand during ingress - driver seat = 12%, backseat = 32%
- Required the use of one arm/hand during egress - driver seat = 24%, backseat = 23%
- Required the use of two arms/hands during ingress - driver seat = one person, backseat = 9%
- Required the use of two arms/hands during egress - driver seat = 9%, back seat = 14%

3.4.9 Limitations of the Study

A major limitation was the use of a relatively small and high functioning convenience sample, which limits the power and external validity of the study. Unfortunately, given the risks involved with conducting an open-road driving study and the large amount of time needed for data analysis, our options were limited. Although the video technology allowed us to perform a less intrusive assessment of driving performance, knowledge of the equipment may have affected performance. Use of the subject's own vehicle allows the driver to perform in a naturalistic setting, but does not allow for a standardized view from the video cameras. Similarly, use a non-standardized driving route in Walnut Creek and at different times of day meant that subjects may have encountered different driving situations.

4.0 CONDUCT DRIVING EXPERIMENTS

4.1 Introduction

In Section 2.0, the case is presented that older drivers are over represented in LTAP/OD crashes (left turn across path with opposite direction traffic). Specifically, older drivers may have difficulty judging the speed of other vehicles and available time to turn in front of oncoming vehicles.

One possible solution conceptualized at California PATH is an in-vehicle message for a LTAP/OD gap advisor. This stems from research conducted under the Intersection Decision Support (IDS) project, conducted under the auspices of the Infrastructure Consortium (IC). The IC is comprised of the US Department of Transportation (DOT), California DOT (Caltrans), Minnesota DOT, and Virginia DOT. The IDS project addresses the application of infrastructure-based and infrastructure-vehicle cooperative systems to address intersection safety and is the predecessor to the US DOT, Infrastructure Consortium and Collision Avoidance Metrics Partnership (CAMP) Cooperative Intersection Collision Avoidance System (CICAS). (For more information on CICAS, see the second initiative under <http://www.its.dot.gov/press/Initiatives4.htm>.) PATH is a research participant in both the IDS and fledgling CICAS programs and the institution most focused on LTAP/OD.

In IDS, our emphasis has been LTAP/OD warning from the infrastructure. However, in concepting alternate messages to make left turns even more safe for older drivers, we have considered a more salient on-board message. This gives rise to the LTAP/OD display used for *Toyota GapAdvise.*

How would such a system work? The subject vehicle (SV) – or the vehicle equipped with the *Toyota GapAdvise* LTAP/OD warning system – approaches the intersection. It has a (permissive) green signal, but there is no left turn arrow or protected cycle, so the driver slows down to a stop to check if it is safe to make a left turn onto at the intersection. The SV driver may be older or otherwise not able to easily judge the speed or location of this approaching traffic, making it hard to decide whether or not to turn. While the SV driver is trying to determine whether the left turn is safe, other vehicles ("Principal Other Vehicles" – POV) are approaching the intersection with the intent of proceeding straight. Therefore, intermittent gaps, some safe and some not safe may be present.

In order to help the SV driver prevent a collision or near collision, the PATH IDS system issues a warning to the SV driver by illuminating the dynamic "no left turn" sign – or the *Toyota GapAdvise* LTAP warning system provides a similar in-vehicle warning. These are the alternatives we studied in this task.

4.2 Research Questions

In exploring the concept of an in-vehicle gap advice system, this study addressed the following four research questions:

1. What is considered an unsafe gap?
2. When should you give the warning to be effective in influencing the drivers' decisions?
3. How should the warning be given?
4. How effective might the system be in reducing the number of unsafe turns?

In order to define what an unsafe gap is, we must first discuss how to measure gap. The term *gap* (either measured in distance or time) is most often used in the literature to refer to the space between the rear bumper of one vehicle and the front bumper of the next where the vehicles are traveling in the same direction. Thus, from the turning vehicle's point of view, there could only be a gap in traffic between two oncoming vehicles. While this is the case sometimes, it cannot be used to describe all possible cases experienced while driving. Occasionally the term *lag* (again either in terms of time or distance) has been used in the literature to describe the space between the front bumper of the turning vehicle and the front bumper of an approaching vehicle. Finally, from an intersection-centric point of view, all vehicle movements might be described in terms of *t2i* (time to intersection) or *d2i* (distance to intersection).

Unfortunately, none of these terms adequately describe the nuances associated with having two moving vehicles. For example, if we were to describe the vehicle movements in terms of lag, the value and interpretation changes as the vehicles approach the intersection. Thus, a lag of 3 seconds where the turning vehicle is already at the intersection is entirely different than a lag of 3 seconds where both vehicles are still 1.5 seconds away from the intersection. To eliminate this problem, we introduced the concept of *trailing buffer*. The trailing buffer roughly equates to a measure of spare time. Assuming the turning vehicle is going to complete its turn in front of the oncoming vehicle, how much spare time would remain before the oncoming vehicle reached the intersection? Given the very preliminary and conceptual nature of this study, trailing buffer was intended to be studied from the range of nobody would turn in front of the approaching traffic to everybody would turn.

The second research topic relates to the question of decision point. At some point during the approach of the turning vehicle, the driver must decide whether there is time to turn, or whether s/he must stop at the intersection and wait for the approaching traffic to clear. Any advice or alert given by a system should coincide with this decision making process. Warnings that come too late carry the risk of being ignored because the driver has already committed to the turn and might not have time to integrate the warning and change his or her behavior. Warnings that come too soon might be seen as a nuisance, especially if the driver disagrees with the system's assessment of the situation.

Ongoing PATH research[14] has examined the decision point issue by observing drivers making left turns in an urban environment setting. As shown in Figure 4-1, as the turning vehicle enters the left turn lane, it is impossible to tell whether that vehicle will turn without stopping, or stop and then turn based on the speed trajectory alone. However, around 20-25 meters from the stop bar, two clusters of speed trajectories become noticeable: those that intend to stop (Trajectory 4), and those that intend to turn without stopping (Trajectory 1). This evidence suggests that the decision point lies in the range of 20-30 m from the stop bar.

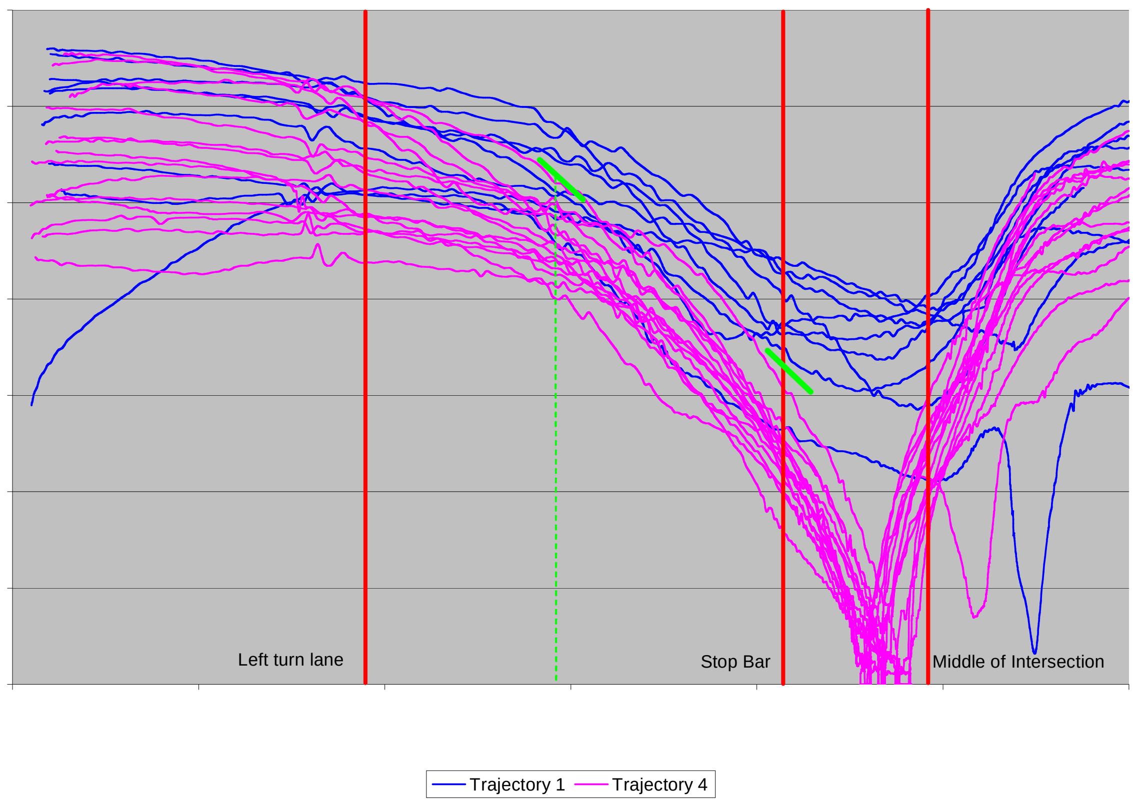


Figure 4-1. Intersection Approaches: Turned Without Stopping vs. Stopped Before Turn.

The final research topics, how to implement the in-vehicle warning and how effective such a warning might be, were not intended to be the primary focus of this study, but they are nonetheless addressed by virtue of creating and testing a prototype gap advice system.

[14] Cody, D. (2004). *Intermediate summary of IDS (intersection decision support) field test results.* Presented at the IDS Quarterly Meeting 9/26-9/29 in Minneapolis, MN. Berkeley, CA: California PATH.

4.3.1 Test Plan

4.3.2 Overview

The goal of this experiment was to observe driver LTAP/OD behavior with the introduction of a conceptual in-vehicle gap advice warning system. The conceptual system would evaluate the speeds and distances of the vehicles approaching the intersection and provide an alert to the driver if it was deemed unsafe to make a left turn in front of the oncoming vehicle. During the experiment, the SV approached the intersection at approximately 20 mph with instructions to make an unprotected left turn at the intersection (i.e., the SV has a green light but must yield the right of way to oncoming traffic). The POV approached the intersection from the opposite direction at approximately 25 mph. The arrival of the vehicles (the available gap to turn in front of the POV) and the timing of the warnings were varied in the experiment.

4.3.2 Test Participants

Twenty licensed drivers in two age groups, ten younger (20 to 38 years old, mean of 28.3) and ten older (65 to 84 years old, mean of 75.2), participated in this experiment. Within each age group, there were five men and five women drivers. Participants were recruited through email advertisements placed on various UC Berkeley student mailing lists and a "Resource Center on Aging" (see < http://ist-socrates.berkeley.edu/~aging/>) monthly newsletter. There was no overlap between the test participants in the focus group and the participants in this test. All subjects were paid a nominal $30 for their participation regardless of their performance in the experiment.

Based on the responses to a background questionnaire, the majority of the test participants regularly drove small to midsized sedans or wagons, such as the Toyota Corolla or Honda Accord. Ten percent of the participants drove small SUV's, such as the Honda Element or Suburu Forester, and twenty percent drove larger cars such as the Buick Century or VW Passat. As shown in Table 1, younger drivers reported driving less than 5000 miles per year more often than older driver, which most likely reflects the younger driver sample population being weighted towards urban university graduate students.

Table 4-1. Annual mileage

Annual Mileage	Younger	Older
< 5000	40%	20%
5000 - 10,000	40%	40%
> 10,000	20%	40%

As shown in Table 4-2, most of the driving time for younger drivers was spent on freeways, with the rest of the time split between urban and suburban settings. Older drivers were more varied, spending most of their time in urban driving. Neither age group spent much time on rural roads. Overall, these results are not inconsistent with the mix of roads in the San Francisco Bay Area.

Table 4-2. Driving habits by driving environment

	Younger			Older		
	Female	Male	Mean	Female	Male	Mean
Freeways	52%	42%	47%	41%	21%	31%
Urban	20%	34%	27%	45%	45%	45%
Suburban	20%	18%	19%	9%	31%	21%
Rural	8%	8%	8%	4%	3%	3%

Tables 4-3 and 4-4 show the mix of day vs. night driving and familiar vs. unfamiliar destinations. Younger drivers reported slightly more night driving with a mean of 40 percent of their time spent behind the wheel at night, while the older drivers only averaged 30 percent. Similarly, younger drivers were also more apt to visit unfamiliar destinations, than were older drivers.

Table 4-3. Driving habits by time of day

	Younger			Older		
	Female	Male	Mean	Female	Male	Mean
Day	57%	63%	60%	61%	78%	69%
Night	43%	37%	40%	39%	22%	31%

Table 4-4. Driving habits by destination

	Younger			Older		
	Female	Male	Mean	Female	Male	Mean
Familiar	79%	59%	69%	81%	77%	79%
Unfamiliar	21%	41%	31%	19%	23%	21%

About 40 percent of older drivers and 70 percent of younger drivers reported that urban/city driving was "sometimes difficult." Regarding the factors that cause the most difficulty in driving, 65 percent reported "other drivers," 45 percent reported "intersection complexity," and 35 percent reported "pedestrians." Left turn across path with opposite direction traffic and freeway merging were most often reported as the most difficult driving maneuvers when it came to estimating vehicle speed.

4.3.3 Experiment Design

Overview

Two factors were manipulated in this experiment. The first factor manipulated was the arrival of the SV and POV to the intersection, which translates time available for the SV to turn in front of the POV. The second factor manipulated was the warning timing, the point during the SV's approach to the intersection, at which, the warning was given. The speed of the SV was fixed at 20 mph and the speed of the POV was fixed at 25 mph; however, as both of these speeds were human controlled, variations were expected between trials. The mean SV approach speed was 20.5 mph ranging from 16 to 29 mph. The mean POV approach speed was 24.4 mph ranging from 21 to 29 mph.

Trailing Buffer (Spare Time)

The arrival to the intersection of both the SV and POV were described using the concept of trailing buffer measured in seconds. This calculation roughly equates to a theoretical projection of how much spare time would remain if the SV made a typical turn in front of the POV. Thus for any given SV position, the predicted trailing buffer could be calculated by subtracting the SV time to clear the intersection from the POV *t2i*. In this calculation it is assumed that the POV will maintain its current speed. Likewise, the SV will maintain its current speed until it decelerates to a turning speed, then continue through the intersection at its turning speed. A regression of trials at the RFS intersection showed that the typical SV turning speed was 13.18 mph (5.89 m/s), and the typical deceleration rate was 0.16 g (1.61 m/s/s). Using this model, the typical turning time for the RFS intersection (the time from SV d2i equals zero to the time the SV rear bumper clears the intersection) was predicted at 2.85 s.

In interpreting the trailing buffer, a positive value (Figure 4-2) would indicate that the SV's rear bumper cleared the intersection before the arrival of the POV. For a nominal POV speed of 25 mph and a 10-meter wide intersection, a trailing buffer between -3.5 and 0 seconds would indicate a very close call or a potential collision. Trailing buffers less than about -3.5 seconds would indicate that the POV cleared the intersection before the SV's arrival. For this experiment, three nominal target trailing buffers, -1.5, -0.5, and 0.5 seconds, were used

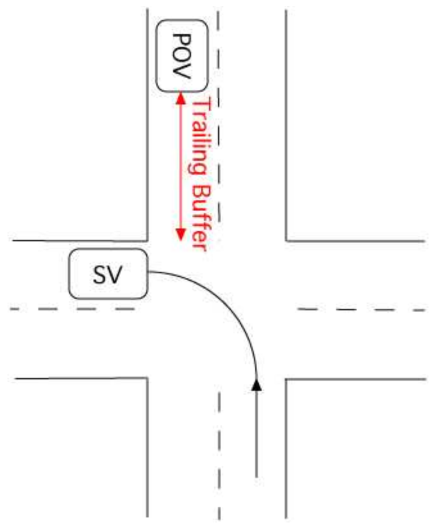


Figure 4-2. Positive trailing buffer.

Warning Timing

There were four conditions relating to the warning timing used in the experiment. First, there was the possibility that no warning would be given on a particular trial. Otherwise, warnings were given in terms of three SV distances to intersection stop bar (outer crosswalk line): 16, 24, or 32 m. At an SV speed of 20 mph, these values roughly translated to 2, 3, and 4 seconds to the intersection stop bar.

Summary

A total of four practice trials and twenty-four test conditions or intersection approaches were completed for each driver. Table 4-5 shows the number of trials for each combination of warning point and target trailing buffer. A warning was not shown when the trailing buffer value was equal to or exceeded 0.5 seconds as this was almost universally considered a safe turning condition in pilot testing. Similarly, a warning was always shown when the predicted trailing buffer was less than -1.5 seconds.

Table 4-5. Number of trials for each test condition.

Trailing Buffer	Warning Point			
	16 m	24 m	32 m	No Warning
-1.5 s	3	3	3	0
-0.5 s	3	3	3	3
0.5 s	0	0	0	3

4.3.4 Test Materials and Equipment

Test Vehicles

The test participants drove the California PATH instrumented Ford Taurus sedan, model year 1998 (see Figure 4-3), which was designated at the SV, or the vehicle making the left turn at the intersection. The POV was a white 1996 Buick LeSabre, driven by a confederate driver. The Taurus was outfitted with a video recording system, a vehicle data recording system, a laptop dedicated to the DVI (driver-vehicle interface), and an off-head, video-based FaceLab eye tracking system (running software version 3). However, the only instrumentation visible to the driver were the two cameras mounted on the dashboard for the eye tracking system, and the display used for the DVI.

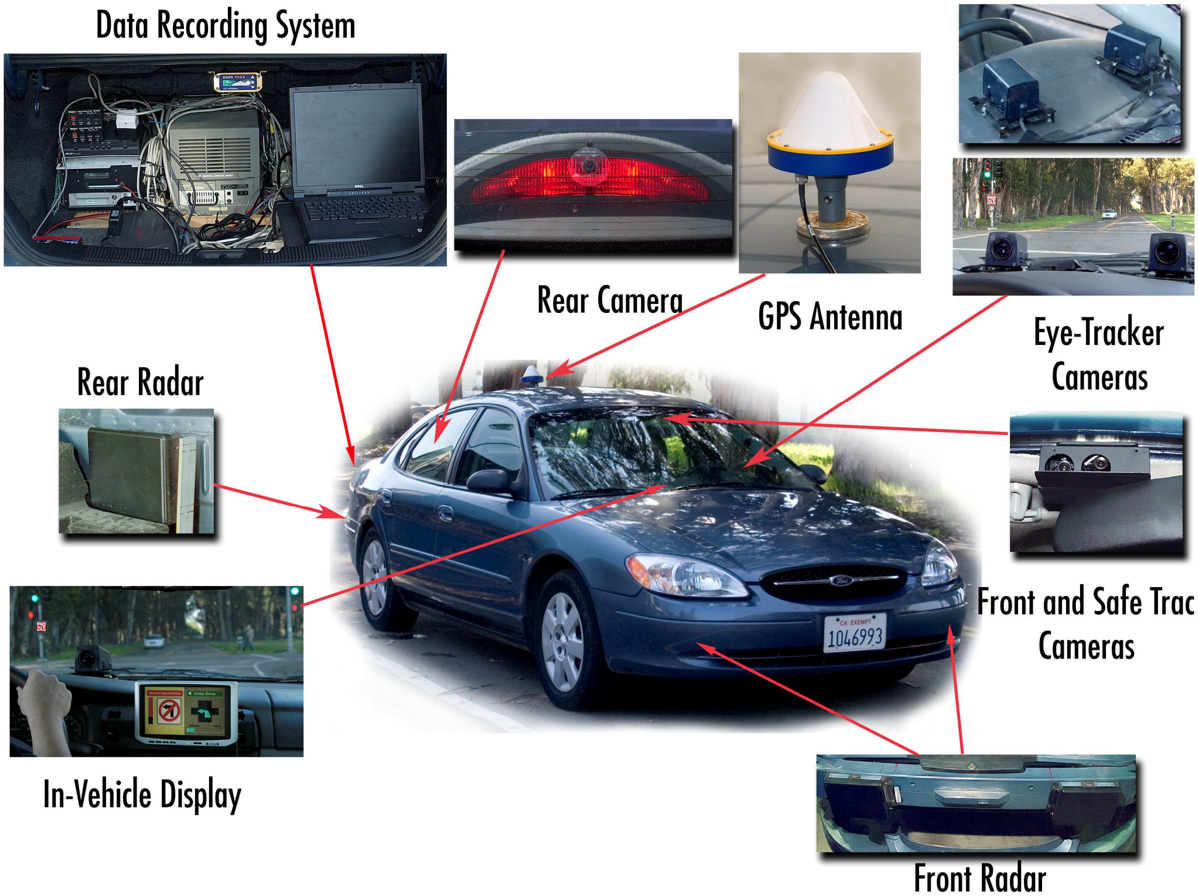


Figure 4-3. California PATH instrumented Ford Taurus sedan.

The DVI used to display the in-vehicle warnings was a 7" LCD display (Xenarc Model 700YV), mounted in the high center position as shown in Figure 4-4 in an attempt to approximate the position of a typical navigation system display. The no-left-turn sign shown on the screen for the visual warning had the characteristic of looming, i.e., the red circle and slash portion of the graphic increased and decreased in width by about 20 percent at a rate of about 2 Hz. This gave the impression of a flashing effect, helping to attract attention to the display, without ever having the no-left-turn warning disappear. The audio portion of the DVI was played through the displays speaker with the volume adjusted to a comfortable level for each driver. The sound used to indicate an unsafe gap was a pair of 2000 Hz tones at a 200 ms cadence. All of the information displayed on the Taurus DVI was received via an 802.11b wireless link from the infrastructure. The vehicle-based sensors, such as the radars, were not used to calculate or display warnings on the DVI.

Figure 4-4. DVI mounted in the Taurus displaying the No-Left-Turn Warning.

Test Intersection

The experiment was run at the UC Berkeley, RFS Intelligent Intersection. This intersection is a typical four-leg intersection with one lane in each direction (no left or right turn lanes). The approach from the POV direction was approximately 1000 meters, while the approach from the SV direction was approximately 100 meters. Using a suite of in-pavement magnetic loops, 3M microloops, and EVT-300 radars, and 802.11b wireless links to the vehicles, a roadside PC-104 monitored the SV and POV speed, distance, and acceleration continuously during each trial. The roadside PC-104 then rebroadcast the information along with a determination of any warning conditions to the SV over the 802.11b wireless link. The traffic signal was kept in the green phase for the SV and POV throughout each trial.

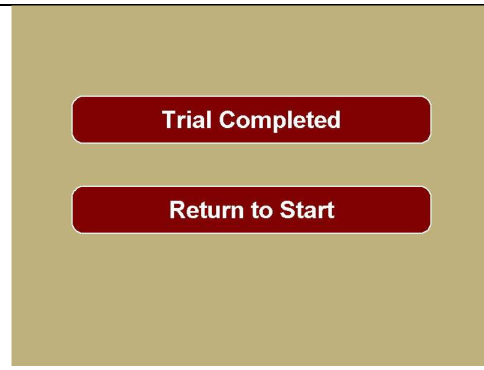
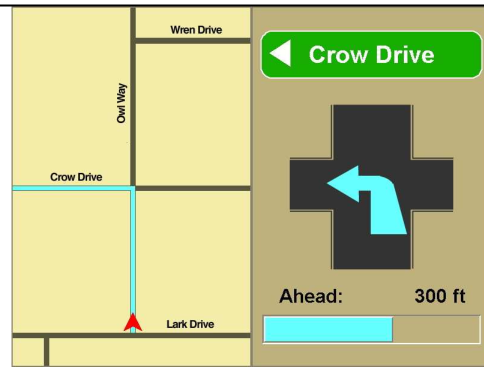
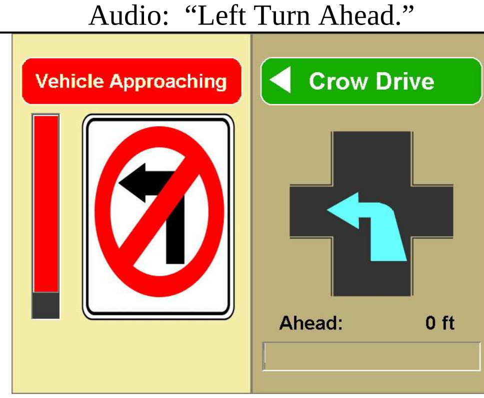
4.3.5 Experimental Protocol

Test Activities and Sequencing

Upon the arrival of the test participant, s/he was greeted and asked to read and sign a consent form and fill out a background questionnaire (both in Appendix C). They were then seated in the instrumented Taurus and asked to adjust the seat, mirrors, and steering wheel to a comfortable position. The eye tracking system was calibrated for the driver, and the sequence of the experiment was explained step-by-step in detail to the driver (see Table 4-6). Throughout the experiment, the experimenter sat in the rear passenger seat of the Taurus.

The arrival of the vehicles at the intersection (and subsequent trailing buffer) was manipulated by adjusting the start time of the SV relative to the start time of the POV, which was controlled by the roadside PC/104 computer stack. The POV driver started each trial by sending a signal to the roadside computer, which in turn, started a countdown, sending a start signal to each driver at the appropriate time. To the SV driver, the start signal seemed to come at a random time between 10 and 15 seconds after the experimenter radioed that the SV was in position and ready. The trial was considered completed after the test participant completed the left turn.

Table 4-6. Typical trial sequence.

Activity Sequence	Driver Instruction	DVI
1. Line up vehicles	The test participant parks the SV approximately 80 m from the intersection and waits for the start signal. (The POV parks 260 m from the intersection.)	
2. Safety check	The experimenter radios that SV is in position and ready to start when the track is clear.	
3. POV driver starts the trial	The POV driver initiates the start of the trial by sending a signal over the wireless network to the roadside PC-104.	
4. POV receives the start signal	The POV driver accelerates up to 25 mph towards the intersection.	
5. SV receives the start signal	Upon hearing the phrase “Left Turn Ahead” spoken by the DVI, the test participant was instructed to accelerate to 20 mph, drive up to the intersection, and make a left turn.	 Audio: “Left Turn Ahead.”
5. SV receives the unsafe gap alert	At the designated warning point for the trial, the SV displayed a warning based on the trailing buffer. The DVI unsafe gap warning screen change was preceded by “beep beep” sound to alert the driver. The warning screen consisted of a looming no-left-turn sign and a countdown bar representing the POV distance to intersection.	 Audio: “Beep Beep”
6. Trial completed	After the SV has made its left turn, the trial was completed, and the experiment asked probing questions about the trial.	(Same as Activities 1-4)

Practice Trials and Instructions to Drivers

The test participants were instructed to approach the intersection at 20 mph and make a left turn as they would normally. They were instructed to turn in front of the oncoming vehicle if they felt it was safe and appropriate, whether or not a warning was present. Warnings were to be treated as advice. The test participants were also discouraged from speeding up faster than 20 mph in order to beat the oncoming vehicle.

Four practice trials were given before the start of the test. The first two practice trials were given without the DVI unsafe gap alert, simply to familiarize the drivers with the trial protocol, the intersection layout, and the handling of the Taurus. The second two practice trials added the concept of DVI warnings. Both the warning and its meaning were described to the driver *a priori*, and thus, the drivers were not required to blindly interpret the meaning of the device.

Post-Trial Probing Questions

After each trial, the test participant was asked two probing questions by the experimenter.

1. Did you think there was enough time to turn in front of that car?

Responses were coded as follows:

a. Driver answered yes, and turned in front of the POV.
b. Driver answered yes, but stopped to let the POV pass.
c. Driver answered maybe, if s/he was in a hurry, but stopped to let the POV pass.
d. Driver answered no, and stopped to let the POV pass.

2. When the warning came, did you feel it was early, late…?

Responses were coded on a scale of 1-5 with 1 being too early, 5 too late, and 3 just right.

4.4 Results

4.4.1 Trailing Buffer

For each trial or intersection approach, there were two possible outcomes, the driver could turn in front of the oncoming vehicle or stop and wait for it to pass. If the driver chose to stop, an opinion was solicited as to whether the driver thought there was enough time to turn after the fact. Figure 4-5 depicts these results broken down by half-second increments of trailing buffer. Thus, when the trailing buffer was greater than 1.0 seconds, almost all drivers turned in front of the oncoming car. When the trailing buffer was between -1.0 and -0.5 seconds, 40 percent of the time, drivers thought there was not enough time to turn; and 60 percent of the time, drivers thought there was enough time to turn. However, the turn was actually only made a little less than 30 percent of the time.

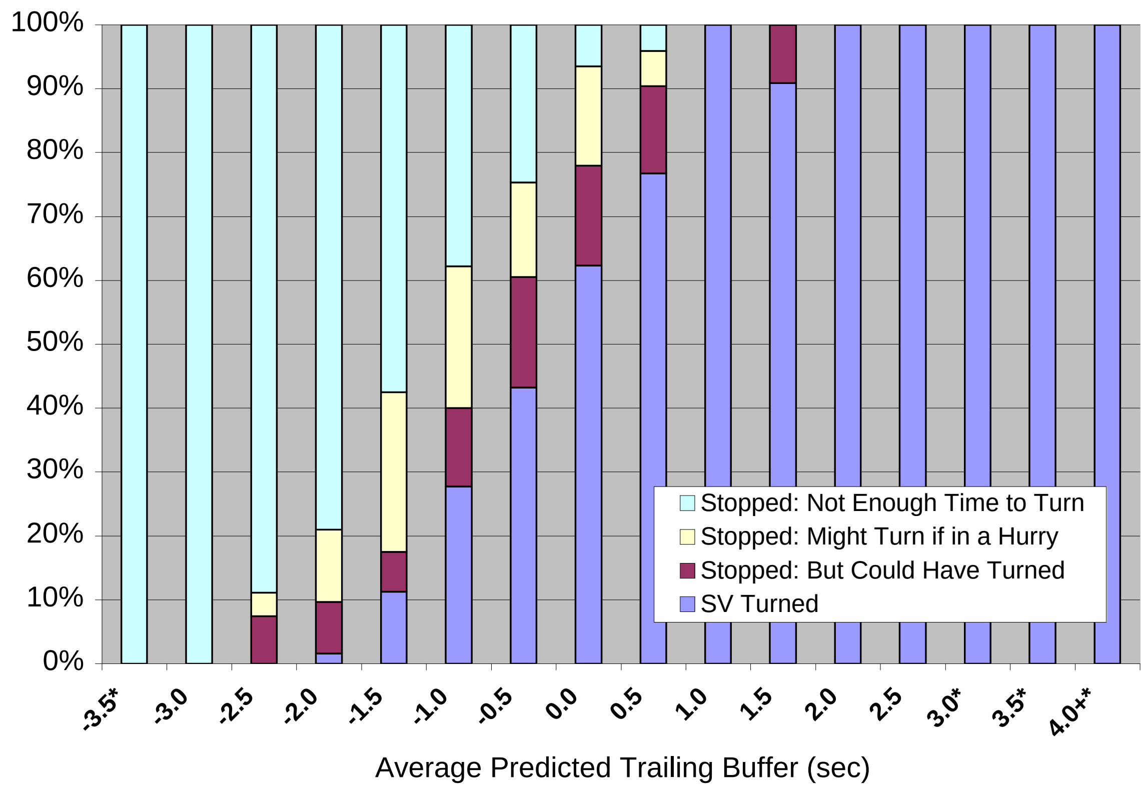


Figure 4-5. Decision to turn as a function of trailing buffer.

As shown in contrasting Figures 4-6 and 4-7, younger drivers were slightly more aggressive than older drivers with a higher percentage of turns being made in the -2.0 to the -0.5 second range. However in the -0.5 to 0.0 second trailing buffer range, older drivers made the turn more than 50 percent of the time, while younger drivers made the turn only about 35 percent of the time.

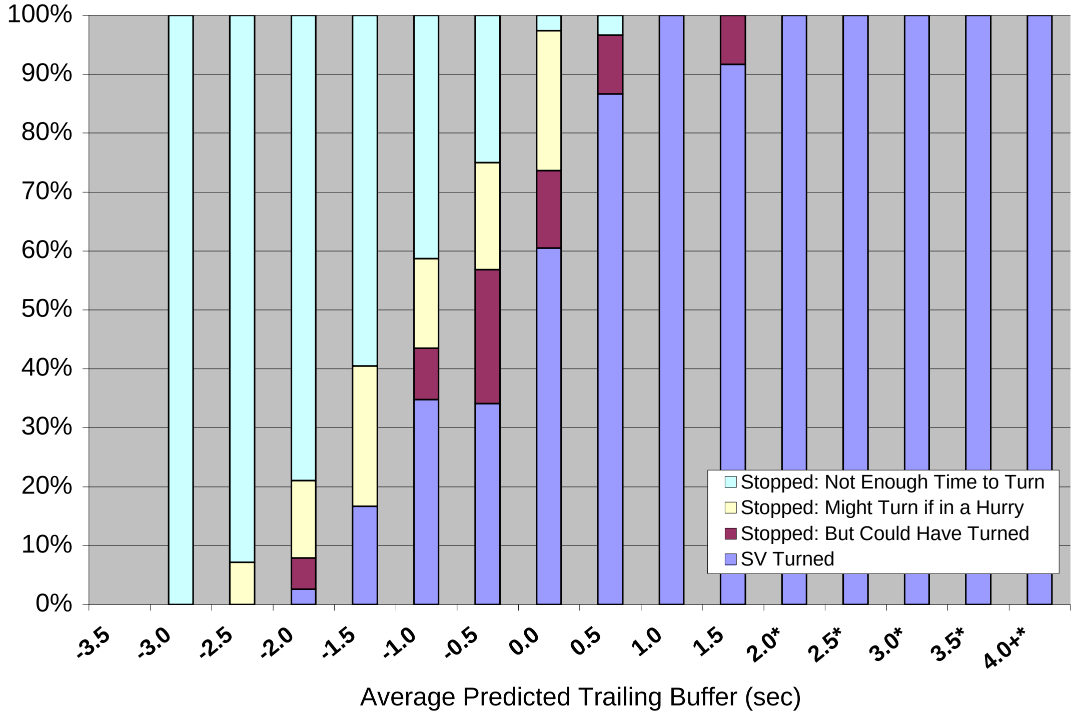


Figure 4-6. Decision to turn as a function of trailing buffer for younger drivers.

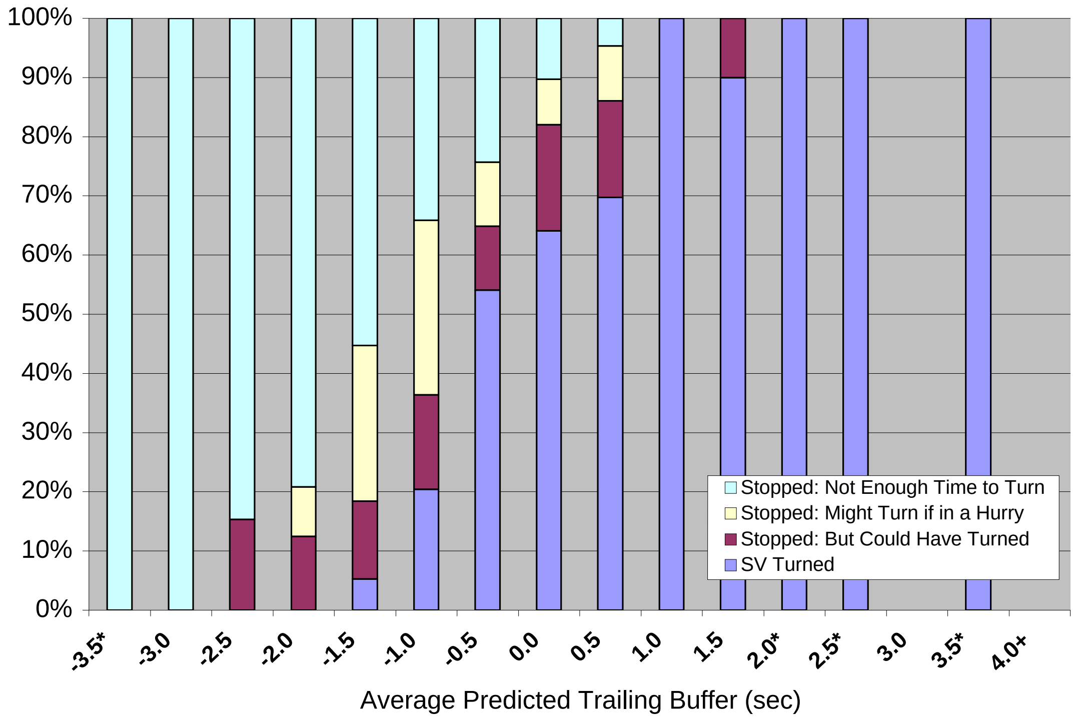


Figure 4-7. Decision to turn as a function of trailing buffer for older drivers.

4.4.2 Warning Timing

It was theorized that the decision of whether to turn or to stop and wait for the approaching vehicle to pass occurred somewhere between 20 and 30 m from the stop bar for a typical 25 mph intersection approach. The values tested for the in-vehicle alert were 16, 24, and 32 m from the stop bar. After each trial, the drivers were asked to rate the timing on a scale of 1 to 5 with 1 being too early and 5 being too late. The mean ratings are summarized for each warning point in Table 4-7; however, the differences in mean ratings were not very large.

Table 4-7. Drivers' mean rating for each warning point

Warning Point	Mean Rating	Young	Older
16 m	3.37	3.28	3.49
24 m	2.94	2.95	2.92
32 m	2.59	2.38	2.85

Figure 4-8 shows the same data in a slightly different way, breaking out the percentage of time each warning point was rated in each category, showing that, overall, drivers were fairly insensitive to the variations in warning point. Each warning point tested was rated as "just right" 50 to 65 percent of the time. However, the 16 m warning point was rated as late almost 40 percent of the time, while being rated early less than 10 percent of the time. Conversely, the 32 m warning point was rated as early at least 35 percent of the time, while being rated late less than 10 percent of the time. The middle warning point, 24 m, was equally rated as too early or too more equally, being too late around 15 percent of the time and too early about 25 percent of the time.

As shown in Figure 4-9, there was a pronounced age effect on the warning point. Overall, older drivers preferred the warning to be given earlier than younger drivers. The older drivers rated the latest warning point (16 m) as being late almost 45 percent of the time, as compared to younger drivers who rated this condition as being late only 30 percent of the time. Similarly for the earliest warning point (32 m), younger drivers rated this condition as early almost 50 percent of the time, whereas older drivers only rated it as early 25 percent of the time.

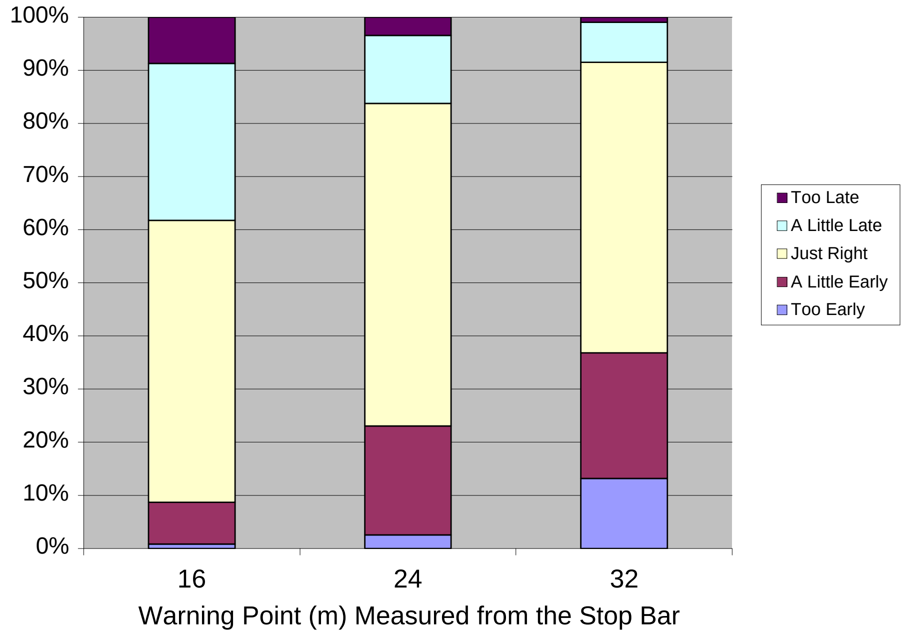


Figure 4-8. Percentage of driver responses by warning point.

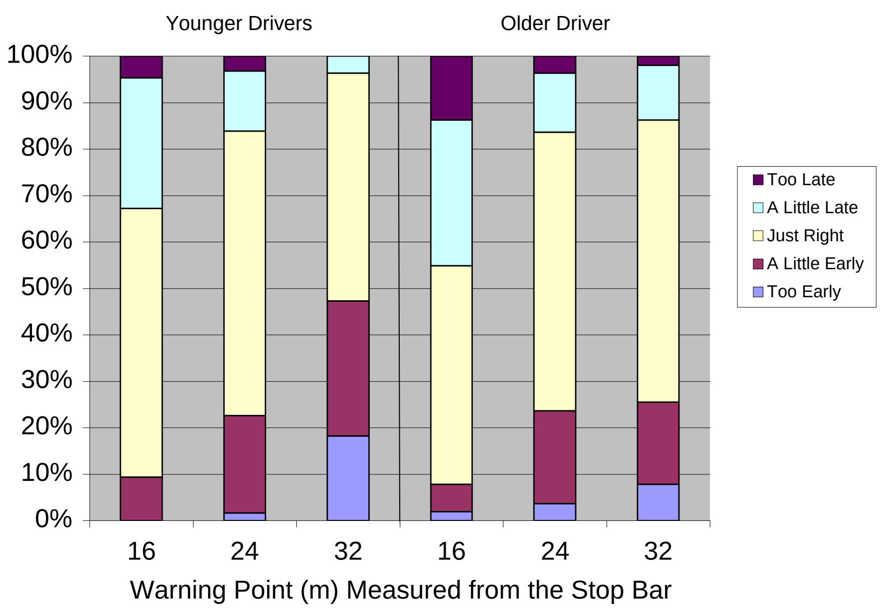


Figure 4-9. Percentage of driver responses by warning point and age.

The analysis of the driver ratings of various warning points provides a subjective evaluation of the warning timing. One possible objective measure would be a comparison of the warning point to the braking point. As shown in Table 4-8, a typical driver began braking 16.9 m from the stop bar when intending to turn in front of the oncoming vehicle and no warning was present. When the drivers intended to stop and let the oncoming vehicle pass, the mean braking point was slightly earlier, near 19 m from the stop bar. Older drivers typically began braking earlier, around 20 m from the stop bar, while younger drivers began braking later, around 18 m from the stop bar. The warning point had little to no influence on the braking point. Given that braking typically started before the 16 m warning point, this analysis would suggest that the 16 m warning came after the driver had already made a decision, and thus, came too late. Assuming the SV was traveling at 20 mph (9 m/s), the 24 m warning came just under a half-second before the typical older driver began braking, suggesting that this condition at least had a chance to influence the driver's initial decision.

Table 4-8. Drivers' mean braking point.

Condition	Mean Braking Point in Meters from the Stop Bar (std. dev.)					
	Overall		Younger Drivers		Older Drivers	
No Warning / SV Turned	16.9	(5.1)	16.3	(5.6)	17.5	(4.5)
Warning Present / SV Turned	16.4	(5.8)	15.3	(6.5)	17.7	(4.7)
16 m Warning / SV Stopped	18.8	(4.8)	17.8	(4.6)	20.0	(4.9)
24 m Warning / SV Stopped	18.9	(5.3)	17.6	(4.9)	20.1	(5.5)
32 m Warning / SV Stopped	19.5	(4.0)	19.1	(3.7)	19.9	(4.2)

4.4.3 Warning Format

The goal of this study was not to design the perfect in-vehicle gap advice warning system, but to create and test the concept of such a system. Since no system like this exists as a reference point, the prototype system was designed to simply build off familiar technology and systems. The gap advice system was presented as an extension to the navigation systems already in some vehicles, and thus the visual portion of the warning appeared in the context of a navigation system screen. The auditory warning, the simplistic "beep beep", was presented as a tone alerting the driver to the emergence of a warning on the navigation screen. The main comments about the warning interface centered around placement of the display and use of the auditory tone.

Most of the drivers commented that the visual information was too low to be seen. During the intersection approach, most said that they felt extremely uncomfortable taking their eyes off the road and, specifically, off the oncoming vehicle. Thus, almost no glances to the in-vehicle display were made during the trial. Several drivers further explained that they were in the habit of visually tracking the oncoming vehicle because of its unpredictability. In an urban environment, the oncoming vehicle may suddenly put on its turn signal or slow or stop for any number of reasons, allowing an opportunity to turn.

As for the auditory warning, drivers commented about its lack of specificity, lamenting that the noise could have come from any one of a number of systems having nothing to do with a left-turn warning. Additionally, many drivers commented that they would not really want a car that beeped at them at every intersection. However, this last comment should be taken with a grain of salt, as the drivers in the experiment performed 54 consecutive left turns in the space of 2 hours, and thus experienced the warning with a frequency unlikely to be matched in any conceptual real world driving scenario.

4.4.4 Warning Effectiveness

Although this experiment put drivers into a highly contrived situation where they were making the same left turn over and over again for about an hour, one measure of the system effectiveness was to compare the percentage of turns made for a given trailing buffer when no warning was present (see Figure 4-10) versus the percentage of turns made when there was a warning present (see Figure 4-11). Comparing these graphs, there was a reduction on the order of 10% in the turns made in front of the oncoming vehicle for trailing buffers between -1.0 and 1.0 seconds. (Note that for trailing buffers less than -1.0 seconds, there were too few samples in the “no warning” category to allow an accurate comparison.)

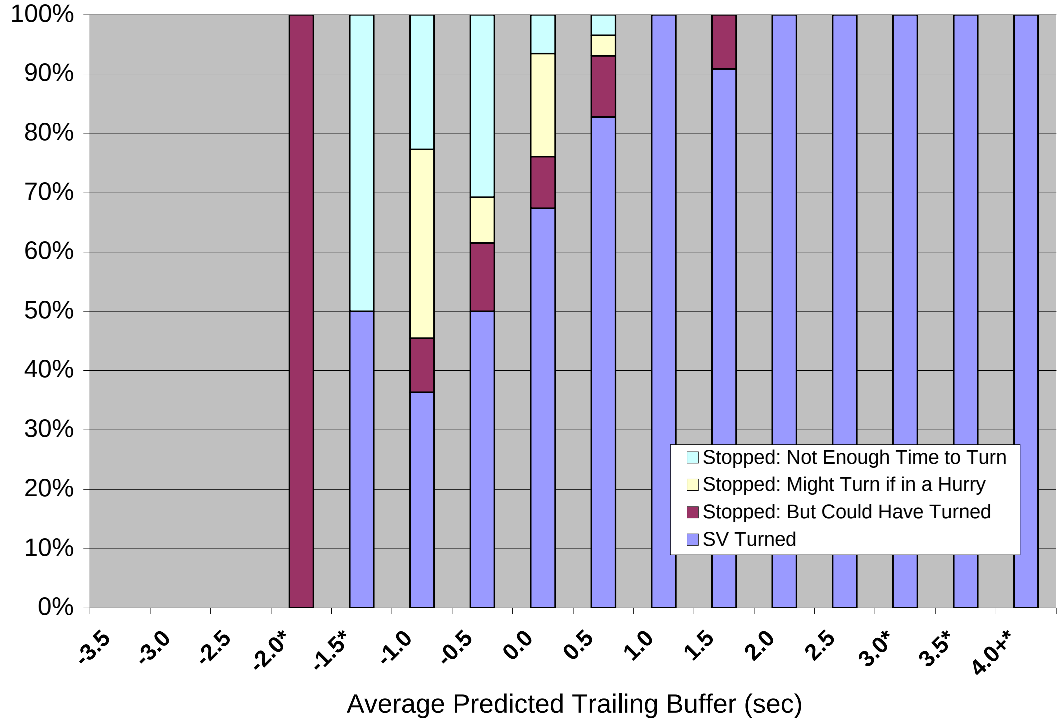


Figure 4-10. Decision to turn as a function of trailing buffer with no warning.

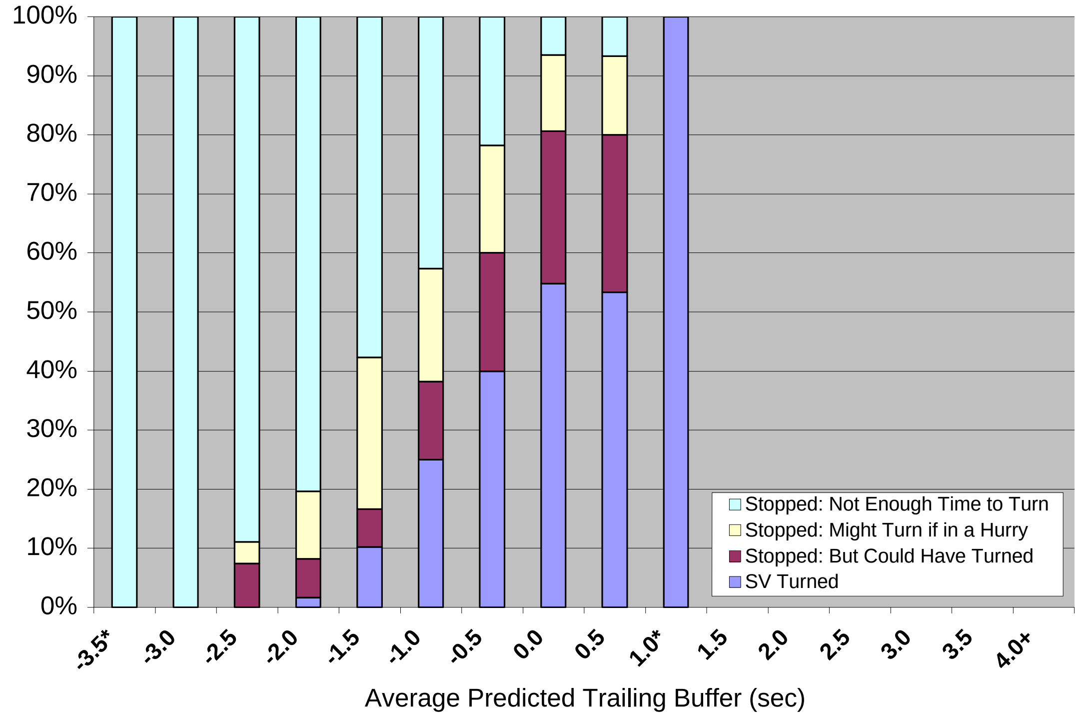


Figure 4-11. Decision to turn as a function of trailing buffer with warning present.

Note: An * indicates that the number of samples for a trailing buffer bin was less than 5.

4.5 Discussion and Limitations of the Results

One glaring issue with the interpretation of these results is the fact that drivers made turns even though the predicted trailing buffer was less than zero. Negative values for the trailing buffer mathematically indicate a close call or high collision potential; however, the trailing buffer is just a prediction. In actuality, the vehicles may slow down, or speed up, or otherwise fail to follow their predicted path, thus altering the outcome. When comparing the predicted trailing buffer with an estimate of the actual trailing buffer, there was a standard deviation on the order of a half-second, meaning that the predicted trailing buffer, currently in half-second bins, has the potential of being a half-second different from the actual outcome.

Furthermore, this variance may further be compounded by the measurement errors present in the estimate of the actual trailing buffer, which was based on the assumption of a 2.85 second turning time. Although attempts were made to try to measure vehicle movements inside the intersection box, none of the sensors used were accurate enough to capture the behaviors of the drivers. As an example, one solution to decrease one's turning time (thus increasing the trailing buffer) was to cut the corner. A centerline to centerline turning arc requires 16.8 m of travel to clear the intersection. Cutting the corner might shave off 4 or 5 m of travel, easily providing an extra half-second or even second of trailing buffer.

From these results, it is clear that the trailing buffer as situational description and the associated model used to describe driver turning behavior are not without flaws. One important lesson learned is that drivers routinely make turns that might be considered as or result in close calls. Even in the turns made with the smallest trailing buffers, the largest deceleration (if any) seen in the oncoming car was on the order of 0.09 g. The POV drivers, when informally probed, would typically comment that although there were some aggressive turns made by the subject, there was nothing out of the ordinary. Further research is needed to develop the trailing buffer concept and model and to correlate the predicted trailing buffer with SV and POV driver ratings on the aggressiveness or comfort level of the resulting turns.

5.0 RECOMMENDED IN-VEHICLE DESIGN

Our recommended in-vehicle design is predicated on the fact that the near future will see a very substantial increase in the number of older drivers on U.S. highways. Older drivers represent a higher crash risk, and both older drivers and their older passengers experience increased susceptibility to injury in the event of a crash. Hence, as a higher-level recommendation, in order to extend safe driving years for older drivers, is that injury prevention programs might focus their efforts at reducing intersection cross-path collisions, since older drivers are over-represented in crossing path collisions. Non-fatal crash rates, as well as the rate of right-of-way violations and traffic-signal violations, are also higher for drivers over age 65 than for drivers age 30-64.

The most common cross-path collision types for the elderly, in decreasing order, are "Left Turn Across Path- Opposite Direction" (30%), "Straight Crossing Path" (28%), and "Left Turn Across Path- Lateral Direction" (20%). In both right and left crossing path collisions, older drivers are more often controlling the turning vehicle rather than the vehicle proceeding straight. Similarly, older drivers are cited for traffic violations in cross-path collisions more frequently than adults age 30 to 64. Previous research identifies both cognition and perception errors as the primary cause of misjudgment at intersections.

Our research has yielded further specificity, however. Consider results from the focus groups and observations and our *Toyota GapAdvise* experiments:

5.1 Focus Groups and Observations

Table 5-1 summarizes the major recommendations gleaned from the four focus groups. The problem areas are divided by category as described in the preceding section, and the recommendations are grouped by difficulty of design and implementation of the proposed change. While not absolute, problems are ranked in an approximate order of importance as subjectively identified during the focus group sessions.

In general, level one solutions focus on redesign of vehicle components or on changes that are already available in some models, such as improved mirrors, minor adjustments to displays or radios, and mechanical seat adjustments and checks on doors. Improvements involving more complicated electronics or major structural changes to vehicle design fall into the second category, and these include redesign for blind spots, flat trunks, and automated or electronically adjustable features, among other recommendations. Level three solutions typically involve intelligent transportation system (ITS) or GPS-based solutions, which integrate enhanced driver information into automatic vehicle navigation or alert systems.

We recommend that future research include the design and possible deployment of prototype vehicles incorporating different level solutions for field tests with older drivers. Because of the high cost and uncertain demand for some technologies, it is possible that the marginal benefits of level one solutions may be the most cost effective for older drivers. Because many drivers also had difficulty with merging, another area that deserves future study is merging and turning behavior, perhaps through a merge assist study with technology development and interface assessment.

Although our sample population of older drivers was relatively robust and most likely higher functioning than the average population of older adults, most drivers in the study made several driving errors which could affect safety. The most common type of error involved inadequate turning of the head while backing up, scanning intersections and making lane changes. Those individuals who had limited head/neck/torso mobility, performed these errors more frequently than those with adequate range of motion. Our observational analysis of driving performance confirm the findings from the focus groups which suggest that blind spots, difficulties changing lanes, and concerns about hitting objects such as a curb or pedestrian were among the most important problem areas mentioned by our participants. Recommendations for vehicle modifications include that might address the reduced neck and torso mobility include: mirror redesign, increased visibility through pillar and window reconfiguration, back-up beepers and cameras, and potentially a warning system of some sort to remind individuals to scan appropriately at intersections and during lane changing.

We were surprised to find that 60% of the individuals in our study had deficits in working memory given that they all easily passed the cognitive screening test. Additionally, four drivers were unable to follow the prescribe route in Rossmoor. These findings might suggest that navigation could be beneficial in this population, however this idea must be tempered by the fact that the majority of participants had mild deficits in directed visual search and half had mild deficits in divided attention.

From a usability standpoint, we observed that those with mobility problems and taller individuals had the most difficulty getting into and out of the vehicle, particularly for the rear passenger seat. Additionally, the smallest women in the study tended to be positioned too close to the steering wheel and sometimes forced into a more flexed, or forward leaning posture. This would place these women in a very risky position if the airbags were deployed. Greater seat adjustment capability (particularly for the height of the seat) might address some of these limitations. Greater space in the back seat, along with some form of adjustment might improve an older adult's ability to perform ingress and egress more easily.

Two of our frailest participants had noted difficulty with the gearshift, with one woman requiring two hands to change gears. We were also surprised by the number of participants who held on the steering wheel by the center spokes instead of the wheel itself. We are unsure as to why participants chose this particular hand placement as it would seem to afford less control of the wheel.

From both a marketing and a design standpoint, older women tend to be less confident in their driving abilities when compared to men and often reduce their driving activity because of their lack of confidence. Targeting older women drivers with ways to make them feel safer and more confident in their driving ability could be beneficial.

We anticipate several possibilities for continued research concerning older adult driving. The equipment used in this study could be mounted in a subject's vehicle on a semi-permanent basis and used to collect data over a period of weeks. This would allow for a more comprehensive look at older adult driving and mobility habits. The older adult could also be studied driving during twilight or night hours. Another interesting study would be to evaluate a prototype vehicle using the same subjects tested in this study to evaluate how their performance changes in a new vehicle targeted to older adults.

TABLE 5-1. SUMMARY OF KEY PROBLEM AREAS AND RECOMMENDATIONS

Major Problem Areas	Level 1 Solutions	Level 2 Solutions	Level 3 Solutions
1. Blind spots while merging and changing lanes and concern about the speed of oncoming vehicles	“wink” mirrors; redesign of convex right-hand side mirrors	redesigned window pillars	
2. Problems gauging when to safely make left-hand turns at unprotected intersections			intelligent intersections, including vehicle-to-infrastructure communication
3. Concern for hitting the curb, pedestrians, and other cars when parallel parking or reversing	reverse beepers (for hitting other cars and pedestrians); “curb feelers” (for hitting the curb)		Cameras to monitor activity behind vehicle; automated parking system
4. Items not staying in place when placed in the trunk and difficulty lifting items	netting; bungee cords; Velcro	low lift-over loading (no trunk lip); compartmentalized trunks	
5. Seats too low for drivers to see above dashboard and/or reach pedals. Difficulty re-adjusting seat when sharing vehicle.	manual up/down adjustment	electric-adjust memory seat settings; adjustable pedals	
6. Difficulty reading displays and using knobs		increased brightness; controls on steering wheel; remote for radio	
7. Physical discomfort or difficulty during access/egress due to limited range of motion or physical impairment	grab-handles above door or on pillars; running boards; mechanical door check to avoid slamming	ergonomic design for taller drivers (e.g., more foot room, wider doors); adjustable steering wheel; sliding front door	

8. Decreased visual acuity when driving at night or during rain		automatic-dimming headlights for incoming glare; faster automatic lights for night driving (e.g., entering a tunnel)	
8. Traveling to unfamiliar locations increases anxiety	digital compass		GPS-enabled in-vehicle navigation system (can also mitigate short-term memory loss)
9. Sun glare	wider or adjustable visors	tinted windshields (top only)	
10. Problems remembering when to turn off turn signals	volume setting; timeout function		

5.2 *Toyota GapAdvise* Experiments

The drivers' comments on the overall concept of a gap advice system were positive. Almost all of the drivers commented that such a system could be useful and come in handy at times, and the data collected showed potential for an in-vehicle LTAP/OD warning to influence drivers' decisions as there was a 10 to 20 percent reduction in the percentage of turns made when the warning was present. However, unsurprisingly, almost all of the drivers also agreed that the interface would need much more study and work before being accepted as an in-vehicle system.

The head-down display used for the visual component of the warning was reported as being too low to be seen, even though it was mounted as high as possible for a head-down display. When asked to comment on the graphical components of the display, such as the looming no-left-turn sign or the oncoming vehicle distance to intersection countdown bar, all 20 drivers reported that they did not glance to the display during their turning maneuver, rather they simply listened for the warning beep. A few of the drivers expounded on this, stating that their eyes and attention were focused on the oncoming vehicle throughout its approach, and they did not feel comfortable taking their eyes off the road.

Comments on the auditory alert mentioned two deficiencies. First, the alert was not specific, i.e., there was no inherent association between the alert and its meaning. The beep could have come from any number of systems in the car. Second, drivers were concerned with the prospect of a car that would start beeping at them every time they approached an intersection.

These comments suggested several avenues of further research needed before an in-vehicle LTAP/OD warning could be implemented:

1. Further research is needed on the potential to use head-up displays for intersection warnings so that drivers don't have to take their eyes off the road.
2. Further research is needed to design auditory warnings specific intersection conflicts.

Two additional parameters critical to the activation of an LTAP/OD warning were studied in this experiment: the warning criteria (trailing buffer) and the warning timing. The warning criteria was based on the concept of the prediction of a trailing buffer (or margin of safety) should the SV actually turn in front of the POV. One glaring issue with the results of this experiment is the fact that drivers made turns even though the predicted trailing buffer was less than zero (practically interpreted as a predicted collision). These results lead to two conclusions. First, drivers are willing to make left turns with little or no trailing buffer (margin of safety). Second, since the trailing buffer is a prediction made before either vehicle reaches the intersection, it would seem that the prediction model used to calculate the trailing buffer needs some fine tuning to better match reality.

Even though the trailing buffer prediction algorithm still needs fine tuning, the experiment showed an approximate 3 second (trailing buffer) range between conditions where no one would turn in front of the POV and where everyone would turn in front of the POV. As the trailing buffer increased, the percentage of turns made in front of the POV also increased fairly linearly. However, the data collected on the decision to turn as a function of trailing buffer does not inherently suggest any guidance towards choosing a specific warning criteria.

The second parameter studied that is critical to the activation of an LTAP/OD warning was the warning timing or the point during the SV's intersection approach, at which, a warning should be triggered. Generally speaking, the warning point should be early enough for the driver to be able to integrate and act upon the warning, but not so soon that the warning is considered annoying. Fortunately, this study found that drivers were fairly insensitive to the warning point. The latest warning tested, 2 seconds before the stop bar, tended to be rated as little too late, and the earliest warning point, 4 seconds from the stop bar, tended to be rated as little too early but not considered annoying. Based on this study, the middle warning point, 3 seconds before the stop bar, would be recommended as it was equally rated as a little too early or a little too late. Further research is, however, needed to investigate whether or not the SV approach speed would have any influence on the desired warning point.

APPENDIX A: FOCUS GROUP SUMMARIES

FOCUS GROUP ONE

July 8, 2004
Rossmoor, Hillside Clubhouse, Delta Room

Safe older driving was explored in a focus groups conducted on July 8, 2004 at the Rossmoor Senior Adult Community in Walnut Creek, California. The participants in the focus group were Rossmoor residents who drove, were between the ages of 70 and 85, and passed a screening test of physical and cognitive acuity (see Appendix B). This summary describes the findings from the focus group. Dr. Susan Shaheen of California PATH facilitated the focus group with researchers assisting and taking notes.

BACKGROUND SURVEY RESULTS

At the beginning of the focus group, PATH researchers administered a survey that explored the socio-demographic attributes of focus group participants, travel patterns, and attitudes toward various transportation modes.

The following were the socio-demographic attributes of focus group participants:

- Five were women, and four were men;
- Five were between the ages of 75 and 84, and four were between the ages of 65 and 74;
- Five had a high school degree, three had a bachelor's degree, and one had a master's degree;
- Five were married, one was widowed, one was single, and one was divorced;
- Five had a household size of one, and four had a household size of two;
- Two had two members in the 65 to 74 age range, one had one in the 65 to 74 age range, and two had two members in the 75 to 84 age range, and three had an unspecified number of members in the 75 to 84 age range;
- Five had two drivers, and four had one driver in the household;
- Five had one auto available to the household, and four had two autos available to the household.
- One reported a 2003 pre-tax household income in the $10,000-$19,000 range, four were in the $20,000 - $49,000 range, and one reported a household income of more than $110,000.

Participants' responses to questions about their travel patterns indicated that they use the auto as their primary commute mode and use BART, buses, trains, and walking as supplemental modes:

- Six participants used a single occupancy vehicle more than two times a week;
- One participant used a single occupancy vehicle and walks to destinations;
- One participant used a single occupancy vehicle, BART, and a bus; and
- One participant used a single occupancy vehicle, BART, a bus, and a train.

In addition, five participants used a cellular phone and the Internet. Three other participants only used the Internet. None of the participants used a personal digital assistant. The average age at which participants obtained their driver's license was 18. Four had previously used transit regularly before moving to Rossmoor and four had not.

In the survey, a series of questions were asked to assess participants' attitudes toward their modal choices. Eight of the nine participants reported that driving is their primary transportation mode. The results indicated that participants generally felt most strongly that their primary travel mode was convenient, an expression of themselves, enjoyable, and economical. Participants felt less strongly about the safety and comfort of their primary mode. The results also indicated that participants' were slightly disinclined to experiment. Their attitude toward ease of auto use was only somewhat positive. They indicated a somewhat more positive attitude toward ease of transit use. In general, the participants who used transit indicated that they were more likely to use it to avoid driving at night (relative to other driving challenges). In addition, they were most likely to avoid taking transit because it took longer and/or cost more than other available modes, required use of a new transit schedule, and involved a transfer and/or a new station or stop.

INTRODUCTIONS & TRAVEL PATTERNS

Most participants reported that they had driven since their teens; only one participant began driving at age 32. One participant avoided driving and preferred to take transit whenever possible. Five participants reported that they took transit when traveling to San Francisco because it was less stressful than dealing with heavy traffic or having to find and/or pay for parking. However, two participants indicated that they still drove to San Francisco. One of these participants specified that he drove to San Francisco rather than riding BART because he was unfamiliar with transit systems. He also stated that he would not go somewhere if it was necessary to ride transit to get there. Six participants reported no limitations on their driving ability or comfort, and two indicated that they would not drive in bad weather. None reported a marked difference in their driving patterns between the weekend days and weekdays.

ACCESSING VEHICLES

Remote Keyless Entry

Participants expressed mixed views about remote keyless entry. Two participants liked the technology, one considered it a necessity for security, and others preferred manual keys. One that used keyless entry liked to open all doors, and mentioned that it was easier for opening the trunk, if holding packages. One liked simpler devices and mentioned that too many buttons are confusing. One expressed frustration with the electronic combination pad, citing it as difficult to use in a hurry. One participant's wife did not like the feature that caused the automatic locking of all doors when exiting a car.

One participant would prefer if the door lock was on the inner door handle, rather than at top of door where the window comes out, because it is easier to reach.

Loading and Unloading Vehicles

Most of the participants (five) agreed that when buying a car, they preferred a low truck lip so that they did not have to lift packages very high. One reported using the trunk very rarely, preferring to use the backseat for groceries, except in the case of valuable goods, which she puts in the trunk. One commented that a drop down rear seat was a nice feature when a flat surface is needed, and a split back seat is very nice and allows one to drop down the passenger seat to store longer objects.

Several participants liked that the idea of a removable partition/netting that did not allow objects to shift around and/or slide to the front of a trunk and, in general, made it easier to retrieve objects. Similarly, a suggestion was made to put hooks in the trunk that allow you to “bungee” objects in place.

Regarding trunk space, a few participants mentioned that they kept their golf clubs or a box of maintenance supplies in the trunk. Several expressed frustration with the donut tire in the car because it does not provide long-term use. Three agreed that cars should just have a regular sized spare tire in the trunk.

Entering and Exiting

Several comments were made about entering and exiting a vehicle. One participant mentioned that certain cars (like the Mercedes Benz) with low-bucket seats made it difficult to get in and out of the vehicle. One participant with a hip replacement said cloth material made it difficult to slide in and out and suggested the use of leather rather than cloth for seniors. Another participant disagreed and stated that leather gets very hot and cold, but cloth handles temperature extremes well. One participant mentioned that hitting his knees on the steering column was a problem when entering a vehicle. One petite participant felt she was too close to the steering wheel and that if an airbag was released she could be hurt.

When the conversation turned to seat adjustment features, eight participants agreed that controls allowing drivers to customize their seats and mirrors would be helpful. One participant said that she was the only person who drove her car and thus found this feature unnecessary. One mentioned that when you take a car to a mechanic they push the seat far back, and it can be inconvenient to get it back to the original setting. Several nodded in agreement, particularly women. One participant cited the advantages of his son’s sports utility vehicle: “when you are ready to get in the car, you can push a button and the seat will go back as far as you want it to and once you get in, you can push a button and the seat slides back into place (i.e., memory seat).” He mentioned that this feature would be great in any car, but noted its cost. Two participants used seat cushions to adjust their seat height.

Vehicle Access Factors that Affect Purchase Decisions

Participants indicated that a shallow trunk depth and four doors were important factors in their decision to purchase a vehicle. It was mentioned that a deep trunk was difficult to load and unload while a shallow loading trunk meant that passengers did not have to lift packages up as high. All nine participants drove four-door cars: four door cars were preferred to two-door cars because it is easier to get more than two passengers in the car, their smaller doors were easier to handle, and, in general, they were easier for passengers to get in and out of.

Handles to Ease Vehicle Entry and Exit

There were a range of views on including handles in vehicles to ease entry and exit. It was mentioned that such handles were helpful for passengers getting in and out, passengers liked holding on to them, and they were useful when teaching kids to drive. One said he currently did not use the handles, but that he may want handles down the road as he aged. Another mentioned that handles might be useful for a temporary disability. Two thought that they were useful for helping people shift position during long trips. Another thought that overall, handles were a good idea, but not essential for this age group. Several mentioned that running boards that emerge when a vehicle door is opened make it easier to get in cars.

DIFFICULTIES DRIVING A VEHICLE

Parking, Merging, and Reversing

One participant said that parallel parking was very difficult because of the need to look behind you. Another mentioned that it is difficult to park because of the variation in the size of cars on the road (e.g., sport utility vehicles and mini coopers). One suggested that every car should have a backup signal, a beep like a truck, to let others know when you are backing up. Two participants preferred street parking to garages because they wanted to avoid the bottlenecks that occurred after events ended. One thought it was safer and less of a hassle to park in a garage rather than on the street because cars passing on the street. Regarding valet parking, several liked valet parking with the exception of the fact that some valet drivers changed the seating positioning without returning it to the original position. Petite women participants were particularly affected by this problem. A few expressed interest in cars that assisted with parallel parking. Some mentioned that, in the past, they used curb feelers to assist with parallel parking (or wires attached to car fenders that scratch the curb).

Left Turns

One participant thought that left turns were difficult because it required physically turning one's neck to the left. This participant thought that there should be something more than the mirror to facilitate rear vision. Many agreed that it would be desirable to eliminate the blind spot. One suggested the use of a larger rear-view mirror that clipped on to the standard rear-view mirror, but another mentioned that this would not eliminate the problem. Three participants agreed that it was disconcerting that the right hand side-view mirror was wide angled and preferred that the mirrors reflect the actual size of the vehicles from behind. One participant said that drivers should not rely too much on mirrors.

Suggestions for Improving Vehicle Design

A few expressed interest in a sun visor that would actually keep sun out of eyes or a tinted windshield that would make driving into the sun easier. One participant suggested a sun visor that extends down the length of the entire front window.

VEHICLE USAGE

Knobs, Dials, LED Lights, and Turn Signals

Three participants mentioned that they sometimes confused the gas tank release lever with the trunk release lever and suggested differentiating these levers. Another participant liked the levers under the seat to release the trunk/gas tank. One participant expressed interest in the idea of cost savings for leaving out extra features (i.e., the feature that pops the trunk from inside the car). Regarding the gas and trunk levers, one said that the size was okay but suggested differentiating them because it is easy to confuse them. Another mentioned problems with confusing the gear shift with the windshield wipers.

A wide variety of views were expressed on these driving design features:

- Transparent extension to sun visor to shield eyes from the sun when driving west (two supported);
- Make visor lower;
- Push buttons rather than turning knobs so you do not have to take your eyes off the road (two supported);
- Remotes for operating radio;
- Buttons to operate radio on steering wheel;
- Improve LED lights so that they can be read during the daytime;
- A sign telling you which side of the vehicle the gas tank is on;
- Lights that provide messages about whether things need to be fixed;
- Light on dash to indicate that brake-light or tail-light is out (a few agreed); and
- Manual override for windows in case of submerged vehicle.

Use of Radio/CD Equipment

Seven participants reported listening to the radio while driving. Another reported not learning to operate it. One reported using the radio to stay alert. Two had experienced difficulty operating the radio.

Driving in New Areas, Getting Lost, and Following Directions

Five participants used Yahoo.com™ or Mapquest™ to find directions, and one mentioned AAA triptiks. One used a regular map from a dealer. One participant's neighbor had to pull over to use GPS wayfinding. This participant thought that this feature was unsafe to use while driving, and that it was better to have a passenger operate it. Two used cell phones while driving, but most thought that is was unsafe to use cell phones while driving.

Driver's Test

One participant thought that people should be required to take an actual driving test every few years. He had not taken a new driving test since his very first one.

FOCUS GROUP TWO

August 4, 2004
Rossmoor, Hillside Clubhouse, Delta Room

Safe older driving was explored in a focus groups conducted on August 4, 2004, at the Rossmoor Senior Adult Community in Walnut Creek, California. The participants in the focus group were Rossmoor residents who drove, were between the ages of 70 and 85, and passed a screening test of physical and cognitive acuity (see Appendix B). This summary describes the findings from the focus group. Dr. Susan Shaheen of California PATH facilitated the focus group with researchers assisting and taking notes.

BACKGROUND SURVEY RESULTS

At the beginning of the focus group, PATH researchers administered a survey that explored the socio-demographic attributes of focus group participants, travel patterns, and attitudes toward various transportation modes.

The following were the socio-demographic attributes of focus group participants:

- Five were men, and four were women;
- One was between the ages of 65 and 74, and the remaining eight were between the ages of 75 and 84;
- Four had a bachelor’s degree, three had a master’s degree, and two had an associate’s degree;
- Six were married, two were widowed, and one was single;
- Five had a household size of two, and four had a household size of one;
- Four had a household with two members in the 75 to 84 age range, three with one in the 75 to 84 range, one with two in the 65 to 74 age range, and one with one member in the 85 and above age range;
- Six had one driver in the household and one auto available to the household, and three had two drivers in the household and two autos available to the household.
- One reported a 2003 pre-tax household income of under $10,000, five were in the $20,000 - $49,000 range, two had household earnings of $50,000 - $79,000, and one reported a household income of more than $110,000.

Participants’ responses to questions about their travel patterns indicated that they used the auto as their primary commute mode and used BART, buses, and walking as supplemental modes:

- Three participants used a single occupancy vehicle more than two times a week;
- Four participants used a single occupancy vehicle and walk to access destinations;
- One participant used a single occupancy vehicle, carpool, and walk; and
- One participant used a single occupancy vehicle, BART, a bus, and walks.

In addition, six participants reported that they used a cellular phone and the Internet, two additional participants only used the Internet, and one only used a cellular phone. None of the participants used a personal digital assistant. The average age at which participants obtained their driver's license was 18. Five had previously used transit regularly before moving to Rossmoor, and four had not.

In the survey, a series of questions were asked to assess participants' attitudes toward modal choice. All participants reported that the auto was their primary travel mode. The results indicated that participants generally felt that their primary travel mode was convenient and comfortable. Participants felt less strongly about the safety, economy, self-expression, and enjoyment of their primary travel mode. The results also indicated that participants' attitudes towards experimentation and ease of transit and auto use were relatively neutral. In general, the participants who used transit indicated that they were more likely to use it to avoid driving at night (relative to other driving challenges). In addition, they were most likely to avoid taking transit because it cost more than other available modes and involved a transfer and/or a new station or stop.

INTRODUCTIONS & TRAVEL PATTERNS

As indicated above, all nine participants reported that the auto is their primary mode of transportation. All participants indicated that they had been driving since their teens or early twenties. Eight participants reported that they took BART when traveling into San Francisco because they were unfamiliar with the city and/or parking was expensive and hard to find. Aside from taking BART into San Francisco, participant's transit use appeared to be limited. One participant stated that she liked taking the shuttle around Rossmoor. Four took the bus occasionally, but three described their frustration at the longer bus travel times relative to auto travel times. Four stated that they did not use any transit other than BART. Five participants reported that they avoided driving during congested roadway conditions on weekday peak commute periods, and one participant avoided driving during and after heavy rain. Only one participant felt completely comfortable driving anywhere at anytime. In general, most participants indicated that they were fairly comfortable driving, but they preferred to avoid peak traffic. None expressed a marked difference in their driving patterns between the weekend days and weekdays.

ACCESSING VEHICLES

Entering and Exiting

Many participants (six) thought that cars with seats too low to the ground were hard to enter and exit, for example, the Mercedes Benz. Another person stated that some friends would not drive with him because his car was too low to the ground, and they had to turn around to get out of his car.

Participants expressed mixed opinions about the ease of entering and exiting vehicles as well as other features of sport utility vehicles (SUVs). One person said she would not drive an SUV because it was too high off the ground. Another person said that it was easy to slide out of an SUV, and it was easier to see ahead. Three other participants agreed with this statement. Another person said he had an accident because he could not see beyond the SUV in front of him.

To address the difficulties of entering and exiting a vehicle, one person stated that he used and liked his hydraulic lift. The other participants seemed interested in this feature.

Loading and Unloading Vehicles

Some participants indicated that they tended to load items inside the passenger area of the car rather than in the trunk. Two participants said that they preferred putting packages on the backseat or the floor, rather than in the trunk. One participant commented that she typically stored one bag on the front seat; however, if there were several packages, then she stored them in the trunk. She stated that placing items on seats could be a problem because if the car stopped quickly, then the bag would tip over and spill its contents. One woman commented that she could not get her walker with wheels into the trunk, and as a result she had to put it in the back seat of her four-door sedan.

On the other hand, one participant felt items should be in the trunk for safety. She also commented that she had to get at a low angle to get something from the back seat or floor. Another participant commented that in most new cars the trunk was down near the bumper to eliminate the need to lift heavy items up high. One person said that it was easy to load and unload her SUV, which had a foam mattress in the back. Another person also said he felt it was easier to unload an SUV relative to a sedan.

Six participants agreed that they would like netting to prevent items from moving around in the trunk. One person commented that it should be possible to easily connect and disconnect the netting.

Remote Keyless Entry

Six participants had remote keyless entry devices. Some participants described the features of the electronic key that they disliked. One did not like the “honk” sound produced when locking and unlocking the doors. One gentleman complained that sometimes his device did not work. Another commented that he had to get used to using it and that he once hit the panic button by mistake (i.e., a learning curve). Another gentleman felt that the alarm was disturbing in quiet areas.

On the other hand, there were features of the devices that they did like. Five agreed that they sometimes used the remote electronic key to locate their cars. Another commented that she could use the panic button for safety if she saw a stranger. One person stated that she wished she had one. One gentleman said that he would never buy another car without one again, and he was upset that his current car does not have one.

Remote Release for Trunk and Gas Tank

A range of opinions were expressed regarding the remote release for the trunk and gas tank and on issues related to the location of such vehicle features. One participant felt the remote release for the trunk/gas was very handy, especially when she did not have her keys. Several people commented on the location of the remote release levers for their gas tanks and trunks. One said that his lever was on the lower part of his dash. One woman was not sure if she had one because she had not found it yet, although this was not a common problem among focus group participants. Another commented that he had just discovered a soda can holder after one year. One gentleman commented that it would be nice to have a map of the location of items in the car. Another commented that color-coded knobs would be helpful. One gentleman suggested a diagram on the trunk. One gentleman said instructions were needed on how to release the front hood. Another said that the release gadget under the hood was difficult to maneuver. Another commented that the brake and hood release levers looked alike. Three to four people agreed that the instruction book was too long to read. One gentleman said his book had 600 pages. One woman commented that she only wanted to know the basics.

DIFFICULTIES DRIVING A VEHICLE

Next, the discussion turned to difficulties faced by participants when driving a vehicle. A wide variety of views were expressed:

- Five people agreed that headlights on other vehicles were too bright and hurt their eyes at night.
- Four agreed that vehicle safety was important. Some were concerned about car safety design (i.e., crash protection and rollovers in SUVs and minivans). Two to three participants stated that they felt side airbags were safer.
- People who drove an automatic (vs. manual) vehicle did not use the hand or footbrake, but they thought that those who did should be careful to release it before driving. No one had a problem using a parking brake.
- One felt that cars were made for "normal-sized people," rather than tall or petite individuals. For tall people, there was not enough legroom, and this interfered with circulation. One felt that SUVs were better for tall people because they could swing their legs around.
- Five participants drove a four-door sedan. One gentleman commented that he had a two-door to avoid taxiing others around. Another person stated that cars with only two doors were dangerous because they were hard to get out of in an accident. One person felt that

the seatbelts in the back seat of a two door were difficult to use and unsafe. Another commented that the door was too wide in a two-door vehicle to get out of the car in a tight parking space.

Parking, Merging, and Reversing

Participants indicated that the lack of available parking and parking expense were significant problems. One person preferred not to parallel park but said that he could if necessary. Four agreed that a tight car turning radius was helpful. One person did not like to parallel park in small spaces. Participants expressed frustration at SUVs parking in compact parking spaces and at people who occupy two parking spots to keep their cars from getting dents.

Some participants expressed difficulty merging. One commented that other cars and people were reluctant to merge or slow down. One individual shared that he had a blind spot in his minivan. Five people also commented that they had problems with blind spots. One woman suggested adjusting mirrors to correct the blind spot. One gentleman stated that you do not have a blind spot, if you can see the car in both the rearview and side mirrors. It was stated that pillars in front of and to the right of cars blocked views and made it harder to see other vehicles.

One person commented that she could not see behind her when she reversed her car. One person suggested that a camera on the rear bumper would be helpful (like motor homes). One gentleman commented that all cars in five years should have cameras – especially in high SUVs. He said that the camera was a plus but not the main reason for buying his car. He stated that he would want a camera in a new car because it would help him avoid hitting people and things. One woman used her hazard light for backing up. One person would like a beeping sound (like trucks) for reversing. One commented that it was a problem when two cars were merging into the same lane from opposite sides. One woman said she used her hazard lights if she was lost and needed to pull over.

Left Turns

One gentleman stated that he would drive around the block or go three blocks out of his way to avoid making a left turn. One woman said that she was told in the “driving alive” class to avoid left turns. Three participants agreed that they avoided making left-hand turns. Another gentleman said he could not see the curb, road divider, or median when making a left-hand turn. Another stated that he needed to adjust the mirror on the left side of his car to see the curb.

VEHICLE USAGE

Adjusting Seats

Two persons stated that they had automated seats with a button for customized adjustment. One gentleman complained that the bar that raised his seat up tilts the seat at the same time. He would prefer the seat to just go straight up. Five participants found it annoying when someone else adjusts their seat, especially if they are taller or shorter. Some indicated that automated seat adjustment was a nice feature. One person commented that it was hard to adjust the seat in other people’s cars because it is difficult to figure out how to use the adjustment levers. She suggested that car manufacturers should standardize seat adjustment levers. The gentleman with the hydraulic lift said it was the reason he bought his car. Others agreed it that it would help if they could elevate their seat. Another person commented that tall people needed more head room.

Mirror Adjustment

One gentleman complained about the mirror distortions that make cars behind you look farther away. He stated that turning is difficult when you do not know where other cars are located. One woman stated that she would like a bigger and longer rear-view mirror.

LED Light Displays

One gentleman complained that the display panel was dim when he turned his lights on to go through a tunnel. Two persons agreed that the dash lights were too dim. One woman complained that the button for the air conditioning was too dim and small to see. She could not tell when the button was pushed in or out.

Turn Signals

One person complained that he could not hear the turn signal, so he forgets to turn it off. He suggested it should be louder or the dash light (signal) should be brighter. Also, he stated that it would be nice to have an adjustable volume control for the turn signal.

Door Handles

One woman complained that the door handles sometimes pinched her hand.

Dashboard

One woman complained that she could see the tachometer but not the speedometer because the steering wheel was in the way.

Cell Phones

Seven participants had cell phones. Many felt uncomfortable using the phone while driving. One person complained that people on phones do not pay attention to the road when pressing cell phone buttons. Others agreed with this statement. Only one person dialed a cell phone while in a vehicle but only after when the car is stopped.

Radio Controls

Participants indicated that radio controls were distracting. One suggested the use of a remote control or easily accessible buttons. GPS (or in-vehicle navigation system) was also considered a driving distraction. On the other hand, one person stated that he used his GPS all the time and would not buy another car without it. Many participants would like a compass in their car. One person complained that the compass readout in his Lexus was too small.

Driving Outside Territory

Four people used the Internet for mapping their destination. One person complained that the Internet map was not always accurate and did not always give the most direct route. Six people used traditional maps – some in addition to the Internet. One person commented that it would be nice to know the street prior to their destination street. Two people stated that they minimized travel outside the Rossmoor territory.

Last Thoughts

Concern was expressed about automatic windows did not stop on the 2002 Camry. It was stated that there should be a safety stop on the window to avoid getting arms caught and to protect children.

A desire was expressed for greater availability of hybrids by more automakers at cheaper prices. It was stated that there is a long waiting list for these cars, they are good for the environment, and they use less gas.

TOYOTA FOCUS GROUP THREE

Morning, September 21, 2004
Rossmoor, Hillside Clubhouse, Delta Room

Safe older driving was explored in a focus groups conducted on the morning of September 21, 2004, at the Rossmoor Senior Adult Community in Walnut Creek, California. The participants in the focus group were Rossmoor residents who drove, were between the ages of 70 and 85, and passed a screening test of physical and cognitive acuity (see Appendix B). This summary describes the findings from the focus group. Dr. Susan Shaheen of California PATH facilitated the focus group with researchers assisting and taking notes.

BACKGROUND SURVEY RESULTS

At the beginning of the focus group, PATH researchers administered a survey that explored the socio-demographic attributes of focus group participants, travel patterns, and attitudes toward various transportation modes.

The following were the socio-demographic attributes of focus group participants:

- Four were men, and six were women;
- Two were between the ages of 65 and 74, seven were between the ages of 75 and 84, and one was 85 or over;
- Four had a Ph.D., one had a master's degree, two had a bachelor's degree, and one had graduated high school (two indicated another degree but did not specify);
- Six were married, one was divorced, and three were widowed;
- Six had a household size of two, and four had a household size of one;
- One had a household with one in the 65 to 74 range, one with two members in the 64 to 74 age range, three with one in the 75 to 84 range, one with two in the 75 to 84 age range, and one with one member in the 85 or above age range;
- Four had one driver in the household and six had two drivers in the household;
- Five had one auto available to the household and five had two autos available;
- One reported a 2003 pre-tax household income of under $10,000, one fell into the $20,000 - $49,000 range, two had household earnings of $50,000 - $79,000, and two reported a household income in the $80,000 to $109,000 range (four declined to respond).

Participants' responses to questions about their travel patterns indicated that the auto was their primary travel mode, followed by walking, and then carpooling.

- Ten participants used a single occupancy vehicle more than two times a week;
- Eight participants walked more than two times a week; and
- One participant carpooled more than two times a week.

In addition, six participants reported that they used a cellular phone and the Internet and two used the Internet. None of the participants used a personal digital assistant. The average age at

which participants obtained their driver's license was 19.5 years old. Two had previously used transit regularly before moving to Rossmoor, and eight had not.
In the survey, a series of questions were asked to assess participants' attitudes toward modal choice. All participants reported that the auto was their primary travel mode. The results indicate that participants generally feel that their primary travel mode is convenient, comfortable, and economical. Participants feel less strongly about the safety, self-expression, ease of use, and enjoyment of their primary travel mode. The results also indicate that participants' attitudes towards experimentation and ease of transit use are relatively neutral. In general, the participants indicated that they were more likely to use transit to avoid bad weather, high traffic roads, and unfamiliar area (relative to other driving challenges). In addition, they were most likely to avoid taking transit because it takes longer than other available modes and involves a transit schedule, transfer, and/or a new station or stop.

INTRODUCTIONS & TRAVEL PATTERNS

Participants expressed an overwhelming preference for travel by automobile. Seven of the nine participants reported that they had driven for at least 55 years; one had been driving for 50, and another for only 40. Every resident reported traveling primarily by car, and only two said that they drive less than seven times per week.

Aware of age-related driving limitations, most tried to avoid congestion or highways when possible, but less than half (three) avoided driving at night. One resident only drove at night within the retirement community because of eye problems. Five residents tried to avoid congestion, the freeway, or both, and one said he used the carpool lane when traveling with his wife. Two residents said they avoid the highway because of vehicle speeds and the traffic, although one resident preferred highways to city streets.

Most participants made local trips primarily, but three participants reported taking longer trips by car, and several traveled throughout the Bay Area. Two residents said they greatly enjoyed driving. Most expressed little difference in their travel behavior on weekends and weekdays, although one took longer trips on weekends. One resident preferred driving on weekends because of reduced traffic.

Despite their overwhelming preference for cars, participants did report using transit. Six participants used BART to travel to San Francisco and/or Berkeley, and one used the service exclusively for travel to Berkeley. The frequency of their transit use, however, varied: one participant reported using it only once in her entire lifetime, and others used it more frequently. Two residents used the Rossmoor shuttle, and one used the ferry twice per month. Three reported never using transit at all.

Of those who traveled to the city by transit, one reported the attraction of cultural activities like the symphony, opera, or museum, and one reported using it to get to the San Francisco airport. Of those who never used transit, two described their cars as more convenient for personal travel, and one said that knee replacements made access at transit stations difficult. One participant said that he uses Amtrak to visit family in Fresno.

Several residents reported difficulty with transit. Aside from the participant with knee replacements, mentioned above, other complaints included limited parking at stations and the complicated interface of BART with San Francisco's MUNI system. The resident who found it difficult to park only used the system on weekends when more spaces were available; the resident who disliked MUNI avoided the city when possible.

ACCESSING VEHICLES

Remote Keyless Entry

Five residents used remote electronic keys for their vehicles. In general, their feelings about the technology were mixed. One noted that they are helpful at night or when carrying groceries. One participant liked the alarm feature, but others complained that it goes off too easily and is often ignored by bystanders. Another participant found it difficult to remember to press the button twice to open the door and once to lock it. Two residents had removed the automatic lock feature on their car because of lockouts. Another resident complained about the short battery life of his device. There was little interest among those residents without the devices to purchase one.

Loading and Unloading Vehicles

Four participants exclusively used the backseat or floor for transporting packages, and five used the trunk. Participants complained that trunks with a high lip were particularly bad for heavy parcels that had to be lifted up before they could be removed. Several residents noted that items tend to slide around in the trunk but are more stable in the backseat. One participant suggested a compartmentalized trunk and another recommended Velcro.

Entering, Exiting, and Seats

Residents expressed varying opinions about their automobiles' seats and doors and were particularly concerned about accessing their vehicles. Participants generally felt that their seats were big enough and had enough legroom to get in and out of the car without difficulty. Three had difficulty when getting into the front seat, and eight had trouble in the back. Adjustable seats were viewed favorably, although one participant complained that it was more difficult to get into his car after his wife had moved the seat forward. One participant said that Suzukis have more legroom under the steering wheel. Four participants complained about doors that closed automatically while they were exiting. Two participants complained that their doors did not open wide enough for easy access, and one mentioned Toyotas in particular as a problem in this regard. Two participants had learned a technique in physical therapy that made getting in and out of cars easier.

Seat comfort and safety were also of particular concern to participants, but there was no clear preference for one type of seat over another. One participant who experienced lower back pain had difficulty with bucket seats, but another found them more comfortable. Two participants expressed a preference for seats higher off the ground, although there was some reluctance to purchasing SUVs. Several participants complained that, because they were petite, they were unable to see over the dashboard, and one noted that, by moving closer to the steering wheel, she was putting herself at higher risk in an accident. One resident expressed preference for the Prius, which had higher seats.

Car Type

Participants expressed a variety of concerns that influenced their automobile preferences. Several complained about blind spots, and two referred specifically to the Honda Accord and Toyota Corolla as problematic in this regard. One participant also complained that the nose of the Honda Accord is too long. However, the Accord, Camry, and Saturn station wagon were identified as particularly easy to enter. Two participants were concerned about the cost of their car; one mentioned that the Corolla was more economical than the Camry, and one drove a four-cylinder sedan because of its gas mileage. Another found that his automatic headlights took too long to activate when driving into a tunnel. Another complained about the pattern his air conditioning vents made on the windshield, and that he was forced to cover them with a leather strap.

Several participants, however, made positive remarks about their vehicles. One resident was particularly happy with her sunroof, and a Lexus driver found the pre-programmed seat adjustments for himself and his wife very useful. An Accord driver expressed similar support for his car seats, which could be adjusted up and down as well as back and forward.

Most drove four-door automobiles. One participant drove an Accord, two drove Corollas, one drove a Camry, two drove a Lexus, one drove a Saturn station wagon, and two others described their cars as typical sedans.

DIFFICULTIES DRIVING A VEHICLE

Parking, Merging, and Reversing

Three participants expressed difficulty with parallel parking, specifically with turning their heads to look behind them and with blind spots in their mirrors. One participant expressed a preference for “wink” mirrors that eliminate blind spots, and another praised her remote-adjustable rear-view mirror as a parking aid. Another complaint was that there was not enough space to park on the street without hitting another car. One participant preferred on-street parking, but another expressed a preference for garages, particularly during hot weather. One participant had never learned how to parallel park.

One participant reported that it was difficult to determine the speed of incoming cars while merging, particularly on curved roads, and another complained about crossing multiple lanes. Six expressed concern about crossing multiple lanes of traffic and tried to avoid the practice when possible. Cars with large pillars in the back (such as the Camry and Accord) were flagged for having blind spots, and one participant mentioned that the hatchback she used to own did not have this problem. Again, several expressed a preference for remote mirrors, and one suggested that convex rear-view mirrors, like those currently used on boats, be installed in new autos.

Several participants felt that reversing was difficult, and one, who had been through the AARP mature driving course, always drove out of parking rather than backing up because of difficulty turning his neck. Participants viewed improvements to vehicle design favorably, including hazard lights and beeps like those currently in use on large vans and golf carts.

Miscellaneous Concerns and Suggested Improvements

One participant found that Berkeley has too few left-turn lanes. Other concerns included glare-blinding headlights. One participant used the adjustable visor on the Accord to block out the sun, and another praised the double visor in his Taurus. Another suggested that automobiles be equipped with an automatic dimmer for approaching other vehicles at night.

VEHICLE USAGE

Knobs, Dials, LED lights, and Turn Signals

Several participants had difficulty with their dashboard displays. One Corolla driver felt that his display was not bright enough and had trouble reading the odometer. A Lexus driver found that his odometer was also difficult to distinguish during the day because the display color was similar to the background. The participant's wife (also present) complained that the mileage display on the Lexus had to be switched between the trip mileage and total miles, and preferred her Saturn, which displayed both simultaneously. An Accord driver could not read the digital clock radio because of the slant of the dashboard.

Several participants had trouble with their radios. One had difficulty adjusting her radio for static and only listened to it in light traffic. Another participant said that he had always had trouble with static but that when he sold his car he realized for the first time that he had never lifted the antenna.

Two participants (a married couple) expressed difficulty with their turn signals because they were both hard of hearing, and the device that makes signals louder was incompatible with their two cars—a Saturn and a Lexus. Another recommended that signals turn off automatically if the driver does not turn for a certain amount of time.

A wide variety of views were expressed on assorted other design features:

- One participant liked the automatic ignition light in his Accord when the car door was opened at night.
- Another liked the two different sounds his car made: one for opening the door and another for when the keys were left in the ignition.
- One Camry driver noted that her car will not allow you to close the door with the key in the ignition, but another participant said she would not like this feature.
- Two participants expressed support for a beep notifying drivers that their headlights are left on.

- One participant inquired about the Studebaker “Hill Lock” on his old car, which automatically prevented cars from rolling backwards on a hill with one tap of the brake.

Cell Phones

Five participants used cell phones, but all said that they did not use them while driving.

Driving in New Areas, Getting Lost, and Following Directions

Two participants used MapQuest™, and another two preferred traditional maps. One avoided unfamiliar locations entirely.

TOYOTA FOCUS GROUP FOUR

Afternoon, September 21, 2004
Rossmoor, Hillside Clubhouse, Delta Room

Safe older driving was explored in a focus groups conducted on the afternoon of September 21, 2004, at the Rossmoor Senior Adult Community in Walnut Creek, California. The participants in the focus group were Rossmoor residents who drove, were between the ages of 70 and 85, and passed a screening test of physical and cognitive acuity (see Appendix B). This summary describes the findings from the focus group. Dr. Susan Shaheen of California PATH facilitated the focus group with researchers assisting and taking notes.

BACKGROUND SURVEY RESULTS

At the beginning of the focus group, PATH researchers administered a survey that explored the socio-demographic attributes of focus group participants, travel patterns, and attitudes toward various transportation modes.

The following were the socio-demographic attributes of focus group participants:

- Four were men, and four were women;
- Three were between the ages of 65 and 74, and five were between the ages of 75 and 84;
- Five had a bachelor's degree, one had an associate's degree, and two had graduated high school (two indicated another degree but did not specify);
- Four were married, one was single, one was divorced, and two were widowed;
- Four had a household size of two, and four had a household size of one;
- One had a household with one in the 65 to 74 range, two with two members in the 64 to 74 age range, four with one in the 75 to 84 range, and one with two in the 75 to 84 age range;
- Four had one driver in the household, and four had two drivers in the household;
- Seven had one auto available to the household and one had two autos; and
- Two reported a 2003 pre-tax household income in the $20,000 - $49,000 range, one had household earnings of $50,000 - $79,000, and one had more than $110,000 (four declined to respond).

Participants' responses to questions about their travel patterns indicated that the auto was their primary mode of travel, followed by walking, carpooling, and BART.

- Seven participants used a single occupancy vehicle more than two times a week;
- Two walked more than two times a week;
- One participant carpooled more than two times a week; and
- One participant used BART more than two times a week.

In addition, five participants reported that they used both a cellular phone and the Internet, and two used the Internet only. None of the participants used a personal digital assistant. The average

age at which participants obtained their driver's license was approximately 19 years. Four had previously used transit regularly before moving to Rossmoor, and four had not.

In the survey, a series of questions were asked to assess participants' attitudes toward modal choices. All participants reported that the auto was their primary travel mode. The results indicate that participants generally felt that their primary travel mode is safe, convenient, comfortable, and economical. Participants feel less strongly about the self-expression, ease of use, and enjoyment of their primary travel mode. The results also indicate that participants' attitudes towards experimentation and ease of transit use are relatively neutral. Most of the participants (with the exception of one or two) indicated that adverse driving conditions (e.g., bad weather, left turns, high traffic roads, and unfamiliar area) were important factors in transit use. In addition, five participants indicated that longer travel times sometimes cause them to avoid taking transit. One or two others indicated that a new transit schedule and/or a new station or stop caused them to avoid transit.

INTRODUCTIONS & TRAVEL PATTERNS

Participants traveled primarily by automobile. Seven of the nine participants reported that they had driven for at least 59 years, and only one had driven for fewer than 50 years. The car was the primary transportation mode for every participant, and only one reported to drive fewer than seven times per week.

Most participants were comfortable driving on congested freeways and at night. Only one participant was bothered by congestion. Several participants, however, reported concerns about driving at night, including incoming lights, driving in the rain when it was dark (two), the threat of a hit and run at night, and glare (although one participant found that glare ceased to be a problem after she had cataract surgery). One resident actually preferred to drive at night because of the reduced traffic.

Most driving was done locally, but two participants made longer trips by car. Residents described their weekend and weekday travel as about the same, although one took longer trips on weekends, and another used the weekends to drive to San Francisco.

Residents reported occasional transit use. Seven used BART to travel to San Francisco, and three used it to get to other destinations in the Bay Area, including Berkeley and Oakland. One resident reported using the Rossmoor shuttle. How often they used transit, however, varied: three participants reported using it four or fewer times per year, and three others used it between one and three times per month. One resident used transit (either the Rossmoor shuttle or BART) only when his wife was using the car. Two others reported never using transit at all, and both described their cars as more convenient for personal travel. Of those who traveled to San Francisco by transit, several reported the attraction of cultural activities.

ACCESSING VEHICLES

Remote Keyless Entry

Five residents had remote electronic keys for their vehicles. Despite the prevalence of this technology, there was no clear preference for it among participants. One resident liked that the car made noise when opened and when locked, and one liked the alarm feature. A Mercury Sable owner, however, found that his device malfunctioned and was unreliable. One participant wished that her lock would fully open the trunk rather than just unlock it.

Loading and Unloading Vehicles

Most participants used their trunks for transporting packages, but one used the seat and another used the trunk and seat interchangeably. One used the backseat for packages simply out of habit, but others complained that trunks with a lip (as opposed to SUVs and station wagons, with completely flat trunks) were particularly bad for heavy parcels that had to be lifted up before they could be removed. One participant preferred to use the trunk because of the protection it provided against theft. Most participants had both automatic hood and trunk releases and used them frequently.

Entering, Exiting, and Seats

Participants generally felt that their seats were big enough and had enough legroom to get in and out of the cars easily. One participant, however, found that the Volvo had enough legroom in the front but not in the back. Generally, the participants liked adjustable seats, and one was particularly happy with the adjustable steering wheel feature, which made entry and exit easier.

Participants expressed a wide variety of preferences for different types of seats, both for access and egress and driving comfort. Feelings were mixed about bucket seats – there was no clear consensus about preference for bucket or bench seats, and one participant complained that his bucket seat was not easily adjustable. Another said his wife felt confined in bucket seats. One participant liked heated seats.

Car Type

Several participants complained about blind spots and difficulty with the right side-view mirror. Their primary concerns were a limited field of vision and depth perception. One participant also complained that the nose of the Honda Accord was too long. Another participant mentioned that his four-door Toyota felt safe. One participant complained that his headrest was too high and too wide. Three participants identified the Volvo as a particularly safe car. An Accord driver complained about the car’s turning radius.

When the discussion turned to gas mileage, participants expressed varying opinions about their automobiles and the benefits of hybrid vehicles. One complained that the Accord only gets 20 miles per gallon on city streets, and another found that six-cylinder cars have worse mileage. Five participants expressed support for hybrids, but others noted that the cost is not justified unless gas prices continue to climb, or if the driver spends a lot of time on highways.

Most drove four-door automobiles. Two participants drove Hondas, two drove Toyotas one drove a Volvo, one drove a Buick, one drove a Mercury, one drove a Mercedes, and one drove a

Hyundai.

DIFFICULTIES DRIVING A VEHICLE

Parking, Merging, and Reversing

Four participants had trouble with parallel parking. Of particular concern were blind spots and the difficulty several participants had turning their necks. One participant had a GPS-enabled camera on the back of her car that made parking easier. Another complained about clearance during parking and was concerned about scraping his car.

Merging into the right lane was particularly difficult because of the depth perception problem in the right-hand mirror and was considered to be particularly dangerous at high speeds. One participant mentioned the Volvo in particular as having a troublesome blind spot when merging. One suggested larger, sectioned mirrors for better visibility. Eight residents thought that a beeper would be useful for reversing their vehicles.

Miscellaneous Concerns and Suggested Improvements

One resident had trouble gauging distances while making left-turns. Other concerns included drivers passing on the right, difficulty at busy intersections, glare, and blinding headlights.

VEHICLE USAGE

Knobs, Dials, LED lights, and Turn Signals

Several participants had difficulty with their dashboard displays. A Volvo driver also was unable to read the digital clock, and another participant expressed a preference for a big clock in the dash rather than a small one on the CD player display. One participant complained that the steering wheel was too large and made it difficult to see the odometer.

Several participants had trouble with their radios. One had difficulty adjusting the tuner for static, and used a CD player for long trips. A Mercedes driver found radio/CD button adjustments confusing, and another participant suggested that knobs be placed on the steering wheel for easy access. One participant found it difficult to remember to turn off blinkers and would have liked an alarm to notify the driver when his or her blinkers were still on. Another noted that GM already has this feature installed in several of its models.

A wide variety of views were expressed on assorted other design features:

- One participant liked overhead interior lights that stay on while driving.
- Five participants would prefer a full spare tire to the “donut” model many had in their vehicles.
- One participant complained about the height of the bumper on SUVs and wished that all cars had the same bumper height.
- Three liked lights that changed direction while turning the vehicle.

- Three expressed a preference for a digital compass installed in their vehicles.
- Several complained that their car manuals were too long and that they had not learned about all the features of their cars.

Cell Phones

Seven participants used cell phones. All nine felt there should be a law against driving while on the phone.

Driving in New Areas, Getting Lost, and Following Directions

Three participants used MapQuest™, and six preferred traditional maps. Several said they would consider using GPS, and one said that she had been impressed with the system on her son's car. Another participant said it was better than MapQuest™, which can be inaccurate.

CRITERIA FOR EXCLUSION FROM FOCUS GROUPS

Rossmoor residents were not allowed to not participate in the focus groups if any of the following were true:

1. History of neurological disease likely to affect neuromuscular function including cerebral vascular accident (CVA), seizure disorder, or Parkinson’s.
2. Diagnosis of dementia or Mini-Mental Status Examination score < 24.
3. Standard visual acuity worse than 20/40.
4. History of any other previous illness or surgery, such as a vestibular disorder, significant visual disorder, arthritis, or cardiovascular disease, which might, in the opinion of the investigator, interfere with normal driving behavior.
5. Currently taking any medications that might interfere with driving.
6. Do not currently hold a valid California driver’s license.
7. Do not currently drive at least three days per week.
8. Do not own/lease your own vehicle.
9. Have been involved in a motor vehicle accident or DUI within the last two years.
10. California car license and registration are not valid and current
11. Proof of liability insurance does not meet the minimum liability requirements of $50,000 for death or injury of any one person, any one accident; $100,000 for all persons in any one accident; and $25,000 property damage for any one accident (California DMV registration requirements are $15,000/$30,000/$5,000).

FOCUS GROUP PROTOCOL

15 Minutes: Pre-Focus Group with Participants:

- Permission to record (i.e., video and/or audio)
- Consent to participate
- Questionnaire
- Table Tents

15 Minutes: Introduction

- Moderator introduction and focus group purpose
- Focus group overview
- Participant introductions (including primary travel modes)
- Car usage during the week & weekends and transit use
- Ask participants to think about their driving experience OUTSIDE OF ROSSMOOR (including automobile Likes and Dislikes)

30 minutes: Difficulties Entering, Loading & Unloading Vehicle

- Discuss concerns/observations of difficulties (unlocking, loading, and unloading)
- Ask about where they put packages and why (front passenger seat, back seat, trunk)
- Ask about electronic key entry and remote release for trunk
- How do these issue affect vehicle ownership (model) choiceb
- Suggestions for improving/modifying vehicle design
- Discuss “good” vehicle design features for entering, loading and unloading vehicle

10 minutes: Break

30 minutes: Difficulties Driving A Vehicle

- Discuss concerns/observations of difficulties (reversing vehicle, parking, merging)
- Left turns (both controlled and uncontrolled, e.g., no dedicated left turn signal)
- Lane changes--Use of mirrors to see behind and around versus turning head/body
- How do these issues affect vehicle ownership (model) choiceb
- Suggestions for improving/modifying vehicle design for driving

30 minutes: Vehicle Usage

- Preparing to drive (e.g., seat and mirror adjustment)
- Knobs, dials, LED lights (reading console), turn signals (size, location, brightness)
- Parking brake, adjusting seat, adjusting mirrors, etc.
- Use of cell phones
- Do they drive outside of normal territory, getting lost, following directionsb
- Discuss “good” vehicle design features for driving (displays, knobs)

5 minutes: Final Questions

End: Adjourn & Incentives ☺

FOCUS GROUP TRANSPORTATION QUESTIONNAIRE

Thank you for filling out this questionnaire. All answers are confidential. First, we have a few travel related questions.

1. How many persons (including yourself) are there in your householdb_____

2. How many people in your household driveb _____

3. How many autos are available to your householdb _____

4. How old were you when you first obtained your driver's licenseb _____

5. Please check the modes that you typically use for travel more than two times a weekb

☐ Drive Alone ☐ Carpool ☐ Bus

☐ BART ☐ MUNI ☐ Train

☐ Bike ☐ Walk

☐ Other, Please Specify_______

6. How frequently do you use transit (e.g., bus, train, BART, or MUNI) when you travelb

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

If you checked "Never" in response to question 6 above, please skip questions 7, 8 and 9 and go to question 10 on page 3.

7. How frequently do you use transit (e.g., bus, train, BART or MUNI) for a trip, if traveling by car involves…

a. Driving at nightb

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

b. Making left turns across oncoming trafficb

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

c. Driving in bad weather (rain, snow, fog, etc.)b

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

d. Driving on high traffic roadsb

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

e. Driving in unfamiliar areasb

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

8. How frequently do you avoid traveling by transit (e.g., bus, train, BART or MUNI), if it…

a. Costs more than other available modesb

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

b. Takes longer than other available modesb

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

c. Involves identifying a new transit scheduleb

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

d. Involves a transferb

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

e. Involves a new transit station or stopb

☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never

9. When you use transit, do you ever experience physical difficulty with any of the following (please check all that apply):

☐ Stepping on or off Bus or Train
☐ Station Stairs
☐ Purchasing Tickets or Paying the Fare
☐ Any Other, Please List ____________________

Start here if you answered "Never" to question 6.

10. Prior to moving to Rossmoor, have you ever lived or worked in a community in which you typically used transit one or more times a weekb

☐ Yes ☐ No

Next, we ask for your views on various transportation issues....

11. For each of the following statements, please check the one response that best expresses how strongly you disagree or agree. "My current transportation methods (that is, all the different transportation modes I currently use) ...

a. "Are enjoyable to me."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

b. "Allow me to visit friends when I want."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

c. "Fit my budget."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

d. "Allow me to be spontaneous."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

e. "Help me go everywhere."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

f. "Say a lot about who I am."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

g. "Do not make me feel safe."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

h. "Give me a sense of independence."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

i. "Are great for my lifestyle needs."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

j. "Allow me to quickly respond to an emergency."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

k. "Are comfortable."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

12. For each of the following statements, please check the one response that best expresses how strongly you disagree or agree.

a. "I like to experiment with new ways of doing things."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

b. "I sometimes don't drive because finding a parking space is difficult and frustrating."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

c. "Transit is too expensive, so I don't use it much."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

d. "Once I'm happy with something, I don't want to change it."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

e. "I spend too much time dealing with car maintenance."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

f. "Keeping licenses and smog checks current is relatively easy."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

g. "I usually do not have to wait too long for buses and trains."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

h. "I use transit when it goes where I want to go."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

i. "If friends and neighbors reduced their driving, I would follow their example."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

j. "I know transit schedules and routes relatively well."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

k. "The benefits of owning a car are higher than the costs."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

l. "I sometimes do not feel safe while using transit."

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Agree Strongly

Finally, we have a few demographic questions that will help us categorize the responses to this survey.

13. Please check all of the devices/services that you use…

☐ Cellular Phone ☐ Personal Digital Assistant

☐ Internet

14. Are you...

☐ Female ☐ Maleb

15. What is your current marital statusb

☐ Single ☐ Married ☐ Separated

☐ Divorced ☐ Widowed

16. What is the last level of school that you completedb

☐ Grade School ☐ Graduated High School

☐ Associate's Degree ☐ Bachelor's Degree

☐ Master's Degree ☐ Ph.D. or Higher

☐ Other, Please Specify_______

17. Please indicate the *number* of your household members (including yourself) that fall into the different age groups listed below.

___ 0 - 5 ___6 - 15 ___16 - 18

___19 - 23 ___24 - 44 ___45 - 64

___65 - 74 ___75 - 84 ___ 85 or older

18. What is your ageb

☐ 24 or Younger ☐ 25-44 ☐ 45-54 ☐ 55 to 64
☐ 65-74 ☐ 75-84 ☐ 85 or Older

19. What was your household's 2003 pre-tax incomeb

☐ Under $10, 000 ☐ $10,000- $19,999

☐ $20,000 - $49.999 ☐ $50,000 - $79.999

☐ $80,000- $109,999 ☐ More than $110,000

☐ Decline to Respond

Thank you very much for your cooperation!

APPENDIX B : OBSERVATIONAL GROUP SUMMARIES

HEALTH/ACTIVITY QUESTIONNAIRE

Name_______________________________________ Address_____________________________

_________________________ City________________________ State__________ Zip___________

Home Phone #________________________________ Gender: Male_________ Female__________

Age ____________ Year of Birth ____________ Height__________ Weight__________________

Ethnicity______________ Highest level of education completed___________________________

Whom to contact in case of an emergency_________________ Phone#_____________________

Name of your Physician__________________________________ Phone #____________________

1. Have you ever been diagnosed as having any of the following conditionsb

	Yes (**X**)	Year of onset (approximate)
Heart attack	_____	_________________________
Transient ischemic attack (stroke)	_____	_________________________
Angina (chest pain)	_____	_________________________
High blood pressure	_____	_________________________
Stroke	_____	_________________________
Peripheral vascular disease	_____	_________________________
Diabetes	_____	_________________________
Neuropathies (problems with sensations)	_____	_________________________
Respiratory Disease	_____	_________________________
Parkinson's disease	_____	_________________________
Multiple sclerosis	_____	_________________________
Polio/post polio syndrome	_____	_________________________
Epilepsy/ seizures	_____	_________________________
Other neurological conditions	_____	_________________________
Osteoporosis	_____	_________________________
Rheumatoid Arthritis	_____	_________________________
Other arthritic conditions	_____	_________________________
Visual/depth perception problems	_____	_________________________
Inner ear problems/recurrent ear infections	_____	_________________________

Cerebellar problems (ataxia) ____ ______________________

Other movement disorders ____ ______________________

Chemical dependency (alcohol and/or drugs) ____ ______________________

Depression ____ ______________________

2. Have you ever been diagnosed as having any of the following conditionsb

Yes (*X)* Year of onset (approximate)

Cancer ____ ______________

If YES. describe what kind____

Joint replacement ____ ______________

If YES. which joint (e.g.. knee. hip) and side (left or right). ____________________________

Cognitive disorder ___ ______________

If YES describe condition ____

Uncorrected visual problems ___ ______________

If YES. describe type ____

Any other type of health problemb ___ ______________

If YES. describe condition ____

3. Do you currently suffer any of the following symptoms in your legs or feetb

Numbness __________________________ Arthritis____________________________________

Tingling ____________________________ Swelling___________________________________

4.Do you currently have any medical conditions for which you see a physician regularlyb YES or NO

If YES. please describe the condition(s).

____

5. Do you require eyeglassesb YES or NO If YES, describe type: _____________________________

6.Do you require hearing aidsb YES or NO

7. Do you use an assistive device for walkingb (circle) No Yes Sometimes

Typeb____

8. List all medications that you currently take (including over-the-counter medications).

Type of medication For what condition

____

____

____

____

____

____

____

____

____

____
____
____
____
____
____
____
____
____
____
____
____
____

9. Have you required emergency medical care or hospitalization in the last three yearsb YES or NO
If YES. please list when this occurred and briefly explain why.

____

10. Have you ever had any condition or suffered any injury that has affected your balance or ability to
walk without assistanceb YES or NO
If YES, please list when this occurred and briefly explain condition or injury.

11 . How many times have you fallen within the past yearb

Did you require medical treatmentb YES or NO

If you answered YES to either question. please list the approximate date of the fall, the medical treatment required, and the reason you fell in each case (e.g.. uneven surface. going down stairs)

12. Are you worried about fallingb (circle appropriate number)

1	2	3	4	5	6	7
no	a little		moderately		very	extremely

13. How would you describe your healthb

Excellent Very good Good Fair Poor

14. In the past 4 weeks, to what extent did health problems limit your everyday physical activities (such as walking and household chores)b

Not at all Slightly Moderately Quite a bit Extremely

15. How much "bodily pain" have you generally had during the past 4 weeks (while doing normal activities of daily living)b

None Very little Moderate Quite a bit Severe

16. In general, how much depression have you experienced in the past 4 weeksb

None Very little Moderate Quite a bit Severe

17. In general, how would you rate the quality of your lifeb (circle appropriate number)

1	2	3	4	5	6	7
very low	low	moderate		high		very high

18. Please indicate your ability to do each of the following.	Can do	Can do with difficulty or with help	Cannot do
a. Take care of own personal needs-such as dressing yourself	2	1	0
b. Bathe yourself using tub or shower	2	1	0
c. Climb up and down a flight of stairs (e.g., to a second story in a house)	2	1	0
d. Walk outside one or two blocks	2	1	0
e. Do light household activities-cooking, dusting, washing dishes, sweeping a walkway	2	1	0
f. Do own shopping for groceries or clothes	2	1	0
g. Walk 1/2 mile (6-7 blocks)	2	1	0
h. Walk 1 mile (12-14 blocks)	2	1	0
i. Lift and carry 10 pounds (full bag of groceries)	2	1	0
j. Lift and carry 25 pounds (medium to large suitcase)	2	1	0
k. Do most heavy household chores-scrubbing floors, vacuuming, raking leaves	2	1	0
l. Do strenuous activities-hiking, digging in garden, moving heavy objects, bicycling, aerobic dance exercises, strenuous calisthenics, etc.	2	1	0

19. In general, do you currently require household or nursing assistance to carry out daily activitiesb

YES or NO

If yes, please check the reasons(s).

__ Health problems
__ Chronic pain
__ Lack of strength or endurance
__ Lack of flexibility or balance
__ Other Reasons:____

20. In a typical week. how often do you leave your house (to run errands. go to work. go to meetings. classes, church. social functions, etc.)b

____less than once/week _____3-4 times/week
____1-2 times/week _____almost every day

21. Do you currently participate in regular physical exercise (such as walking. sports, exercise classes, housework, or yard work) that is strenuous enough to cause a noticeable increase in breathing, heart rate, or perspirationb YES or NO

If yes. how many days per weekb (circle)
One Two Three Four Five Six Seven

22. When you go for walks (if you do). which of the following best describes your walking paceb (check)
____Strolling (easy pace, takes 30 minutes or more to walk a mile)
____Average or normal (can walk a mile in 20-30 minutes)
____Fairly brisk (fast pace. can walk a mile in 15-20 minutes)
____Do not go for walks on a regular basis

23. Did you require assistance in completing this formb

None (or very little) Needed quite a bit of help

Reason:____
____

Thank you!

Reprinted from the Center for Successful Aging at California State University, Fullerton.
Question 18 reprinted from Rikli & Jones, 1999

Driving Confidence Rating Scale

1. How confident are you when driving at nightb

Not at all confident Completely Confident
0 1 2 3 4 5 6 7 8 9 10

2. How confident are you when driving in bad weatherb

Not at all confident Completely Confident

0 1 2 3 4 5 6 7 8 9 10

3. How confident are you when driving in rush hour or heavy trafficb

Not at all confident Completely Confident

0 1 2 3 4 5 6 7 8 9 10

4. How confident are you when driving on the highwayb

Not at all confident Completely Confident

0 1 2 3 4 5 6 7 8 9 10

5. How confident are you when driving on long tripsb

Not at all confident Completely Confident

0 1 2 3 4 5 6 7 8 9 10

6. How confident are you when changing lanes on a busy streetb

Not at all confident Completely Confident

0 1 2 3 4 5 6 7 8 9 10

7. How confident are you when you have to react quicklyb

Not at all confident Completely Confident
0 1 2 3 4 5 6 7 8 9 10

8. How confident are you when pulling into traffic from a stopb

Not at all confident Completely Confident
0 1 2 3 4 5 6 7 8 9 10

9. How confident are you when making a left turn across trafficb

Not at all confident Completely Confident
0 1 2 3 4 5 6 7 8 9 10

10. How confident are you when parallel parking or backing into a space between carsb

Not at all confident Completely Confident
0 1 2 3 4 5 6 7 8 9 10

DRIVING QUESTIONNAIRE

Subject: ____

Driver's License Number: ____________________ Employment Status:

_____(1) Unemployed
_____(2) Work part time
_____(3) Work Full time
_____(4) Retired
_____(5) Volunteer part time
_____(6) Volunteer full time

1. How many days per week do you normally driveb (circle one) 1 2 3 4 5 6 7

2. How many total miles do you drive in a normal weekb _________

3. How many miles <u>per year</u> do you driveb (circle one)

Less than 1,000	1,001 to 2,500	2,501 to 5,000	5,001 to 7,500	7,501 to 10,000	10,001 to 12,500	12,501 to 15,000	15,001 to 17,500	17,501 to 20,000	20,001 to 25,000	25,001 to 30,000	30,001 or more
1	2	3	4	5	6	7	8	9	10	11	12

		Always	***Usually***	***Sometimes***	***Rarely***	***Never***
4a.	Do you avoid driving at nightb	5	4	3	2	1
4b.	Do you avoid making left turns across oncoming trafficb	5	4	3	2	1
4c.	Do you avoid driving in bad weather (rain, snow, fog, etcb)	5	4	3	2	1
4d.	Do you avoid driving on high-traffic roadsb	5	4	3	2	1

4e.	Do you avoid driving in unfamiliar areasb	5	4	3	2	1
4f.	Do you pass up opportunities to go shopping, visit friends, etc…because of concerns about drivingb	5	4	3	2	1

5. How long have you have been drivingb
____

6. How long have you been living at Rossmoorb
____

7. How long have you been living in the Walnut Creek areab
____

Open Road Driving Evaluation – Rossmoor (ORDE –R)

Depart ☐
Parking ☐
Space ☐

Fastens seatbelt before driving ☐
Releases brake; shifts gears ☐
Looks both ways before moving ☐
Looks through rear window initially ☐ ☐
Looks appropriately as pulling out ☐
☐ Pedestrian awareness
Appropriate speed ☐
Reverse ☐ Forward ☐

☐☐

R turn ☐☐
from lot ☐☐

Signals ☐
Slows vehicle ☐
Completes stop ☐ ☐☐
Stops before cross traffic ☐ ☐☐
Follows lane markings ☐
Proper speed ☐ ☐☐
Looks both ways ☐ ☐☐
Proceeds when safe ☐
☐ Accept/yield right of way
Appropriate evasive action ☐☐
Follows prescribed route ☐

☐☐

4 way ☐
stop

Slows vehicle ☐☐
Completes stop ☐☐
Behind crosswalk ☐☐
Follows lane markings ☐☐
Proper speed ☐☐
Accept/yield right of way ☐☐
Looks both ways ☐☐
Forward check ☐☐

3 way
stop

Slows vehicle ☐☐☐☐☐
Completes stop ☐☐☐☐☐

Yield

Signals
Slows vehicle
Looks left
Forward check
Proceeds when safe
☐

Lane
Change

Checks traffic
Signals
Appropriate speed
Appropriate spacing
Appropriate lane

General

Appropriate speed
Self distracting activities
Two hands on wheel
☐
Appropriate spacing
Scans repeatedly

Legend
√ = Error
Blank = No error
Filled in black = Not observed
X = Not applicable
Filled in red = Critical error

Overall

Operational Definitions

Errors

Critical error = An action or lack of action that could potentially result in an accident, whether the accident occurs or not.

Checks traffic as appropriate (backing out from parking space)

- Turns body and looks directly behind through rear window to check for cross traffic before moving vehicle
- Continues looking directly behind through rear window while backing out
- Looking through rear view mirror is not acceptable

Pedestrian awareness (departing parking space)

- Scans for pedestrians before moving vehicle
- Yields to pedestrians if present at corners or crosswalks
- Does not pass a car from behind that has stopped at a crosswalk

Appropriate speed

- +/- 5-10 mph of speed limit is a minor error
- > +/- 10 mph of speed limit is a critical error

Signals

- Signals during the last 100 feet before reaching the turning point

Slows vehicle

- The driver slows the vehicle prior to arrival at the intersection

Stops vehicle

- The driver stops the vehicle completely prior to the intersection
- The vehicle does not roll through the intersection

Behind crosswalk

- No error=behind both crosswalk lines
- Minor error=behind front line

- Critical error=beyond both lines/into the line of cross traffic
- This criteria is difficult to observe on the video; it is easiest to judge based on the vehicle's relation to other vehicles or street reference points

Follows lane markings

- Stays within appropriate lane
- Turns from appropriate lane
- Turns into appropriate lane
- Critical error=turns from inappropriate lane
- Minor error=turns into inappropriate lane if no accident would result
- Critical error=turns into inappropriate lane if an accident could result (e.g. turns into oncoming traffic)

Looks both ways

- Head visibly turns both ways to check for traffic prior to moving vehicle

Forward check

- After looking both ways, driver looks forward again before proceeding

Obeys signal light

- Responds appropriately to red, yellow, and green light

Accept/yield right of way

- At an intersection without STOP or YIELD signs, driver slows down and is ready to stop. Driver yields to vehicles already in the intersection or just entering it. Also, yields to the car which arrives first *or* to the car to the right if it reaches the intersection at the same time. At a "T" intersection, without STOP or YIELD signs, vehicles on the through road have the right-of-way.
- When there are STOP signs at all corners, driver follows the above rules.
- When turning left, driver gives the right-of-way to all vehicles approaching you that are close enough to be dangerous.
- Whenever parking off the road or leaving a parking lot etc., yield to traffic before entering the roadway.

Self distracting activities

- Critical error=holding and talking on cell phone while vehicle is moving (one hand driving), or eating while driving
- Minor error=talking on cell phone with hands free phone (two hands driving)
- Blowing nose with one hand is ok

Two hands on wheel

- Minor error=driver repeatedly uses one hand for driving

Appropriate evasive action

- Proceeds cautiously through construction areas
- Critical error=does not yield to emergency vehicle
- Minor error=does not signal when proceeding around an obstacle in road

Follows prescribed route

- Minor error if deviates from prescribed route
- See Rossmoor map for route

Appropriate spacing

- Maintains appropriate following distance behind other vehicles
- Minor error=driver is not abiding the “three-second rule.”
- If possible, use the “three-second rule” to determine appropriate spacing. When the vehicle in front passes a certain point, such as a sign, count “one-thousand-one, one-thousand-two, one-thousand-three.” This takes about three seconds. If the vehicle passes the same point before you finish counting, the vehicle is following too closely.
- Critical error=hits object

Check your rear view mirrors frequently (every 2 to 5 seconds) so that you know the position of vehicles near you.

Open Road Driving Evaluation (ORDE)

		Stop sign **Signal light**	
Uncontrolled	**Score**		
Right turn	Signals	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	_____
	Slows vehicle	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	_____
	Completes stop	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	_____
	Behind crosswalk	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	_____

	Follows lane markings	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Proper speed	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Accept/yield right of way	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Looks both ways	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Forward check	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Obeys signs/signals	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
Left turn	Signals	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Slows vehicle	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Completes stop	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Behind crosswalk	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Follows lane markings	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Proper speed	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Accept/yield right of way	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Looks both ways	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Forward check	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Obeys signs/signals	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
Straight	Slows vehicle	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Completes stop	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Behind crosswalk	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Follows lane markings	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Proper speed	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Accept/yield right of way	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Looks both ways	☐ ☐ ☐ ☐ ☐☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Forward check	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Obeys signs/signals	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______

Lane		Left Right	Merge
Change	Checks traffic (turns head)	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Signals	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Appropriate speed	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______
	Appropriate spacing	☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	______

	Appropriate lane	□ □ □ □ □ □ □ □ □ □ □ □	______
Parking		Parallel: in/out Pull in: in/out	
______	Signals	□ □ □ □	
______	Appropriate speed	□ □ □	
______	Follows markings	□ □ □	
______	Looks appropriately	□ □ □	
General	**Appropriate speed**	□ □ □ □ □	
______			
Driving	Self distracting activities	□ □ □ □ □	
______	Two hands on wheel	□ □ □ □ □	
______	Appropriate evasive action	□ □ □ □ □	
______	Other critical error	□ □ □ □ □	
______	Inappropriate equipment use	□ □ □ □ □	
______	Scanning	□ □ □ □ □	
______			

Overall ___Would ride with this driver ___Would not ride with this driver

Comments

____

____

____

____

Legend

√ = Error

Blank = No error

Filled in black = Not observed

X = Not applicable

Filled in red = Critical error

Critical Errors

- Strikes object
- Up and over curb or sidewalk
- Drives into oncoming traffic lane
- Disobeys traffic sign or signal
- Dangerous maneuver (could result in accident)
- Inappropriate reaction to school bus
- Inappropriate reaction to emergency vehicle
- Inappropriate speed (fast/slow)
- Turning from improper lane
- Stopping beyond crosswalk at intersection
- Poor pedestrian/cyclist awareness
- Not turning to look back when in reverse
- Failure to check blind spot before/during lane change
- Talking on cell phone while driving

INGRESS/EGRESS SCORING CRITERIA AND INDIVIDUAL RESULTS

Legend

- Normal = performed activity similar to healthy, young adult
- S = backseat of car
- F = floor of backseat
- T = trunk
- UE = upper extremity
- L = left
- R = right
- A = person enters or exits the vehicle in one fluid motion
- B = 3 steps (distinct movements) to perform task; left leg, then right leg, then stand (egress); sit, right leg, then left leg (ingress)
- C = uses one arm/hand to help stand up or sit down
- D = uses two arm/hand to help stand up or sit down
- E = pushes up on both legs to stand up

Subject	Driver seat Ingress	Backseat Ingress	Driver seat Egress	Backseat Egress	Suitcase	Grocery bag	Other
002 M, 78 '93 Dodge Shadow	Normal speed; A; L UE assists with R LE	Not observed	Normal speed; B; L UE assists with R LE	Not observed	S	S	
003 F, 72 Hyundai Elantra	Normal	Not observed	Slow; B; C	Not observed	F	S	
004 F, 78 '94 Toy Tercel	Normal	Not observed	Normal	Not observed	T	T	- 2 pushes to open car door from inside and outside
005 F, 83 Buick Century	Normal	Not observed	Normal	Not observed	F	F	
006 F, 74 '01 Hyundai Elantra	Normal	Not observed	Normal	Not observed	F	F	- 2 pushes to open door from inside
007 M, 73 '98 Toy Corolla	Normal	Not observed	Normal	Not observed	T	T	- Key to open trunk
008 M, 71 '96 Dodge Intrepid	Normal	Not observed	Normal	Not observed	S	F	
009 F, 83 '98 Chevy Malibu	Normal speed; A; Slow with bringing L LE into vehicle	Not observed	C	Not observed	T	F	- Remote to open trunk

Subject	Driver seat Ingress	Backseat Ingress	Driver seat Egress	Backseat Egress	Suitcase	Grocery bag	Other
010 M, 81 ’94 Merced E420	Normal	Not observed	Normal	Not observed	T	T	- Key to open trunk
013 F, 76 ’00 Dodge Durango	Normal, but slower	Normal speed; A; Maintains contact with door during entry (1 UE)	Normal, but slower	Normal speed; A; Maintains contact with door during entry (1 UE)	T	T	- SUV - 2 pushes to open door from inside - Latch to open trunk
014 M, 77 ’01 Ford Escort	Normal	Not observed	Normal	Not observed	T	T	- 2 door vehicle - Latch to open trunk - Key to open trunk
015 M, 70 ’02 Toy Camry	Normal	Normal	B, E	B, C	F	F	
016 M, 81 ’00 Dodge Caravan	Normal	Normal; takes extra hop due to recessed seat	Normal	Normal	T	T	- Mini-van
017 F, 77 ’96 Toy Camry	Normal speed; A; C; Slow with bringing L LE into vehicle	D, slower	B; D; uses pillar initially to pivot in seat	B; D; uses pillar initially to pivot in seat	T	T	- Latch to open trunk
018 M, 78 ’04 Lexus RX330	Normal	Normal	Normal speed; B	Normal speed; B	T	T	- Latch to open trunk

Subject	**Driver seat Ingress**	**Backseat Ingress**	**Driver seat Egress**	**Backseat Egress**	**Suitcase**	**Grocery bag**	**Other**
019 M, 83 ’93 Lexus ES300	Slow, C	Slow, especially L LE; C	Slow, B, C	Slower	T	F	- Key to open trunk
020 F, 76 ’01 BMW 325i	Normal	Normal	B	B, plus more effort	S	T	- Key to open trunk - 2 pushes to open door from inside
021 M, 83 ’98 Lexus Sedan	Normal	Normal	Normal	Normal speed; B	T	T	-Key to open trunk
022 F, 85 ’04 Honda Civic	Normal	Normal	Normal speed; C	Normal ; Maintains contact with door during exit (1UE)	T	T	-Key to open trunk -Had some difficulty using remote to open car doors
023 F, 83 ’88 Toy Camry	Slow; C	Slow; C	Normal	Increased effort needed to open door; Slower	T	F	-Latch to open trunk -Some difficulty lifting grocery bag
024 M, 83 ’91 Toy Corolla	Normal	Unable to get L LE into backseat; D slower	B	Not observed	T	T	-lifts grocery bag and suitcase together -Key to open trunk -tall subject

Subject	Driver seat Ingress	Backseat Ingress	Driver seat Egress	Backseat Egress	Suitcase	Grocery bag	Other
025 F, 85 '02 Honda Accord	Normal	Slower; B, C	B, C	Slower, pivots in seat, brings out both feet together, then stands; D	F	S	
026 M, 73 '99 Acura Integra	Normal	Slower; C	2 steps	Slow; C	T	T	
028 F, 84 '98 Honda Accord LX	Normal	Normal	Normal	Normal	T	T	-Key to open trunk
029 M, 79 '96 Mercury Sable	Extremely slow, D; increased effort, uses both hands to bring R then L LE into vehicle; B	Unable	Extremely slow, L then R LE out of vehicle; D, increased effort going from seated to standing	N/A	T	T	-Maintains contact with vehicle while walking around it -Used remote to open trunk when loading, used key to open trunk when unloading
030 M, 84 '96 Toy Camry	Used a forward kneeling motion to lower to seat height while entering; C	Used a forward kneeling motion to lower to seat height while entering; C	B, C	B, C : Slower, leaned back before pushing up to stand	F	S	
031 F, 80 '04 Hyundai Sonata	Normal	Normal but slower vs. driver seat ingress	Normal speed; B, C	Normal speed; B, C	T	T	

Subject	**Driver seat Ingress**	**Backseat Ingress**	**Driver seat Egress**	**Backseat Egress**	**Suitcase**	**Grocery bag**	**Other**
033 M, 74 Buick LeSabre	Normal	Slightly slower, C	Normal speed, B	Slightly slower, B	T	T	-Uses remote to open trunk
034 F, 81 ’02 Mercedes C240	Normal	Normal; Slower vs. driver seat ingress	Normal speed, B, C	B, C; Slower vs. Driver seat egress	T	T	
035 F, 75 ’95 Saturn Wagon	Normal	Normal	Normal	Normal but 2 pushes to fully open door	T	T	-Station wagon
036 F, 71 ’98 Toy Camry XLE	Normal	Normal	Normal speed, D	B, D	F	S	
037 M, 82 ’00 Lexus 300ES	Normal	Normal but slower vs. driver seat ingress	Normal speed, B	B; Slower, had to shift body forward on seat before coming to stand	T	T	-Used Remote to open trunk
038 M, 74 ’96 Volvo 850	Slow; sits bringing R LE in, then uses L hand to assist L LE in	Slow, C; L hand assists L LE into vehicle	B, E	Slow, B; Used hands to assist both LE into flexion to exit vehicle	T	T	

APPENDIX C: DRIVING EXPERIMENT SUMMARIES

APPENDIX A - Consent Form

Informed Consent for the Evaluation of a Gap Advice System

My name is Christopher Nowakowski. I am a researcher at the California PATH program, part of the University of California at Berkeley. I would appreciate your participation in my research study on driving behavior. The aim of this research is to observe driver's decision making behavior at intersections.

You will to come to my office at UC Berkeley's Richmond Field Station on a weekday between 9:00 a.m. and 12:00 a.m. or between 1:30 p.m. and 4:30 p.m. There we will show you the instrumented vehicle that you will use and describe the content of the test. This test will include a questionnaire on your driving practice and a test drive. You will be asked to drive through an intersection at the Richmond Field Station several times for a period of about 2 hours. During the entire driving test, video will be recorded. The cameras will be aimed at your face, front and rear traffic. If you are not allergic to latex, you will be asked to wear several dime-sized sticky markers on your forehead while driving in the experiment to improve the tracking accuracy of our eye-tracking equipment. If you agree to participate in the experiment, we will make an appointment for you to participate in the study.

If you agree to take part in the research, you must certify the following by signing this consent form:

1. You must provide a valid driver's license to show the experimenter.
2. Your driving record must be clear of any moving violations or DUI convictions for the past 3 years.
3. You must provide proof of insurance to the experimenter (as evidence of insurability).

All of the information that I obtain about you during the research will be kept confidential. I will not use your name or identifying information in any reports of my research. I will protect your identity and the information I collect from you to the full extent of the law (this does not include subpoena). Should you be involved in an accident while driving the study car, the videotapes taken may be subpoenaed as evidence. Liability and Physical Damage insurance for this vehicle will be provided by the University of California during your participation in the research.

After this project is completed, I may make the information collected during your participation available to other researchers or use the information in other research projects of my own. If so, I will continue to take the same precautions to preserve your identity from disclosure. Your identity will not be released to other researchers.

If you are injured as a result of taking part in this study, care will be available to you. The costs of this care may be covered by the University of California depending on a number of factors. If you have any questions about your rights or treatment as a participant in this research project, please contact the University of California at Berkeley's Committee for Protection of Human Subjects at 510/642-7461, subjects@uclink.berkeley.edu."

Your participation in this research is voluntary. You are free to refuse to take part, and you may stop taking part at any time. There is no direct benefit to you from the research. I hope that the research will benefit society by improving our knowledge about driver behavior and using this knowledge to improve the development of advanced transportation concepts and prototypes.

You will be paid a total of $30 for your participation in installments of $10 per hour of participation.

If you have any questions about the research, you may call me, Christopher Nowakowski, at (510) 231-5756.

I have read and understood this consent form. I agree to take part in the research.

________________________________ ______________
Signature Date

APPENDIX B - Driver Background Questionnaire

Driver Information

Age: .... Gender: ....

For how many years have you been regularly driving? ....

What is the type of vehicle you are currently driving?

Make: ....

Model: ....

Annual Mileage:

❏ Less than 5000 ❏ 5000 - 10,000 ❏ Greater than 10,000

What Percentage of your driving includes the following?

.... Freeways

.... Rural Highways

.... Suburban/Residential (Walnut Creek, Peninsula)

.... Urban/City (downtown Berkeley, Oakland, or San Francisco)

What percentage of your driving is done during the Day/Night?

.... Day

.... Night

What percentage of your driving is to Familiar/Unfamiliar destinations?

.... Familiar Destinations

.... Unfamiliar Destinations

Driving Opinions

Do you think that urban/city driving can be difficult or problematic?

❑ Often Difficult ❑ Sometimes Difficult ❑ Not a Problem

What factors cause the most difficulty? *(Please check any that apply)*

❑ Intersections Complexity

❑ Other Drivers

❑ Pedestrians

❑ Other: ....

Estimate the speed of other vehicles is…

❑ Often Difficult ❑ Sometimes Difficult ❑ Not a Problem

What situations cause the most difficulty in speed estimation?

❑ Left Turn with Oncoming Traffic

❑ Left Turn with Lateral Traffic

❑ Right Turn

❑ Merging

❑ Overtaking

❑ Other: ....

Would you like to be contacted about participation in future driving-related studies organized at California PATH? *(Answering "Yes" in no way obligates you to participate in future studies.)*

❑ Yes ❑ No

Driver Vision and Health

Do you wear corrective lenses when you drive?

❑ Glasses ❑ Contacts ❑ None

If so, How long have you worn glasses/contacts? ....

Are you: *(Please check all that apply)*

❑ Myopic (Near sighted)
❑ Hyperopic (Far sighted)
❑ Astigmatic
❑ Presbyopic (Far sighed due to aging)
❑ Other: ....

Have you had corrective eye surgery (e.g., LASIK)?

If so, what procedure? ....

When? ....

Are you currently taking any medications? ❑ No ❑ Yes

If yes, please describe?

....

If yes, for how long? ....

Do any of the medications you are currently taking contain warnings against driving while on that medication?

❑ No ❑ Yes