ITS Technologies and Mature Drivers

Final Report 562

Prepared by:
Mary Kihl, Ph.D.
with Sweta Bansal, Jennifer Brungart, Aaron Gannon,
Thara Johnson, & Debarati Majumdar
School of Planning
College of Architecture and Environmental Design
Arizona State University
Tempe, AZ 85287-2005

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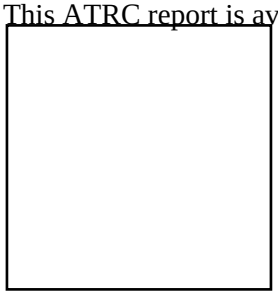

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16. Abstract –
This report presents the findings of a research project pursued by a faculty-student team from Arizona State University in cooperation with the Arizona Department of Transportation (ADOT), Arizona Transportation Research Center (ATRC) and the Maricopa Association of Governments. The research focused on the perception of Older Drivers of ITS technologies, specifically those deployed on the urban freeway system in the Phoenix Metropolitan Area.

A series of 11 focus group sessions held with drivers over age 65 from fall 2003 to spring 2004 provided the primary source of information on perceptions of ITS technologies. Both year-round residents and winter visitors were represented in focus groups that were held in a variety of locations and settings across the Phoenix urban area. One additional focus group with drivers aged 40 to 55 served as a control group. The study emphasized three technologies—variable message signs (VMS), portable variable message signs, and ramp meters. Focus groups and an additional group of older drivers in two heuristic user evaluation sessions also assessed the evolving ADOT Advanced Traveler Information Systems (ATIS) effort that includes both a dedicated interactive 511 telephone highway conditions reporting system, and an AZ511.com web site that provides almost real time highway conditions reports. An assessment of freeway on-ramp accidents involving older drivers for the period 2000-2003 offered a basis for a more objective review of the challenges faced by older drivers.

The older drivers involved in the study were frequent users of the Phoenix urban freeway system, and were generally enthusiastic about the ITS devices that they felt responded to some specific challenges they faced while driving on freeways. They offered relatively small changes that would enhance their effectiveness. Large VMS with 18-inch yellow fiber optic letters displayed against a black background caught the attention and were far easier to read than standard highway signs. Drivers urged using them only to convey short, specific directions to current roadway users. Portable electronic signs captured attention near construction sites, but placement only on the right side of the freeway limited visibility. Legibility was a significant concern and double phased signs were particularly challenging to read in time to process information effectively. They preferred sequential signs mounted high above trailers. Ramp meters not only helped the flow of traffic, but also benefited older drivers by providing about 4 seconds to find a gap in traffic. Accidents have declined at on-ramps; the ramp meters and new acceleration lanes have both played a role. Older drivers also have identified key elements that they believe will enhance the usability of both the evolving 511 and AZ511 systems.

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SI (MODERN METRIC) CONVERSION FACTORS*

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
	AREA			
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
	VOLUME			
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: Volumes greater than 1000L shall be shown in m^3.			
	MASS			
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")
	TEMPERATURE (exact)			
$^\circ F$	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	$^\circ C$
	ILLUMINATION			
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
	FORCE AND PRESSURE OR STRESS			
lbf	poundforce	4.45	Newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	KPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
	AREA			
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
	VOLUME			
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.315	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
	MASS			
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
	TEMPERATURE (exact)			
$^\circ C$	Celsius temperature	1.8C + 32	Fahrenheit temperature	$^\circ F$
	ILLUMINATION			
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
	FORCE AND PRESSURE OR STRESS			
N	Newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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

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ARIZONA STATE UNIVERSITY PROJECT TEAM

Research Project SPR 562 was envisioned as a "student research project" involving an interdisciplinary team of graduate students from Arizona State University (ASU).

PROJECT DIRECTION

Mary Kihl, PhD and FAICP, Professor of Planning, served as principal investigator for the project. She managed the field research effort, developed and coordinated all aspects of the project, and prepared the final report.

Jennifer Brungart, Assistant Professor of Design, provided a specialty in computer-based graphic design. She served as mentor for the Advanced Traveler Information Systems (ATIS) assessment phase of the project and contributed the content of the AZ511.com web site assessment.

STUDENT RESEARCHERS INCLUDED:

Sweta Bansal, is a candidate for the degree, Master of Environmental Planning, with a background in architecture and design. She participated in focus groups and transcript analysis, the heuristic assessment, and designed the web page concepts included in the final report.

Aaron Gannon, is a candidate for the degree, PhD in Environmental Design and Planning, with a background in industrial design and human factors. He developed the heuristic assessment concept and completed the telephone 511 analysis included in the report.

Thara Johnson, is a candidate for the degree, Master of Environmental Planning, with a background in computer analysis and geographic information systems (GIS). She participated in focus groups, the heuristic assessment of ATIS and was primarily responsible for completing the accident analysis included in the final report. She also created the two GIS maps included in the final report.

Debarati Majumdar, a candidate for the degree, PhD in Environmental Design and Planning, with a background in environmental psychology. She participated in the focus groups, developed the content analysis dictionary and applied it to focus-group transcripts, and also contributed to the qualitative assessment of focus-group transcripts included in the report.

Kathleen Zanon, is a candidate for the degree, Master of Environmental Planning, and **Matthew Zabel**, a candidate for the degree, Master of Design, assisted with the followup heuristic study in June/July 2004 and helped develop the assessment in Appendix G.

ACKNOWLEDGMENT

The project team wishes to thank members of the Arizona Department of Transportation (ADOT) Technical Advisory Committee (TAC), and their respective staffs, for their active involvement and helpful suggestions over the course of the project.

Members of the TAC included: Jim Decker, City of Tempe; Sarath Joshua, Maricopa Association of Governments; Dave Wolfson, Maricopa County Department of Transportation; Cydney DeModica, ADOT Motor Vehicle Division; Reed Henry and Michael Marietti, ADOT Traffic Engineering; Manny Agah and Lydia Dukelow of the ADOT Transportation Technology Group; Cindy Eiserman, ADOT Risk Management; Lt. Tim Lane, Arizona Department of Public Safety; and Alan Hansen, U.S. Department of Transportation Federal Highway Administration.

Special credit is due to the leadership of the Maricopa Association of Governments for providing 50 percent of the project funding, as well as to the AZTech Executive Committee for recognizing the issues and conceiving the project topic.

Stephen Owen, Arizona Transportation Research Center (ATRC) project monitor, did yeoman service in working with the project team and coordinating the efforts of the TAC members. The TAC's close working relationship with the students involved in the project helped to strengthen the educational experience associated with their effort and the overall quality of the project.

The project would not have been possible without the enthusiastic involvement of the focus-group participants and the active work of conveners at each of the sites who invited participants and handled logistics.

ABBREVIATIONS

TERM	DEFINITION
AAA	American Automobile Association (AAA Foundation for Traffic Safety)
AARP	American Association of Retired Persons
ADOT	Arizona Department of Transportation
ATIS	Advanced Traveler Information Systems
AZ511.com	Arizona Department of Transportation web site presenting road conditions and traveler information
DPS	Department of Public Safety (Highway Patrol)
GIS	Geographic Information Systems
ITS	Intelligent Transportation Systems
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
VMS	Variable Message Signs
TTG	Transportation Technology Group of ADOT: responsible for design and operation of the freeway management system and related ITS elements.
RV	Recreational Vehicle
I-10	Interstate 10 (in Arizona, specifically in greater Phoenix area)
I-17	Interstate 17 (in Arizona, specifically in greater Phoenix area)
S.R. 101	State Route 101, also referred to as Loop 101 (Part of Phoenix urban freeway system)
S.R. 202	State Route 202, also referred to as Loop 202 (Part of Phoenix urban freeway system)
S.R. 51	State Route 51 (Part of Phoenix urban freeway system)
U.S. 60	United States Highway 60 (Specifically, the urban-area limited-access route from Tempe to Apache Junction, AZ)

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EXECUTIVE SUMMARY

INTRODUCTION

The increasing number of older drivers in the United States is well documented. Drivers over age 65 accounted for 6.7 percent of all miles driven in 1990, and that proportion is expected to rise to 18.9 percent of all vehicle miles driven by 2030 (US DOT 2001). Older residents, who have been driving since they were sixteen, continue to regard their drivers' licenses as symbols of their independence. In the Phoenix metropolitan area and other sprawling low-density urbanized areas, automobile travel seems essential.

Unfortunately, the per mile crash rates of those over age 65 are higher than those of any group except those under age 24, and they have the highest crash fatality rate (NHTSA 2001). Unlike youthful drivers for whom speed and alcohol are primary causes of accidents, older drivers often become involved in accidents because they find it difficult to note, interpret, and respond to visual cues. Merging and changing lanes is particularly challenging. As the proportion of older drivers increases, it is important to take advantage of opportunities to enhance driver safety through improved signage and technology.

A substantial proportion of current older drivers voluntarily limit their driving on fast-paced urban freeways, but others continue to regularly drive on freeways. For example, 52 percent of older drivers who responded to a 2002 survey in the Phoenix area reported that freeway driving was not at all difficult (Baggett 2003). These confident drivers will soon be joined by urban and suburban baby boomers who grew up driving on urban freeway systems. Some analysts have argued that freeway driving is actually less challenging for older drivers than driving on surface streets (Sadalla 1994). Freeways offer less visual distractions and allow drivers to focus more completely on the tasks of steering and managing their vehicles (Staplin 2001).

There are, however, some aspects of freeway driving that are stressful for mature drivers. The literature has identified several key elements: merging into traffic flow from on-ramps, changing lanes, reading and interpreting road signs, and responding quickly to road hazards (FHWA 1994, Sadalla 1994, Staplin 2001). Physiological changes that accompany the aging process contribute to that stress.

Researchers note a more rapid decline in visual acuity after about age 60. These changes are associated with sensitivity to glare, problems with peripheral vision, reduced ability to judge gaps in traffic flow, and limitations in distinguishing colors and contrast (Koepke 1993, Wolf 1960, Schieber 1988, Morimer 1988, FHWA 1994). Driving a vehicle requires an ability to respond to visual cues, to multi-task, to switch the focus of attention, and to prioritize efficiently. Those skills decline with age (Shinar 1993).

Intelligent Transportation Systems (ITS) technologies, intended primarily to increase the efficiency of traffic flow and reduce congestion on highways, can also help address a number of challenges faced by older drivers. These technologies include:

- Fixed electronic variable message signs (VMS)
- Portable electronic VMS signs
- Ramp meters
- Advanced Traveler Information Systems (ATIS) road condition reports

PROJECT FOCUS AND APPROACH

The objective of this study for the Arizona Department of Transportation (ADOT) was to assess the responsiveness of older drivers (over age 65) to deployed ITS technologies, and to identify ways to increase the effectiveness of those technologies in responding to their needs. The primary approach involved a series of focus-group sessions with older drivers who regularly drive on the Phoenix-area urban freeway system, and who are familiar with deployment of ITS technologies.

Between October 2003 and March 2004, 11 focus groups were held with drivers over age 65 in varied settings across the Phoenix metropolitan region. Both year-round residents and winter visitors were represented. An additional focus group with drivers aged 40-55 provided a control group. Focus-group discussions were augmented by short surveys and trip logs documenting the travel patterns of participants. Participants also took a "Trails Test," a test for motor speed and attention function that requires the participant to sequentially connect letters and/or numbers randomly scattered on a page. The Trails Test was intended to document the ability to multi-task and respond to visual cues (Staplin et al. 1993). Additional groups of older freeway drivers participated in heuristic assessments of the usability of the evolving Arizona 511 traveler information system and the ADOT web site, http://www.AZ511.com (AZ511.com), in March and July.

A parallel study of accidents at Phoenix area freeway on-ramps from 2000 to 2003 compared involvement of drivers over age 65 with drivers aged 40 to 50. The study also compared findings for 2000-2003 with those for 1996-1999, when a limited number of ramp meters were deployed.

FINDINGS AND RECOMMENDATIONS

All focus-group participants were experienced freeway drivers both in the Phoenix area and other areas of the country. Overall, they agreed that ITS technologies, specifically VMSs and ramp meters, were helpful in communicating key information and assisting with merging into traffic. They were enthusiastic about accessing up-to-date road current condition reports. Through discussions in the focus groups they proposed ways to make these technologies even more valuable. Their suggestions would help to compensate for challenges that are, according to the literature, associated with the aging process — problems with visual acuity, contrast, brightness, and peripheral vision. They also emphasized sharpening of visual cues that could enhance driver response, and addressed issues of merging onto freeways. The following summarizes the group responses:

Fixed Variable Message Signs

The older drivers agreed that the large, centrally placed fixed VMS with yellow letters on a black background were easier to read than the standard highway signs. Yet reading any

sign while driving at freeway speed is challenging. Focus-group participants urged using the signs only to convey critical directions to drivers about current road conditions. Drivers cannot absorb lengthy messages quickly, and abbreviations can distract and confuse them. Given the challenge of reading signs while driving, focus-group participants opposed using VMSs to post ozone alerts, convey general information, or to warn motorists about restrictions several days in the future. (They did, however, favor posting "Amber Alerts," emergency notifications regarding missing children.)

Brightness and high contrast are essential, given the glare of bright sunlight. Text on elongated signs should be limited to two lines, and where possible, key messages should be centered in the middle of the sign, where they can be read more quickly. Conveying the same message on more than one sign can reinforce the directive to the driver.

Portable Message Signs

Portable electronic signs succeed in capturing the attention of older drivers when they are within their line of vision, but if they are to communicate, they must be read and the driver must respond appropriately. High contrast and sharp resolution are essential to compensate for glare. The ideal placement is both the median and right side, but that is not always possible, and the message can be lost to someone driving in heavy traffic behind trucks or sports utility vehicles (SUVs). A partially read message can confuse the driver. Older drivers suggested using high trailers and sequential signs instead of presenting messages in two or more sequential parts on the same sign. They urged using the portable signs only to convey short messages with essential directions for the driver.

Ramp Meters

Ramp meters, intended primarily to assure freeway traffic flow, help give drivers time to judge a gap in traffic and merge onto freeways. On-ramps with two lanes are confusing and invite competition among drivers, but the current practice of using separate sets of signal lights for each lane helps to address this problem. The double signals—angled to be seen by the front driver and those behind—are helpful. Mature drivers are slower to merge than are younger drivers, and accelerating after stopping at the signal is sometimes difficult. Focus-group participants found acceleration lanes helpful in getting up to freeway speed and in permitting impatient drivers behind to enter the flow more quickly.

Accident Assessment

A study of accident records indicated that there were far fewer crashes involving older drivers in the period 2000-2003 than in 1996-1999. Despite an overall 43 percent increase in the number of crashes in all areas of the Phoenix metropolitan area and a greatly expanded freeway system, the number of accidents involving older drivers at on-ramps declined from 194 to 115 in the second three-year period. About half of the accidents (59) in the recent period were in peak hours. The number of crashes involving drivers aged 40 to 50 similarly declined. It is not possible to attribute the general decline of accidents directly to the installation of ramp meters. Still, the ramp meters in combination with new acceleration lanes seem to have had an impact. The overall reduction in accidents at on-ramps is impressive.

Traveler Information System: Dedicated 511 Telephone Number

Mature drivers were enthusiastic about information that would assist with trip planning and help them avoid problematic roadway conditions. Information presented from points of origin to points of destination would be most helpful. In assessing the emerging Arizona 511 telephone system, mature drivers both in focus groups and in heuristic evaluation sessions underscored the importance of brevity and simplicity in providing instructions for the dial-up system. They underscored the importance of an early announcement of a backup keypad system as an alternative to voice recognition. Much as busy commuters, the older drivers wanted information quickly without putting forth much effort – a simple menu with a minimum amount of instructions, and the ability to key ahead to get information relating specifically to their trip.

Traveler Information System: AZ511.com Internet Site

In almost all focus groups a number of participants reported regularly using home computers to get trip directions, and some had Global Positioning Systems (GPS) installed in their vehicles. Focus-group comments, reinforced by hands-on use of the emerging ADOT web site in two heuristic assessments, highlighted key factors that would enhance usability. The pattern of navigation through the site should be clear, with additional guidance offered with a help button. The site should relate to travel agendas of individual users, organized to zoom in to specific to origins and destinations. Consistency in the classification scheme between the dial-up and Internet service is essential. To minimize visual confusion, participants suggested using a simple high-contrast state highway map with icons replaced by geometric shapes in contrasting colors that would be easy to see and interpret. Road condition information should be grouped into a few major categories with definitions evident to all site users. A link between the freeway speed map and the highway conditions map would convey explanations for speed reduction.

SUMMARY

The mature drivers' recommendations for simplicity of message, clarity in presentation, and sharpness of image related to all of the technologies explored in this study. Older drivers have increasing problems with visual acuity, and in processing and responding quickly and effectively to visual cues. Hence short messages focusing specifically on the action required of drivers can reduce confusion and increase the speed of response. Minimizing glare in bright sunlight is particularly challenging in Arizona. VMSs, particularly the fixed signs, make an important contribution, but the goal must remain sharpening the image, enhancing legibility, and increasing communication. With the ATIS media, similar recommendations apply. Short simple instructions on the telephone, with a clear backup system to voice recognition, can minimize frustration and increase usefulness to older drivers, particularly those with declining hearing ability. A web site with enhanced usability is easy to negotiate and conveys information helpful for planning individual trips. These guidelines respond specifically to needs of older drivers, but they can also benefit hurried commuters who want to grasp key information efficiently, and in time to take alternative action. ITS technologies can and do enhance communication with older drivers. As such, they can increase the safety of the highways for all drivers.

1. PROJECT INTRODUCTION

DEMOGRAPHIC TRENDS

Trends toward an increasing number of older drivers have been well documented. The proportions of people over ages 65, 75, and even 85 are expected to increase substantially as the baby boom generation reaches retirement age. By 2030, more than one in five Americans will be over age 65, and one in 11 will be over age 85 (Rosenbloom 2003). Unlike many of those in the current older generations, both women and men newcomers to the ranks of the retired will have grown up driving since age 16. The proportion of older women who drive regularly is expected to increase substantially since 94 percent of women age 45 to 49 are currently licensed drivers (Rosenbloom 2003). These mature drivers are also expected to take more trips and drive many more miles than previous generations of older drivers. Between 1990 and 2020 the total annual vehicle miles driven by male older drivers is expected to increase by 465 percent and by women, almost 500 percent. While older drivers accounted for 6.7 percent of all miles driven in 1990, by 2030 that proportion is expected to rise to 18.9 percent of all vehicle miles driven (USDOT *National Household Travel Survey* 2001). These national trends are also reflected in Arizona where 15 percent of licensed drivers are over age 65.

These well-documented trends raise concerns among many analysts who point out that older drivers are far more likely to be involved in fatal accidents than are younger drivers. When considered in relation to the number of miles driven, the number of older drivers involved in fatal accidents is exceeded only by those drivers under age 25 (Burkhart 1998). Others echo this assessment and concern. A recent study completed by Lindsay Griffin for the American Automobile Association (AAA) Foundation for Traffic Safety found that drivers over age 65 are 1.54 times more likely to be killed in automobile accidents than are drivers in the 55 to 64 age group. This proportion increases with age (Griffen 2004). Older drivers involved in single-vehicle injury crashes (where they are themselves totally responsible) are 4.9 times more likely to be killed than are drivers involved in multiple-vehicle injury crashes where younger drivers may share responsibility (Griffen 2004, Rosenbloom 2003).

The response of many analysts and policy makers to this assessment is to propose programs that will limit travel by older drivers and provide screening mechanisms that will restrict or limit licenses of those perceived to be high-risk drivers (Baggett 2003). Others focus on developing alternative modes of transportation that can maintain the mobility and independence of older residents while at the same time urging them to surrender their car keys (Burkhardt 1998). This is a complex task in scattered suburban areas. While not denying the importance of screening older drivers to identify those at risk, the current study focuses on competent older drivers and the potential for enhancing their ability through sensitive application of Intelligent Transportation Systems (ITS).

CHALLENGES FACED BY OLDER DRIVERS

The challenges that are faced by older drivers as they travel along city streets are well documented. The 2001 Federal Highway Administration (FHWA) *Highway Design*

Handbook for Older Drivers and Pedestrians acknowledges the significant problems faced by older drivers at intersections and focuses attention on the design or redesign of key types of intersections. A 2003 study that Sharon Baggett completed for the Arizona Department of Transportation (ADOT) Arizona Transportation Research Center (ATRC) identified left hand turns and driving through intersections as the most challenging maneuvers for older drivers. That report, which was based on a review of accidents involving older drivers from 1999 to 2001 and a survey of older Arizona drivers, advocated: more left hand turn bays; increased use of left turn arrows; enhanced signage as well as advance notification of merging lanes, highway exits, and four-way stops. The current project builds upon the Baggett study, but focuses primarily on freeway driving.

A substantial number of drivers report that they have voluntarily reduced their freeway driving. A 1996 American Association of Retired Persons (AARP) survey of more than 700 respondents over age 70 found that 30 percent avoided freeway travel because of concerns about heavy traffic. A considerable portion of respondents, however, did not report avoiding freeways (Straight 1997). As the baby boomers who grew up driving on freeways highways in suburban and urban areas join the ranks of older drivers, they are expected to continue to drive on limited access highways. Urban development patterns have continued to explode. Increasing numbers of older residents have taken advantage of lower cost homes or new leisure communities miles from the urban core. Nationally 56 percent of the population over the age of 65 lives in suburban communities (Rosenbloom 2003). From another perspective, almost one-third of the residents on the urban fringe in the Phoenix metropolitan area are over age 65. For these older suburban residents, freeway driving continues to represent an important link with shopping, services, and entertainment in the rest of the urban area.

FREEWAY DRIVING CHALLENGES

Some analysts, including Edward Sadalla (1994), argue that freeway driving is actually less stressful for older drivers than negotiating surface streets. The FHWA Highway Design Handbook shares the perspective that freeways offer less visual distractions and allow drivers to focus more completely on the tasks of steering and managing their own vehicles. While 22 percent of the older drivers who responded to the 2003 ADOT survey considered freeway driving very challenging, a far greater proportion, 52 percent, reported that freeway driving was not at all difficult (Baggett 2003). A poll conducted of 75 participants in three AARP safe driving classes in the Phoenix area in fall 2003 found that one-third of the class members reported driving on freeways at least once a week.

A closer look at the freeway experience identified several specific elements that are particularly stressful for older drivers: merging into traffic flow from on-ramps, changing lanes quickly, reading and interpreting road signs, and responding quickly to unexpected changes in driving patterns. These issues become particularly challenging for someone who is less familiar with the roadway system in a specific urban area (Sadalla 1994). There are, however, areas that can be addressed with specific ITS technologies. Ramp metering can assist with merging into traffic flow, while large electronic variable message signs (VMSs) attract the attention of motorists and warn them of problems

ahead like incidents or road construction. Advanced Traveler Information Systems (ATIS) can assist in trip planning and can divert travelers from more challenging roadway conditions, like construction zones and weather-related road hazards.

Thus, while these ITS technologies are primarily intended to increase efficiency of traffic flow and reduce congestion on highways, they also have the potential to offer additional benefits by addressing concerns faced by older drivers. Some of these benefits that are now associated primarily with freeway travel may also extend to highway and arterial driving as these ITS technologies are employed more widely.

ITS AND FREEWAY DRIVING IN THE PHOENIX AREA

There are, of course, a number of different ITS technologies and applications that benefit the traveling public. For example, the application of ITS to signalization and traffic management operations is enhancing traffic flow on arterials in major metropolitan areas. This type of application is, however, largely transparent to individual drivers and does not respond specifically to the documented concerns of older drivers. Since the current project is related to the responsiveness of older drivers to ITS technologies, it focused on technologies that are readily observed by older drivers and may also potentially respond to some of their challenges with freeway driving.

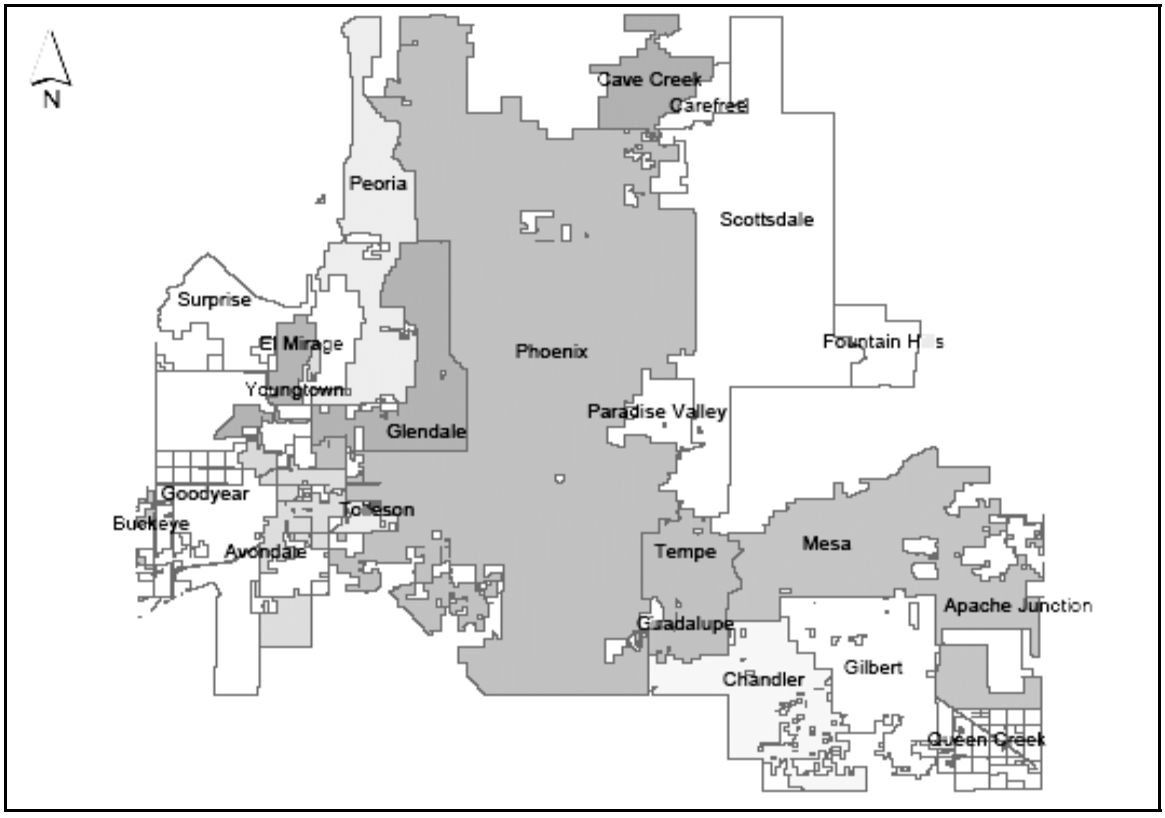


Figure 1. Phoenix Metropolitan Area

Can ITS help confident older drivers respond to the challenges associated primarily with freeway driving? This potential is best explored through discussions with older drivers who can elaborate on their own problems with freeway driving, and offer observations regarding the effectiveness of various ITS technologies in addressing those concerns.

The concerns of older drivers are national in scope and implications of an assessment of the potential for enhanced application of ITS technologies are national as well. This project is, however, focused primarily upon the Phoenix metropolitan area. The Phoenix area is, in many ways, an appropriate laboratory for the study. A rapidly growing metropolitan area, the Phoenix metropolitan area is now home to more than 3.3 million people within a 9,200 square mile area. The map in Figure 1 indicates the extent of the metropolitan area and the emerging communities on the periphery.

Unlike many older urban areas, the urban freeway network in the Phoenix area is still emerging. Since voter approval of a half-cent sales tax to fund an urban freeway system, the Phoenix metropolitan area has added more than 100 miles of limited access highways, and more than 50 additional miles are anticipated by 2007. These routes will link newer developing areas in the far-flung suburbs with the more established communities, work sites, and entertainment options closer to the urban core.

Clusters of homes of older residents—both of year-round and winter visitors—located at the periphery of the region, now have ready access to the freeway system. Older residents can enjoy the economy of "a home with a view" on the urban edge or the comforts of a leisure community and still have ready access to sporting events, the symphony, theaters, regional shopping centers, or medical facilities. These residents can and do regularly travel on the freeway system.

ITS technologies, including electronic variable message signs and ramp meters, are now an accepted part of the established Phoenix area freeway landscape. The map in Figure 2 shows the currently programmed extent of the Phoenix area freeway system.

Fiber-optic fixed VMSs present 18-inch alphanumeric characters in up to three-line displays. These signs are managed centrally by the traffic management center and placed in advance of freeway-to freeway interchanges and at two-mile spacing in the urban area and at intermediate locations based on volume-to-capacity ratios. Electronic portable electronic VMSs are mounted on trolleys and located in advance of highway maintenance or construction sites. Ramp meters are now deployed at almost all on-ramps in the Phoenix urban area on Interstate 10 (I-10), Interstate 17 (I-17), and U.S. Highway 60 (U.S. 60). With adequate funding these devices will emerge on other sections of the roadway network as well.

There is, however, a current window of opportunity that allows for an assessment of the existing electronic signage and ramp meters in terms of their responsiveness to the needs of older drivers and the potential for adaptations that could enhance their usefulness. On-going modifications of the ATIS also offer the potential for enhanced responsiveness to

the needs of older drivers. The timing of this study is intended to coincide with these opportunities.

STUDY APPROACH

The primary approach used in the study was to involve older drivers who are comfortable with freeway driving in focus-group discussions. Over the period from October 2003 to March 2004 11 focus groups were conducted in different locations across the Phoenix metropolitan area. These discussions were augmented by surveys, trip logs, and "Trails Tests" completed by participants. The Trails Test is a test of motor speed and attention function that requires the participant to connect sequentially letters and/or numbers that are scattered randomly on a page. A focus group with younger drivers in their 40s offered a basis for comparison. A modified heuristic evaluation of ATIS applications was conducted by a group of older drivers in March. This helped to sharpen and underscore points presented in the focus group sessions. In July, 2004 a follow-up heuristic study reassessed a newly modified version of the website. The results of that study are included in Appendix G. A parallel study of freeway accidents of older drivers at freeway on-ramps from 2000 to 2003 provided grounding for the ramp meter assessment in the study and helped put observations shared by focus group participants into a broader perspective.

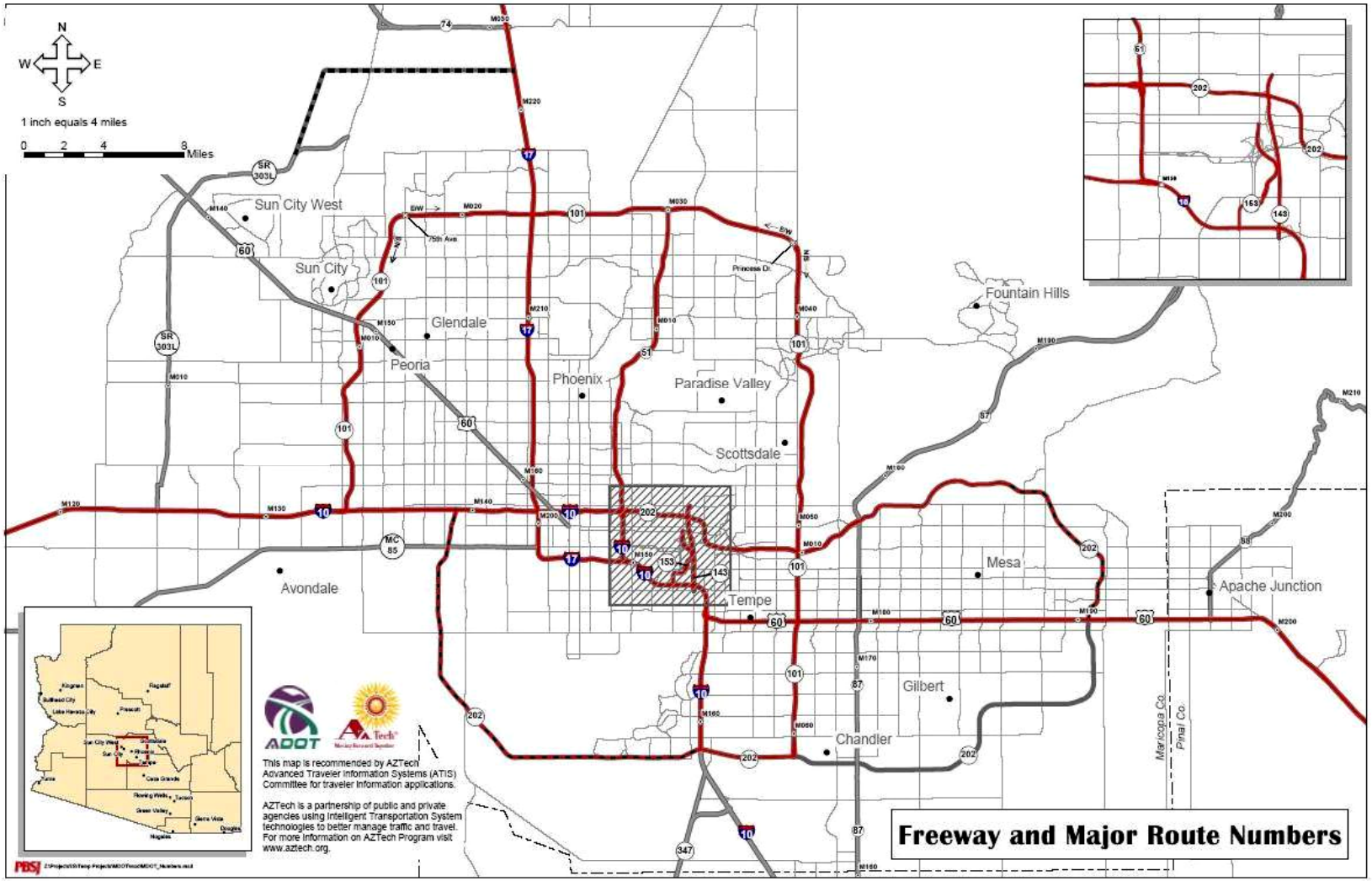


Figure 2. Urban Freeway Routes in the Phoenix Metropolitan Area

Source: Arizona Department of Transportation, ATIS Task Group

2. CHALLENGES FACING OLDER DRIVERS: LITERATURE REVIEW

INTRODUCTION

When trying to account for the significant proportion of fatal accidents associated with older drivers relative to the number of miles that they drive, many researchers focus on physical changes associated with the aging process. For example, a recent study by the AAA Foundation for Traffic Safety completed by Lindsay Griffen reported that drivers over age 65 who are involved in injury-related accidents are 1.83 times more likely to be impaired by illness or some other physical defect at the time of their crash than drivers in the 55 to 64 age group. Those drivers in the 76 to 85 age bracket involved in injury-related crashes are 2.38 times as likely to be physically impaired, and those over 85 are 3.06 times as likely to be physically impaired in some way (Griffen 2004). There are also a number of studies that reflect upon the onset of dementia, arthritis, or heart disease and the effect of medications on driving ability (Baggett 2003). The focus of this study is on the larger proportion of older drivers who are competent and confident, but are, nevertheless, affected by gradual physical changes that accompany the aging process.

Analysts have identified a range of changes associated with the aging process that relate directly to the capacities essential for driving. Concerns relate to changes in visual acuity and peripheral vision as well as to increased difficulty in turning the neck to observe the actions of other drivers. Additional issues relate to perceptual lapses, cognitive changes, and increases in response time. There is no evidence to associate the onset or development of such physical changes with a specific chronological age. Individual differences are certainly apparent. Some older drivers respond to a diminished driving ability by voluntarily restricting their driving to daylight hours, city streets, and off-peak periods, but other older drivers continue to drive successfully on the freeway system. The intent of this study is to identify applications of technologies that can enhance their ability to drive safely.

FREEWAY DRIVING: THE PERSPECTIVE OF MATURE DRIVERS

When asked about their concerns about freeway driving, the older mature drivers in the focus groups conducted in connection with this project spoke first about the speed of other drivers: “They all drive too fast and whiz past me;” “It is difficult to get them to give me a chance to get on the freeway;” “At times other drivers seem to intentionally cut you off;” and “The entrance ramps seem to be a race to the finish line.” Drivers also noted the difficulty in reading directional signs: “Some signs are hard to see, particularly signs with white letters on brown backgrounds; even white letters on green backgrounds are difficult;” “Glare makes it almost impossible to see anything;” “When [directional] signs are on the side of a four-lane freeway, someone in the center lane can’t see them, especially when there are trucks in the way;” “Sometimes when you pass a sign, you keep thinking about it wondering what it said.” Trying to interpret abbreviations on some signs can be distracting: “Sometimes I really don’t know what part of the road is closed.” Legibility and content of signs is an issue for some: “When you try to read a sign and that takes two tries, you are really unhappy if it tells you about a problem next week or an

ozone alert." Lane changes are difficult, and response time is increased. "It is easy to miss an exit when you can't see the exit signs early enough and you can't get off in time. When that happens I keep driving to the next exit, but that takes time." Still all agreed, "The freeways get you there."

FREEWAY DRIVING AND THE AGING PROCESS: A SUMMARY OF RELATED RESEARCH

Driving a vehicle requires multi-tasking—one must steer, brake, process incoming information about the vehicle, and make navigational decisions. Given the quantity of information associated with the driving environment, it is essential that the driver be able to prioritize and attend to information that is of primary importance for maintaining the driving function (FHWA 1994). Searching and scanning behaviors that involve attention switching, of particular importance for driving, become less efficient with aging (Shinar 1993). One must remain alert, process information effectively, and respond quickly to unexpected stimuli.

Making quick, effective responses to changes in road conditions becomes increasingly challenging as drivers age. Researchers agree that the ability to process multiple sources of information efficiently and effectively decreases with age. Driver inattention and deficiencies of information processing is documented as a major factor in automobile accidents. While some researchers associate changes in ability to multi-task with a decline in the working memory, others associate this with a decline in the ability to processing information quickly (Salthouse and Babcock 1991, Salthouse 1991). Variation in completing cognitive tasks that include memory, reasoning, and verbal knowledge can, according to these researchers, be primarily explained through a discussion of the speed mechanism (Salthouse 1991). Despite this disagreement on the specific cause for the change, all agree that older adults are disadvantaged in complex situations that require a quick response. The speed of travel on freeways certainly does require drivers to respond quickly. Although there is no substitute for effective defensive driving, relatively minor changes in highway infrastructure can help to reduce some of the strain on older drivers. Adequate advance warning signs offering specific directions and guidance can assist the older driver with prioritizing information (Craik 1986, FHWA 1994). Visual stimulation can attract attention to significant changes in the highway conditions. Well-placed, brightly lit, electronic VMS may offer older drivers an important enhanced level of visual stimulation.

Changes in Responding to Visual Cues

If electronic signs are to be effective in communicating with mature drivers, however, they must also respond to changes in visual ability that accompanies the aging process. Driving relies heavily on visual observations and the ability to respond appropriately to visual cues. Hence the greater prevalence of visual problems and eye disease among older persons has been assumed to be a primary cause of their driving difficulty (FHWA 1994, Ball and Owsley 1991). Although evidence from studies attempting to link changes in any type of visual acuity to increased crash rates for older drivers is inconclusive, comfort in driving is affected. Safety-oriented older adults are keenly aware of this and

try to compensate for it by changing driving patterns. Reading road signs does become more difficult with age. Letter acuity declines during adulthood (Pitts 1982), and older adults' loss of acuity is accentuated under conditions of low contrast and low luminance (Adams 1988, Pitts 1982). Although various researchers disagree on the onset of changes in visual acuity, all note a more rapid decline after about age 60. Physiological changes also result in greater sensitivity to glare and a reduction in sensitivity to contrast. In most cases these changes can be addressed through increased illumination and optical correction, but the presence of cataracts, macular degeneration, and glaucoma contribute to sharper declines in visual ability.

Visual Acuity

Static visual acuity, the type tested with the standard letter-based eye test, has little relationship to the driving experience (Ball et al. 1993) except perhaps when someone is reading a sign while stuck in traffic that is hopelessly congested. Dynamic visual acuity, on the other hand, reflects the ability to resolve the details of a moving target. This is much more closely related to the typical driving experience that involves reading street signs and directional signs while in motion. This ability declines with age, and dynamic visual acuity also decreases with increased speed (Burg 1964). This can be an issue with freeway driving, although these are no strong statistical correlation between dynamic visual acuity (?) and the crash rate of older drivers (FHWA 1994). Dynamic visual acuity can be enhanced with longer viewing time, brighter illumination, and practice (FHWA 1994). Electronic VMS can potentially meet that need. The FHWA Highway Design Handbook recommends that the driver should be able to read an entire message twice (Staplin et al. 2001). A motorist traveling at 55 miles an hour would have about 12 seconds to read the sign. To accommodate those driving at regular freeway speeds not only would letters need to be larger but also the width to height ratio would need to be changed from .7 to 1, a ratio that older drivers found easier to read, according to a study conducted by Garvey and Mace in 1996 (Staplin et al. 2001).

Contrast Sensitivity

Contrast sensitivity is related to the ability of a driver to see patterns in the environment, and that ability also declines with age (Owsley et al. 1987). Although there may be neurological losses, the major cause for a reduction in ability to distinguish colors or contrast is the result of changes in the eye's optics. The lens becomes more opaque and the pupil shrinks allowing less light to enter the eye. At age 60 the amount of light reaching the photoreceptors in the eye is only about one-third the amount available at age 20 and these changes continue to accelerate with age (Green 2004). This loss is more apparent at lower light levels (Schreiber 1988). Green Laboratory studies found that difficulties with observing contrast affected the ability of older drivers to read words on signs (Green 2004). Ball and Owlsley found a significant relationship between contrast sensitivity and crash rates in a three-plus year crash rate study for drivers over the age of 66 (Ball and Owlsley 1991, Decina and Staplin 1993).

In studies attempting to respond to this significant challenge, Garvey and Mace (1996) found that for all drivers, signs with light letters on dark background (positive contrast)

were legible at a longer distance than signs with dark characters on a light background (negative contrast). In fact, for someone driving 55 miles per hour, positive contrast added about 220 feet of legibility for characters 450 mm (18 in) tall. Drivers up to age 73 found that white or yellow letters on black were equally legible, but for drivers over age 74 yellow letters on black proved to be significantly more legible. One study noted that white or yellow pictorial displays on a black background were legible to older drivers at even great distance (Kettles, Kline, and Schieber 1990). The FHWA Highway Design Handbook (Staplin et al. 2001) provides convincing evidence for the FHWA 2001 guidance recommending use of positive contrast electronic signs with 18-inch yellow characters on black background on VMS.

Minimizing Glare

The related issue of brightness is also important, particularly in response to glare conditions. Glare is defined as brightness within the field of vision that is substantially greater than the luminance to which the eyes are adapted (McCormick and Sanders 1982). The clouding of the eye's optics cause bright light to scatter, making it very difficult for the older driver to see shapes and contrasts when confronted by headlights at night (Wolf 1960, Schieber 1988, Morimer 1988, FHWA 1994). Glare associated with bright sunlight offers similar challenges. It is debilitating to central vision, the region of the eye most sensitive to light and instrumental for seeing detail. Many older drivers report increased glare sensitivity during nighttime driving, and those most affected elect not to drive at night or in the rain. The issues associated with glare do, however, persist in bright sunlight and in early morning or early evening. In the desert southwest, these concerns are significant for older drivers who try to read and respond to freeway signs that are washed out by bright sunlight.

Studies show that there is an increased elevation of rod and cone thresholds with age (Pitts 1982) and an accelerated loss over age 60. This issue is reflected in decreased legibility distance at night for older old drivers. Increasing luminance during daylight hours up to 850 cd/m^2 significantly increased legibility distances for drivers of all ages, but further increasing luminescence did not produce significant improvements, according to the Garvey and Mace study (Garvey and Mace 1996). Alternative technologies respond to this need for enhanced brightness in signs, but as Upchurch found in a study conducted in 1991, there are differences between the responsiveness of these different technologies to the needs of older drivers. Light-emitting diode (LED), fiber-optic, and flip-disk technologies are all available for portable electronic message signs. The FHWA Highway Design Handbook reports Upchurch's findings that fiber-optics offer greater legibility in both day and nighttime conditions for older drivers. LED signs were less effective for older drivers both in backlit (sun behind sign) and washout conditions (sun behind driver), and the flip-disk technology offered older drivers considerably less legibility at a distance.

In reporting these findings, the FHWA Handbook notes that there have not been more recent tests of updated products or a hybrid flip-disk LED technology (Upchurch et al. 1991). Nevertheless, the current level of research does underscore the continued need to

respond to issues of glare, brightness, and legibility over distance if electronic signs are to be effective in communicating with older drivers.

Additional attractor-like flashers mounted above the display may help to orient visual attention to the variable message signs, particularly portable signs on the side of the road (FHWA 1994). Placement of these signs can be an issue if they are placed at the side of the road and other vehicles block the view. This requires drivers to take their eyes away from the road to read to sign. Height of temporary signs is important. The FHWA Handbook recommended placement at 6 feet from the ground.

Legibility incorporates the concept of information processing as well as observation. For older drivers who are challenged both by reduced visual acuity and a slower response rate, reading signs can be particularly difficult, particularly if the sign has more than one phase. Motorists should be able to read the message entirely twice, in order to process the information (FHWA 2001). Hence, the FHWA Handbook recommended using no more than two phases and limiting messages on portable message signs to only three "units." ("Units" are words to answer the following questions: What happened? Where? What is the effect on traffic? What is the driver to do?) (FHWA 2001).

The Challenge of Merging onto a Freeway

Age-related functional decreases in visual acuity, motion judgment, and information processing all contribute to making the merging maneuver one of the most complex for the mature freeway driver (FHWA 1994). A study using a multistate freeway safety database found that older drivers were overly involved in accidents that involved changing lanes. A paired vehicle analysis found that 13.7 percent of precrash maneuvers of older drivers involved merging or changing lanes as compared to 8.4 percent of precrash maneuvers involving younger drivers (HSIS 1996).

A number of other studies document the level of stress and accidents associated with the merging process (Sadalla 1994). The difficulties relate primarily to a diminished ability to judge the gap in the traffic flow and to judge the speed of other vehicles (Koepke 1993). This is a result of changes in depth perception defined as "the ability to judge the distance and changes in distance of an object" (Burg 1964). When the lens of the eye and the ocular muscle hardens it is more difficult to shift one's gaze to a closer or further distance with the lens providing a cue about the distance of an object. This is even more challenging for drivers with arthritis who have difficulty turning their necks to observe approaching vehicles (Kline et al. 1992, Cornwell 1988). Merging requires scanning directly and indirectly through the mirrors on the rear and sides of the vehicle to avoid conflicts (Ostrow et al. 1992). Joint flexibility is an essential component of driving skill. When upper extremity movement is limited, the driving ability is seriously weakened (FHWA 1994). A simulator-based study by Staplin in 1996 and others found that older drivers took considerably longer to make a decision to merge (Staplin et al. 2001).

Crash rates confirm that in urban areas 68 percent of interchange ramp crashes occurred at the entrance ramps (HSIS 1996). Failure to yield the right-of-way is a major cause of

accidents among older drivers (Gebers 1993, FHWA 1994, HSIS 1996). These statistics, along with findings from several studies that observed the behavior of older drivers merging into a freeway system, led to recommendations for longer parallel acceleration lanes, particularly when the proportion of merging traffic was over 6 percent of that on the mainline (HSIS 1996, Staplin et al. 2001). The cost of rebuilding entrance ramps is considerable, and the space for additional roadway may not be readily available. The HSIS study recommended exploring not only ramp and mainline geometries, but also the potential for using traffic control devices as a means of reducing the number of crashes associated with mergers (HSIS 1996). Ramp meters may offer an additional means of assisting older drivers. They provide each driver with approximately four seconds in which he or she can independently gauge a gap and merge onto the freeway.

Trip Planning and Avoiding Road Hazards

Driving is complex, given the requirements for incorporating perceptual, motor, and information-processing skills. Nevertheless the majority of mature drivers have had thousands of hours of experience. There is evidence that highly practiced behaviors are more resistant to negative changes that come with age (Salthouse 1991). Increased familiarity and expertise on a roadway may help to compensate for cognitive decline that would affect driving behavior (FHWA 1994, McCoy 1991). Cautious older drivers may compensate for this by not listening to the radio or talking to passengers, but rather devoting all their resources to driving (FHWA 1994).

The literature on selective attention relates to the process of selecting or controlling new stimuli. There is considerable evidence that automatic processes are age-insensitive, and that controlled processes require effort and drain cognitive resources. Older drivers with diminished automated processes may be particularly disadvantaged when dealing with a road hazard or road maintenance areas. They are slow to respond to changes in a largely automated driving pattern. Changes in the roadway, construction zones, or new directional road signs are far more problematic for older than younger drivers (FHWA 1994, Sadalla 1994). The addition of a secondary task affects the performance on the primary task, negatively. While this is true for younger as well as older adults, the magnitude of the decrease in performance of older adults is far greater (Sadalla 1994, FHWA 1994).

This is evident in the difficulty that older drivers have in completing Trails Test B, which involves two tasks—connecting letters and numbers sequentially. A study by Korteling argues that the problems older drivers encounter are not with practiced responses like driving a car, but with handling a vehicle in an unfamiliar situation (Korteling 1992, FHWA 1994, Sadalla 1994). Both pretrip advanced traveler information and advanced placement of electronic message signs may be able to assist the mature driver in compensating for these challenges.

SUMMARY

In summary, there is a considerable body of literature documenting the increasing challenges that are associated with the aging process. As is indicated, a number of these

studies point to specific concerns that relate to the complex task of driving a vehicle. The safety of both the older drivers and those with whom they share the road is dependent upon their ability to compensate for these physical changes.

While some older persons voluntarily limit their own driving to familiar roadways or try to avoid the complex left hand turn or night driving, others are more confident of their continued ability and continue to travel along urban freeways. For some the answer to the changes that are associated with the aging process is to look to vehicles with devices such as heads-up displays. A far greater number are benefited by highway and freeway modifications that can help to enhance driver safety. Although initially intended to ease congestion on roadways, a number of specific ITS technologies serve an important role in assisting older drivers in negotiating freeways.

3. METHODOLOGICAL APPROACH

Having underscored a number of challenges facing mature drivers on freeways and the potential response offered by some ITS technologies, the next step was to find out how older drivers responded to these innovations. Did these ITS technologies actually assist older drivers? How might they be made more effective? The study relied on a series of focus groups to address those questions. Individual participants in the focus groups also completed trip logs, a short survey, and a Trails Test. An assessment of accident records associated with older drivers on freeways helped to provide the context for the study.

FOCUS GROUPS

Focus groups are regarded as an effective means of gaining in-depth observations reflecting attitudes regarding a product or policy. Used initially to improve the quality of manufactured products, the approach is now widely used to stimulate citizen participation in making public policy. Focus groups do not offer any type of statistically accurate assessment of public opinion since participants are not selected randomly, but rather they offer a thoughtful reading of public attitudes. Sessions typically involve between five and nine individuals selected to reflect a range of perspectives on an issue. Focus groups are most effective in gaining information about how people think or feel about a topic, and why they hold certain opinions. They have been used effectively to improve the planning and design of new programs, to evaluate existing programs, and to develop strategies for outreach. In the area of public policy, focus groups can take advantage of group interactions to find out about community needs, whether a program is responding to those needs, and what might help to make it more effective in reaching those needs (Marcrak and Sewell 2002, Krueger 1988, Morgan 1988).

The small group format enables all participants to be heard and encourages all to share their ideas. Group dynamics contribute to the level and range of discussion as participants build upon the ideas presented by others. An objective facilitator encourages all to participate actively, keeps the discussion on target, and moves the discussion through an established agenda. Recorders note all observations. Discussions are taped and transcripts are made available for later assessment.

During the period from October 2003 to March 2004 this research team conducted 11 focus group discussions with mature drivers in an effort to gain their perspectives on use of specific ITS technologies and innovations to address concerns about freeway driving. A pilot focus-group discussion with instructors involved in the AARP Driver Safety Program (a driver refresher course specially designed for motorists age 50 and older) helped to refine the agenda and the approach used to present issues in the subsequent focus group discussions. The transcript from this discussion also helped to frame the dictionary for the content analysis of subsequent focus groups.

Participants

Participants in the mature driver focus groups regularly drove on the urban freeway system in the Phoenix metropolitan area. The intent was to involve individuals who had

personal experience both with freeway driving and with observing ITS technologies– including fixed and portable VMSs and ramp meters – and who would also be aware of the potential for using advanced traveler information. Although some participants had met previously, none had previously been involved in group discussions on highway or transportation issues. There was a clear effort to include a broad representation of older freeway drivers in the Phoenix metropolitan area. The expectation was that freeway driving experience would vary depending on residence location, travel patterns, and age. The groups represented drivers in the East Valley, the West Valley, and the City of Phoenix and included residents of age-restricted communities as well as intergenerational communities. Locations of focus groups were also selected to reflect ethnic and income diversity. Table 1 indicates the locations of the focus groups.

Table 1. Focus Group Locations

Mature Driver Focus Groups (Pilot Group: Pyle Center, Tempe)
• Oasis Senior Center, Metro Center, Phoenix • Scottsdale Senior Center • Sun Lakes (south of Chandler) • Residence in Phoenix with participants from Scottsdale and Paradise Valley • Mesa Community Library • Peoria City Hall • Sun City West • Maricopa County Workforce Center in Peoria • Westwood Community (adjacent to Peoria) • Venture Out Resort (winter visitors) East Mesa • Silver Ridge Resort (winter visitors) East Mesa

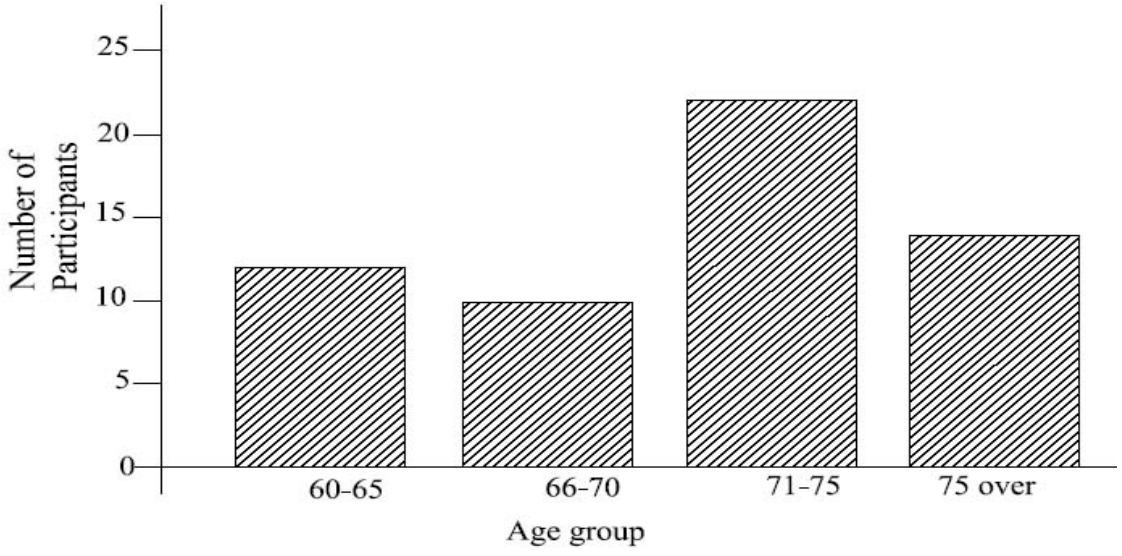


Figure 3. Age Groups of Focus Group Participants

A total of 61 drivers over age 65 participated in the various focus groups. As Figure 3 indicates, the participants included both younger-old and older-old drivers. They included 26 women and 35 men. A short survey questionnaire administered to all focus-group participants permitted the research team to document the age range of participants.

Focus-group participants were given a small monetary contribution in exchange for their participation. However, in almost all groups, the participants were unaware that they would receive any compensation when they agreed to join the focus group. Hence the compensation would not have been a factor in their extent or substance of participation.

Focus Group Agenda

The agenda was consistent across all the mature driver focus groups. Participants engaged in a discussion on a common set of topics. They also completed trip logs, a short survey, and a Trails Test. (See Appendix A for a script of questions raised in the focus groups.) The literature on focus groups suggests using no more than five or six overall questions for each session. In this case the agenda was focused on four specific ITS-related topics: fixed VMSs, portable VMSs, ramp meters, and the 511 ATIS. Given that the overall objective of the project was to reflect upon the responsiveness of older mature drivers to ITS technologies, this approach helped to direct the discussion to the specific technologies rather than covering a full range of the concerns experienced by the older drivers. Nevertheless, concerns regarding freeway driving emerged in relation to discussion of the specific technologies.

The research team expected that participants would differ in their experience with the ITS technologies and their familiarity with nomenclature used to describe the devices. Hence, they introduced the discussion of each technology with a Power Point slide showing examples of various deployments in the Phoenix area and beyond. Although the selection of visual images did tend to direct the discussion to some degree, all groups quickly moved on to aspects related to that individual technology that were of concern to them.

Each mature driver focus group informally selected their own subtopics for discussion and the order of subtopics, so the extent of discussion about each subtopic varied among the various focus groups. After each group exhausted its own set of subtopics, the moderator prompted the group with questions related to other images on the slide that they had not discussed. In general, the relatively short discussion that followed such prompts underscored the group's limited concern with issues that they did not raise themselves. Although there were certainly differences of opinion among participants and differences in extent of concern expressed by the various groups, the set of issues that generated most discussion was fairly consistent across the groups. Given the number of groups held and the differences in location, age, and experience, this consistency helps to underscore the importance of these issues among older drivers.

Control Focus Group with Younger Drivers

A control group of younger drivers (age 40 to 55) also participated in a focus group session. These drivers were employees at two different campuses of Arizona State

University (ASU) — the Tempe Campus and the Downtown Phoenix campus. The objective in choosing the participants for the control group was to hold as many variables as possible constant and to control specifically for age. Of the six drivers in the control group, four were working part time, one was working flexible hours, and one was working a more typical 8:00 to 4:00 day. Hence they had flexible and varied driving patterns much like the older drivers. They lived and worked in different locations in the Phoenix metropolitan area.. Several were actively involved in community activities and volunteer efforts. All regularly drove on the freeways.

The control group participated in all the same activities as the older mature drivers including a focus group session, the Trails Test, trip logs, and the survey. The focus group agenda was the same as that used with the older drivers, and the younger drivers chose to discuss sub-topics that closely paralleled those chosen by the older drivers.

Approach to Reviewing Focus-Group Transcripts

The review of focus-group transcripts incorporated both quantitative and qualitative approaches. Catterall and MacLaran, in an article entitled "Focus Group Data and Qualitative Programs: Coding the Moving Picture as Well as the Snapshots," underscored the importance of observing group interaction and the context for observations as well as providing a checklist for words used in focus groups. Unlike group interviews, focus groups benefit from the synergy, snowballing, and stimulation that come from the group interaction and provide data that is rich in detail (Asbury 1995).

There are two general approaches to analyzing the findings from focus groups. A more quantitative approach emphasizes primarily the verbal content of the sessions as reflected in the choice of words used as reflected in session transcripts, while the other more qualitative approach places more emphasis on the group dynamic and group reinforcement of ideas. The current study employed both a content analysis of transcripts and a more in-depth look at individual and group observations.

Content analysis as deployed by some social scientists, involves taking a close look at a series of transcripts generated by meetings or focus groups on similar or related subjects. Following an initial review of one or more transcripts the analysts develop "a content analysis dictionary," that is a list of the terms or phrases that are frequently used by group participants to note concepts of interest or concern. Multiple analysts look at the same documents to insure agreement on terms to be included in the dictionary. Additional words on concepts are added to the dictionary as more transcripts are read. Researchers then review transcripts from all meetings and note the number of times that those terms or phrases are used by different individuals, the direction of interest– positive or negative– and the level of intensity reflected by each comment (Stewart and Shamdasani 1990). To guard against reviewer bias, several reviewers read the same transcripts and then compare results and resolve differences in interpretation. The result is a tabulation reflecting topics of relative interest and concern among participants.

Market researchers, who employ focus groups for product testing, deliberately avoid analyses that involve counting terms. They note the nuances suggested by participants. They also distance themselves from qualitative researchers who use what they regard as a journalistic approach of taking responses at face value (Robson and Hedges 1993). Instead, they involve themselves in what they regard as "clinical interpretation" of observations by delving deeper into the context and meaning behind observations.

Some focus group analysts suggest an approach that would blend both quantitative and qualitative analysis (Agar and McDonald 1995). All researchers caution against what they call "group think" in which individual perspectives are overwhelmed by the opinions of more vocal participants, and then all participants appear to be echoing the same point of view (Catterall and Maclaran 1996). Catterall and MacLaran suggest several readings of each focus-group transcript, first to code content, and again to assess the group dynamic.

The current project chose an analytic approach that incorporated both quantitative and qualitative assessment. As such the project team employed both content analysis and contextual assessment that noted group interaction and comments that provided glimpses into the driving experiences of older drivers.

Content Analysis

When used appropriately, content analysis is a powerful data reduction technique (US GAO 1996). In the context of the current project, content analysis provided a means of reflecting the consistency of opinions and observations presented across a number of different focus groups. A primary reason for holding 11 different focus groups among diverse groups of mature drivers was to identify issues that reached beyond the opinions of a particular group or location and seemed to represent more broadly the perspectives of mature freeway drivers in the Phoenix area. Content analysis offered the opportunity for this type of cross group assessment. All focus groups were transcribed and those transcriptions formed the basis for the content analysis.

As advocated by Steve Stemler in his article "An Overview of Content Analysis, A Practical Assessment" (2001), the research team members focused not only on words used but also the concepts as used in context. The number of times that a concept was referenced in any one focus group by different participants offered an indication of saliency. This approach helped to underscore significant concerns, but also discounted repeated references to the same point by a single participant. Three team members worked independently on building a content analysis dictionary that would note categories that were both mutually exclusive and exhaustive (GAO 1996). The content analysis dictionary, as it appears in Appendix E, lists the terms and observations that were used in multiple group sessions.

The transcript of the pilot focus group with AARP Driver Safety Program instructors served as a common source for building this dictionary. Three members of the research team used what is known as "emergent coding" in applying the draft dictionary to an additional transcript. A few additional concepts were added to the dictionary and a few

categories were collapsed. Once the categories were collapsed, variation among reviewers was within the guideline of 95 percent agreement among reviewers (Weber 1990). To assure reliability, two researchers used the dictionary to code all of the other transcripts independently, and a third reviewer checked for variation. Differences were resolved in a joint strategy session. Findings indicated a substantial clustering of observations and perspectives across focus groups, providing confidence that the findings were broadly representative of the older freeway drivers included in the Phoenix metropolitan area.

The research team supplemented the quantitative assessment offered by content analysis with a qualitative analysis of the various focus groups. The transcripts were reviewed a second time to identify specific observations that captured the "insightful communication and learning processes that occur in focus groups" (Catterall & MacLaran 1996). Detailed notes taken by research team participants during the various focus groups and discussions among researchers after the sessions helped to identify and underscore the primary points raised in each of the groups. Phrases and observations that reflected these key ideas were selected from the transcripts and woven into a narrative that helped to capture the spirit and perspectives of the various focus groups.

TRIP LOGS

As noted above, the focus of this study was on freeway driving. When reviewed together, anecdotal information, census figures, and the increasing proportion of older persons with drivers' licenses seem to point toward a steady increase in the number of older freeway drivers. Yet, there is little data regarding the travel patterns of older mature individuals who travel on urban freeways. One study completed by Phillip Shapiro for the ADOT ATRC in 1985 focused on residents of Green Valley, a retirement community south of Tucson, Arizona (1986). The study, based on travel diaries of 688 households in the community, did not specifically focus on freeway driving. It did, however, find that households of that community (95 percent over age 60) made more frequent trips and shorter trips than would have been predicted by the regional model for Tucson. Green Valley respondents also made far more nonhome-based trips (multipurpose trips) than anticipated by the regional model and significantly favored daytime travel. Although the study did not distinguish between travel patterns of residents based on age, the substantial proportion of retirees living in the community led to an underrepresentation of work trips. Work trips would have required a regular 20-mile freeway trip to the Tucson urban area.

In order to get a clearer indication of the experience of focus-group participants with freeway driving, the current study team requested that all focus-group participants complete a trip log (see Appendix B). The participants documented the purpose, time, and mode of trips taken during the two days prior to their focus group and brought the logs to the focus group meeting. The trip logs were accompanied by a short survey intended to complement the trip log and indicate whether the two days reported on the logs adequately represented the travel pattern of these individuals. The surveys also inquired about use of traveler information with a question similar to a study using trip logs to assess use of ATIS sources in the Seattle area (Pierce 2003) (see Appendix C).

The surveys also helped to gain additional information about the extent of experience with freeway driving both in state and beyond. In a number of cases, while the logs did not indicate trips on the freeways on the days prior to the focus group, the same participants noted that they were involved in a considerable amount of freeway driving on other days of the week or month. One additional survey question asked respondents to indicate their age group. The logs and the surveys indicated considerable differences in driving patterns among the focus group participants. Although all were, in fact, freeway drivers, the extent of their exposure to freeway driving varied considerably.
The surveys and trip logs were analyzed using Statistical Package for Social Sciences (SPSS). Given the categorical data provided on the surveys and the trip logs, the research team relied on descriptive analyses involving cross tabulations and summative reports indicating the percent of respondents who favored each option.

TRAILS TEST

As the literature clearly indicates, chronological age is not necessarily an indicator of driving competence. The aging process affects each person somewhat differently. There was no effort to request information about individual driving records or medical condition. All joined into the discussions freely, although there were some observations that indicated individual differences in terms of experience and comfort on the freeways. One way to gain a better understanding of these differences was through the use of a Trails Test. The Trails Test, originally designed as part of a U.S. Army individual test battery, has been used widely to test for motor speed and attention function. Performance on Trails Test B has been affected by both changes associated with the aging process and by brain injury.

The test requires that someone first connect sequentially letters of the alphabet that are randomly scattered on a page (Trails Test A), and then connect sequentially a series of randomly scattered letters and numbers in a pattern A-1-B-2-C-3, etc. (Trails Test B). A number of researchers have underscored the validity of the Trails Test as a means of assessing individual competency and ability to multi-task. As with any test in which speed is a factor, performance on the Trails Test declines with age. When the number of seconds taken to complete part A is considerably less than that required to complete part B, the subject probably has difficulties in conceptual tracking or symbol interpretation. A slow performance on both parts points to likelihood of brain damage. The slower performance of older persons on this test is attributed to deficits in the functioning of the frontal lobe of the brain that is known to occur with age. "Researchers have also found that the test can show how well a subject responds to a visual array, how well he or she performs when following a sequence, and how well the subject can deal with more than one stimulus at a time" (Sadalla 1994, 36).

Staplin, Lococo and Sim used the Trails Test to compare the speed, accuracy, and flexibility of directed visual search among younger and older drivers (Staplin et al.1993). "Since the visual search plays an important part in the driving function, the Trails Test provides a quick and clinically proven technique for comparisons in terms of operator performance" (Sadalla 1994). It is one test that has been regarded by a number of

researchers as an indicator of ability of a driver to focus and accomplish interconnected tasks efficiently and effectively. In the current study the expectation was that the overwhelming majority of the freeway drivers participating in the focus groups would complete the Trails Test successfully, thereby indicating that they had the visual ability, competence, and mental agility needed to drive on freeways. Their success would help to underscore the rationale for enhancing freeway infrastructure to accommodate their needs as competent mature drivers.

Hence, at the conclusion of the focus-group discussion, each of the participants was asked to complete a Trails Test. (See Appendix D). All but one participant agreed to try the exercise that was presented in a relaxed way as a means of demonstrating how much more difficult it was to focus on two or more activities than to concentrate on a single activity. The experience on the test was presented as analogous to the type of multi-tasking needed to follow a set of directional signs while at the same time steering the car. Participants were timed for completing both Trails Test A and B. Participants were assured of anonymity in all parts of the focus-group session, especially the Trails Test. They signed consent forms indicating that they understood that all information, including the results of the Trails Test, would be reported only in the aggregate.

MODIFIED HEURISTIC ASSESSMENT OF 511

The final series of questions in the focus groups involved a discussion of the 511 telephone and computer-based traveler information systems. At the time of the initiation of the current study in September 2003, the Arizona 511 dial-up system was in a fairly mature state after having been implemented in 2000. The expectation was that the focus-group participants could contribute to a qualitative assessment of the system, from the perspective of older drivers.

Focus group participants were asked to try the 511 traveler information phone line before coming to the sessions. Unfortunately, very few actually had used the telephone system before the focus-group meetings, and none of the participants had used the AZ511.com Internet-based traveler information system. During the October and November 2003 focus group sessions, most participants discussed the 511 telephone system in concept, referring to circumstances when they would use the system and what might be important to them in a traveler information system.

Halfway through the research effort, before the January focus-group sessions, the 511 telephone system was given a major lifecycle upgrade that fundamentally changed the hardware, software, and user interaction characteristics of the 511 system. Effectively the 511 telephone system changed from a push button approach to a completely voice activated system. The study team, therefore, reformulated an evaluation plan and re-collected user data on the system.

As part of the focus-group sessions, participants were also shown a series of PowerPoint slides taken from the AZ511.com Internet site. These slides showed the state map and demonstrated how to click on pictorial icons that would highlight specific issues related

to roadway conditions and the statewide limited access highway system. In addition they were shown a sample pop-up slide showing information that would be available to a user who clicked on an icon. They also were shown the colored Phoenix-area freeway real-time congestion map as it appeared on the computer screen between September 2003 and March 2004, and they were given a handout that showed each page in the AZ511.com series in sequence.

The discussion focused on the focus-group participants' experience in using computer-based traveler information. A substantial number of them regularly used MapQuest for pretrip information and several used an OnStar™ system (subscription in-vehicle information and emergency assistance service) while enroute. Participants then discussed what they would expect to see in a computer-based traveler information system and their response to the 511 system as presented in the PowerPoint slides and handouts. A new computer-based system was under construction at the same time that focus-group participants were being shown the version that was currently available through the AZ511.com Internet site.

Since focus-group participants generally lacked personal experience with the emerging Arizona 511 traveler information system, it was important that the study team provide an opportunity for a group of mature drivers to interact directly with both the telephone and computer-based systems. This was particularly important for assessing their response to the telephone system, which had changed from a push-button system to a voice-activated one in December. The intent was to assess their interface with the 511 telephone system and to identify aspects of an ATIS system that they felt would respond to the needs and interests of other mature drivers. A type of heuristic evaluation seemed appropriate.

This effort supplemented the efforts of ADOT's Transportation Technology Group (TTG) in its ongoing broad-scale user evaluation of the telephone 511 system. Current software not only tracks usage rates, but also monitors aspects of the system that are causing users difficulty. These areas are then addressed by the ADOT TTG. A monitored telephone call-in line also allows any user of the 511 telephone system to record concerns with the system. The ADOT 511 user evaluation does not, however, attempt to track the age of the drivers accessing the systems.

The heuristic approach, popularized by Jakob Nielson as discount usability engineering, is used most often to assess user interface with products and computer software. It is an affordable, rapid, and simple means to review a system during the design ideation or prototyping phase, and is particularly useful at capturing interaction errors that have not yet been designed out of the system. User interaction research can be very expensive, particularly if fully instrumented usability laboratories are used for the research effort. As part of an effort to reduce the cost and increase the benefit of usability studies, Nielsen (1993) proposed the concept of discount usability engineering, which focused on retrieving the greatest amount of system usability data for the least amount of investment. With just five evaluators, teams were able to find 75 percent of the system errors (Neilsen 1994).

An adaptation of heuristic evaluation was employed for the 511 telephone system review. Although initially developed to observe human interaction with a computer, the heuristic evaluation approach is also appropriate for interactive voice response design research. Typically a team of approximately five user evaluators is given either a paper or physical prototype and performs a system walk through according to a given scenario; the users evaluate the system according to a series of "rules of thumb" or heuristics. Output from the evaluation is typically a list of system design failures, and notes suggesting improvements to be made.

Ten common usability heuristics are:

- Visibility of system status.
- Match between system and the real world.
- User control and freedom.
- Consistency and standards.
- Error prevention.
- Recognition rather than recall.
- Flexibility and efficiency of use.
- Aesthetic and minimalist design.
- Help users recognize, diagnose, and recover from errors.
- Help and documentation.

Rather than applying this general list of usability heuristics to an assessment of the Arizona 511 telephone system, the study team developed a brief questionnaire in which the questions reflected the usability heuristics. Five of the basic usability heuristics applied directly to telephone "menuing" issues, and others could be easily adapted. The telephone 511 system and the AZ511.com web site were assessed separately, but by the same team of evaluators (see Appendix F).

In a typical heuristic test, all five "evaluators" independently employ the product or software to address a common scenario that involves several steps. Each evaluator goes through the scenario and lists any issues that they had with usability. An "observer" is available to note nonverbal responses and the level of comfort with the system (Dykstra 1993). Following the independent test of usability, all evaluators are brought together for a discussion of findings.

For purposes of this study, a group of five mature drivers—two female and three male—used the Arizona 511 voice recognition telephone system independently in March 2004. Each was in a different cubicle over the lunch hour on a weekday in a quiet office at ASU. Two observers were present with three users assigned to one observer and two users assigned to the other. One additional observer was assigned to the same users as they interacted with the computer-based traveler information system, AZ511.com, independently or in groups of two. In July, 2004, a similar heuristic study was conducted of the website after ADOT personnel had made a number of further refinements to it. (see Appendix G).

All mature driver evaluators were retired ASU employees and active members of a retired volunteer group. They traveled regularly to campus and volunteered regularly at ASU, and one still teaches as a faculty associate. All user evaluators had lived in Phoenix for many years, and traveled regularly on the freeway system (at least once a week). As one noted, "We can't survive around here without traveling on the freeways." However, since they did not need to maintain an 8-to-5 schedule, these mature drivers reported trying to avoid traveling at times of heavy traffic congestion. All of them had traveled outside of the Phoenix area on freeways during the last six months.

All the mature driver evaluators used computers on a regular basis, and one owned an automobile OnStar™ system. Potentially, these users were at the upper end of an experience pool in using phones and information technology devices. However, no one had used the 511 or other travel reports before. They relied on the radio for traffic information. Some users had used the telephone to retrieve travel information, but only in other states at rest stops. They all were very happy to share the ideas for improvement.

ACCIDENT REPORT ASSESSMENT

In addition to the focus group activity, the project also included an assessment of crashes involving older drivers on Phoenix area freeways, specifically those associated with merging onto the freeway from an on-ramp. The intent here was to document objectively the level of difficulty that older drivers in the Phoenix area face with regard to merging and changing of lanes at entrance ramps on the freeways. These are maneuvers that are generally noted to be among the most difficult for older drivers and could be potentially assisted by use of on-ramps.

Using crash data provided by ADOT, the study selected all accidents involving drivers over age 65 at freeway on-ramps for the period 2000–2003 and documented them on maps provided by ADOT. Clusters of these accidents were identified as information noting the speed of the drivers at the time of the accidents and the type of impact. Parallel comparative data was also assembled for drivers in the 40 to 50 year old age group. The study also noted the locations of ramp meters and when they were deployed. It was possible to note the number of crashes at individual on-ramps before and after ramp meters were deployed, although it was not possible to draw any statistical inferences. The data provided in the accident assessment offered an objective context for reviewing observations shared in the focus groups.

4. ANALYSIS OF FOCUS GROUPS

INTRODUCTION

As indicated above, the research team conducted 11 focus groups with mature drivers over a five-month period from October 2003 to March 2004. These sessions involved 61 mature drivers who also kept trip logs and filled in a short survey. Nine of these focus group sessions were with year-round residents and two were with winter visitors living in recreational vehicle resorts. The mature driver respondents reported their age groups as is indicated in Table 2:

An additional pilot session involved four mature instructors in the AARP Driver Safety Program who did not fill in the trip logs and surveys. The control group of six younger drivers, aged 40 to 55 did keep trip logs and complete the survey, but their responses and trip logs were analyzed separately.

Table 2. Proportion of Participants in Each Age Group

Mature Driver Age Groups	Proportion of Participants
Age 60-65	20 percent
Age 66-70	17 percent
Age 71-75	40 percent
Over Age 75	23 percent

The age range of participants in the winter visitor focus groups closely parallels that among year-round residents, as Figure 4 indicates.

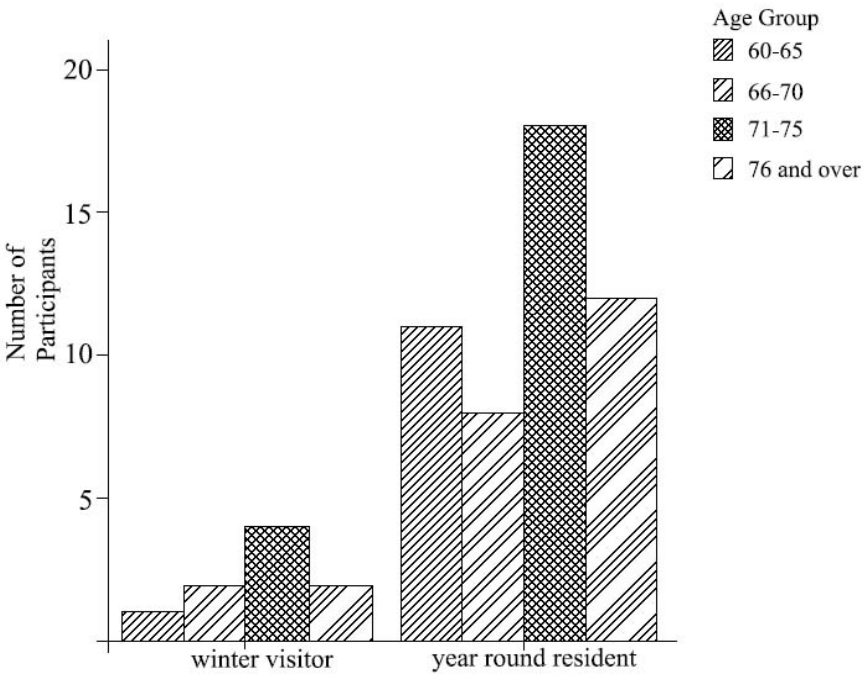


Figure 4. Comparison of Age Grouping for Winter and Year-Round Residents

The majority of participants were retired. Eight percent of these mature drivers indicated that they worked full time (as volunteers) and 21 percent worked part-time.

TRIP ACTIVITY

Only 26 percent of these mature drivers had voluntarily limited their driving in recent years. The primary change was voluntarily limiting night driving. A substantial number reported avoiding left hand turns, combining trips, or walking as an alternative to driving. The overwhelming proportion (49 percent) of the trips taken by these mature drivers was on city streets. However, on their trip logs participants also reported walking, bicycle riding, and golf cart travel in addition to traveling as a passenger in someone else's auto. None of them reported a transit trip. Table 3 shows distribution of trips by mode.

Table 3. Proportion of Trips Reported On Logs by Mode

Travel Mode	Percent of Overall Trips
Bicycle	3
Golf cart	5
Walking	6
Passenger in a car	12
Freeway driving	25
City Street driving	49

The median length of trips by these participants was between one and five miles, indicating that they were able to complete most of their trips within a fairly close proximity of their homes. Table 4 shows the proportion of trips reported on the trip logs of older drivers by trip length.

Table 4. Proportion of Trips by Distance

Length of Trips Reported	Percent of Total Trips
Less than ½ mile	5
Half to 1 mile	10
1 to 5 miles	38
5 to 10 miles	22
10 to 20 miles	15
Over 20 miles	10

Winter visitors took fewer and longer trips than year-round residents by combining trip purposes. They also made somewhat longer trips; the median trip length for winter visitors was between 5 and 10 miles.

Freeway Driving Experience

The primary emphasis in the various focus-group sessions was, however, on freeway driving and on observations regarding deployment of ITS devices on freeways in the Phoenix area. It was, therefore, important to document the experience of participants

with freeway driving. Although the trip logs kept by the focus-group participants for the two days prior to their group meetings indicated that only about one quarter of the total number of trips made by all focus group participants were on freeways, the participants indicated on the short survey that they had extensive experience in driving on the freeway system. The age of individual participants did not appear to be an indicator of the extent of freeway driving, in that respondents over age 76 were among those reporting the most extensive recent freeway driving experience in the Phoenix area.

Focus-group participants also reported driving on freeways well beyond the Phoenix area. As retirees, they had time to travel, and 78 percent of these mature drivers reported driving on freeways outside the Phoenix metropolitan area within the last six months. As the graph in Figure 4 indicates, 33 percent of these freeway trips had been along the west coast while 31 percent involved trips to other locations in Arizona, such as to Tucson or Flagstaff. Twenty percent traveled within the mountain states, but others had traveled to the Midwest and to the East Coast. Again, the age of the driver did not seem to be a factor in driving on freeways outside the Phoenix area, as Figure 5 indicates. While traveling outside the Phoenix area, these mature drivers observed VMSs and ramp meters used elsewhere and referenced both positive and negative experiences while discussing the various technologies.

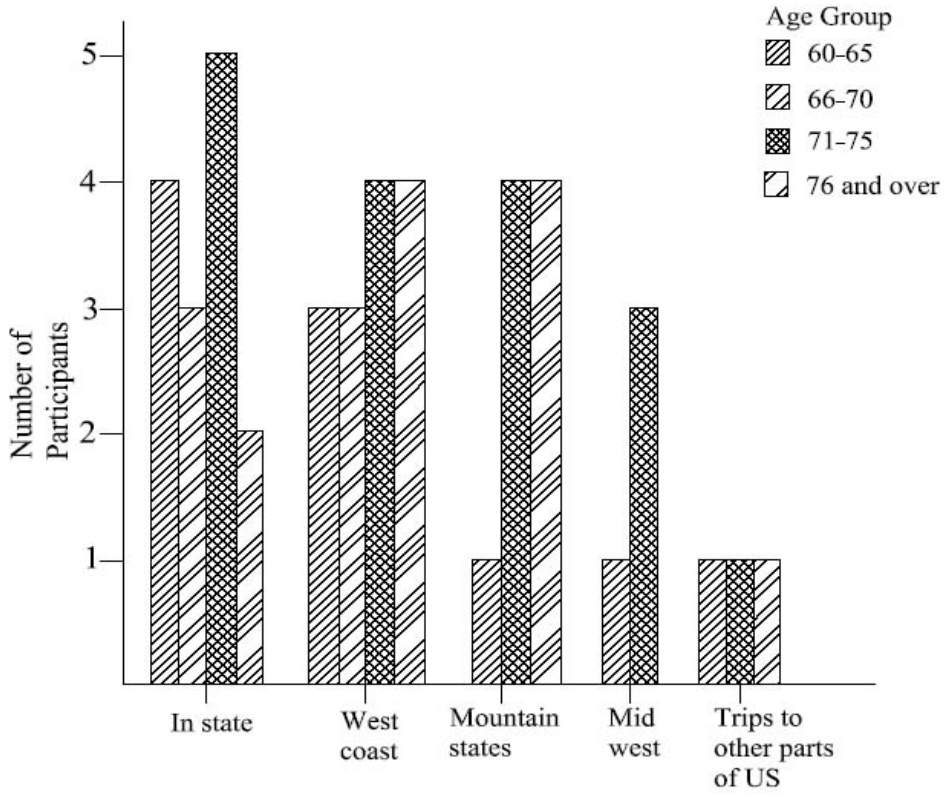


Figure 5. Freeway Trips Out of Phoenix Area in Last 6 Months by Age

Freeway Driving Patterns
These mature drivers were selected because they were comfortable with freeway driving, so it was not surprising that more than 75 percent of them said that they would choose to drive on a freeway even if there was an alternative route available on city streets.

In making their decision about whether to drive on the freeway or use surface streets, the time of day was the primary factor for 63 percent of respondents, but trip purpose (49 percent) and whether they were in a hurry (29 percent) also were considerations.

In the two days that they kept trip logs, half of the mature drivers made one or more trips on the freeway system. The primary purpose for these freeway trips was social. In fact, 32 percent of all freeway trips reported by year-round residents were for social purposes. Shopping accounted for 19 percent of freeway trips while work or volunteer services accounted for 15 percent. Eight percent of freeway trips were for medical purposes. The chart in Figure 6 shows the variation in travel patterns between year-round residents and winter visitors. The winter visitor freeway trips included far more multipurpose trips, somewhat fewer social trips, and a greater proportion of shopping trips.

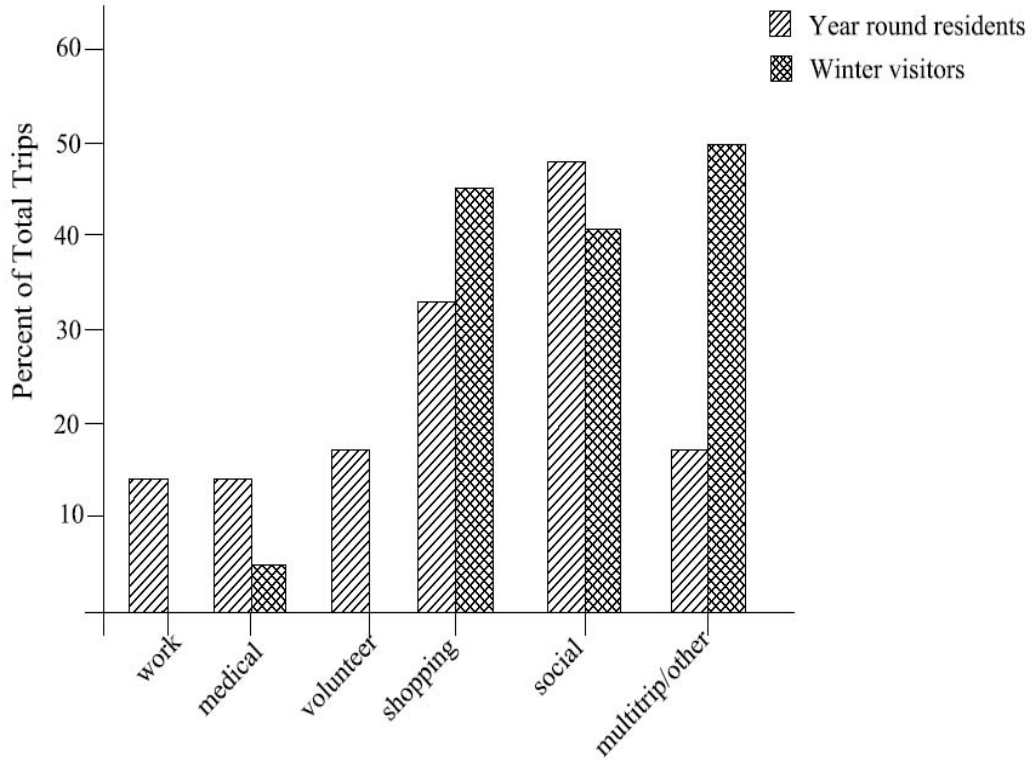


Figure 6. Comparison Between Winter and Year-Round Resident Trip Purposes

Trip Length
The length of reported freeway trips varied considerably as the following three charts (Figures 7, 8, 9) will indicate. Most mature drivers are able to address basic needs for medical appointments, banking, and shopping relatively close to their homes, even in the

sprawling Phoenix metropolitan area. They also work or pursue regular volunteer efforts within about five miles of their homes.

The trip logs did not distinguish between grocery and other shopping. Hence, the mature drivers reported that they travel both fairly close to home (five to 10 miles) and also somewhat farther (10 to 15 miles) for other shopping. Access to shopping centers typically does require a longer trip, and frequently requires travel on the freeways. A considerable proportion of trips in the 10- to 15-mile range involved mature driver carpools.

Social and recreational trips can include everything from a trip to a friend's home to a trip to the symphony, or to the ball game in downtown Phoenix. The overwhelming proportion of trips over 20 miles was for social purposes and includes travel on the freeways. Social trips can involve travel at any time of day, but the longer trips to evening concerts or sports programs do require travel at night and during peak hours.

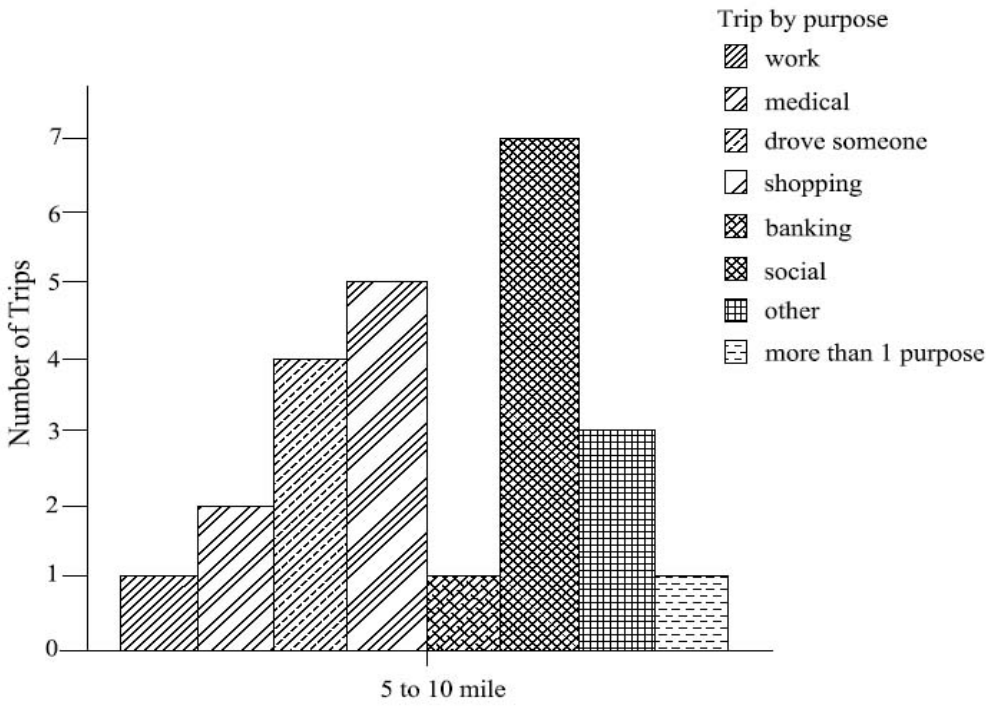


Figure 7. Five- to 10-Mile Freeway Trips by Purpose

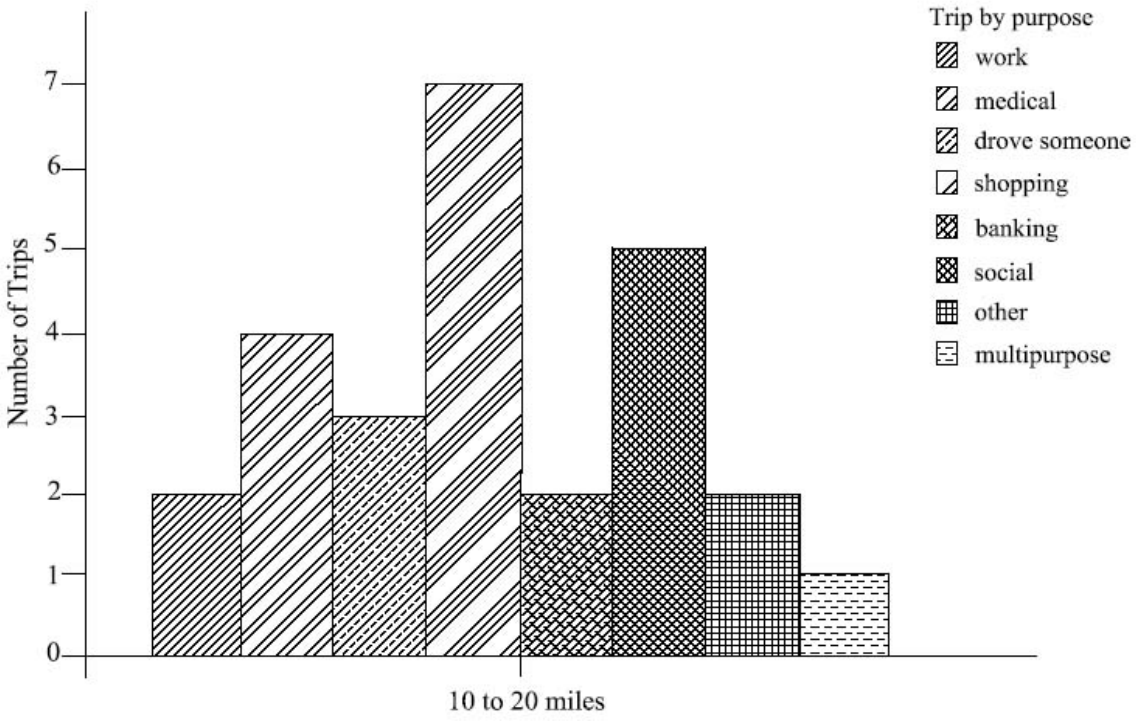


Figure 8. 10- to 20-Mile Freeway Trips by Purpose

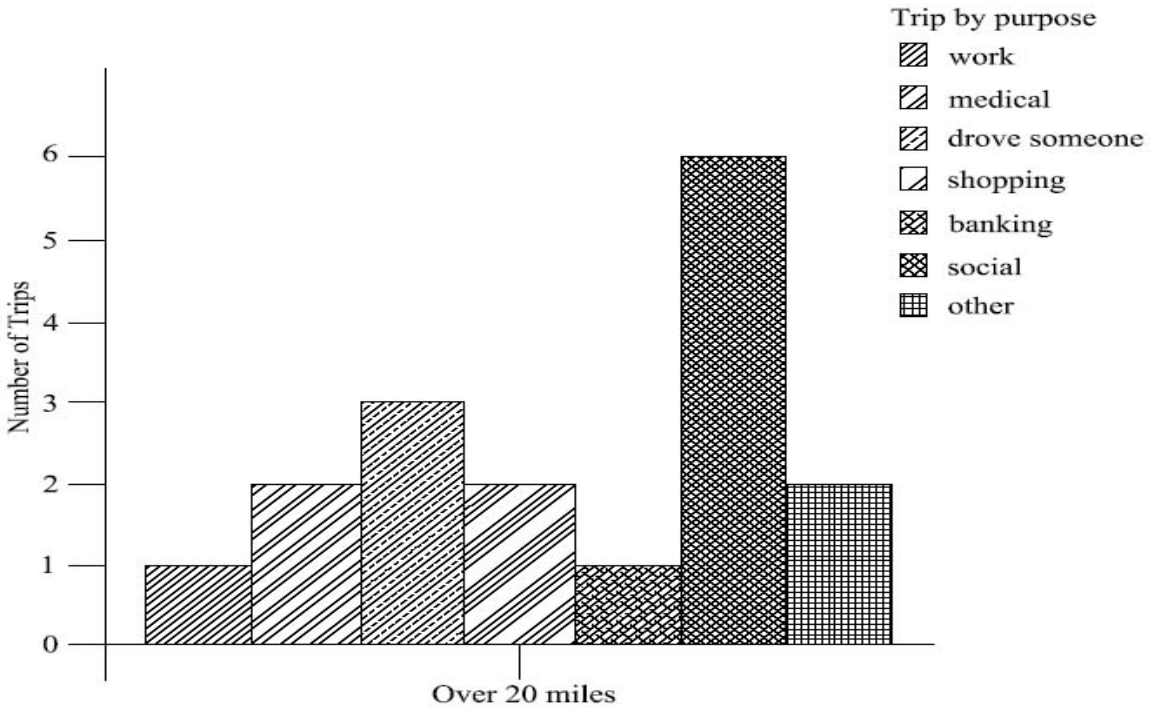


Figure 9. Over 20-Mile Freeway Trips by Purpose

Freeways Traveled in the Phoenix Urban Area

In a study focused on ITS devices deployed on freeways, it is important to note on which Phoenix area freeways the focus-group participants drive. Table 5 indicates the proportion of participants noting travel on the various freeways in the metropolitan area within the last month. To date I-10, I-17, and U.S. 60 have a number of fixed VMSs and also ramp meters at almost all on-ramps. Participants in all focus groups in the East and West Valley areas, as well as in Phoenix, had traveled on I-10 and shared a common experience with VMSs and ramp meters on that freeway. Participants in Phoenix and in the West Valley traveled I-17 more frequently, although at least one participant in all focus groups had traveled I-17 within the last month. U.S. 60 was traveled primarily by focus-group participants from the East Valley.

Table 5. Phoenix Area Freeway Travel

Phoenix Area Freeway	Proportion of Participants Reporting Travel at Least Within Last Month
State Route 101	40%
I-10	36%
State Route 202	16%
I-17	15%
State Route 51	14%
U.S. 60	9%
State Route 143	3%

Not surprisingly, older mature drivers in all focus groups referenced recent trips on the new S.R. 101, referred to as Loop 101. That route serves the West Valley age-restricted communities as well as other communities with a substantial proportion of older residents. In addition it serves East Valley communities including the Sun Lakes age-restricted community. S.R. 202, also referred to as Loop 202 with its new extensions into eastern Mesa was also well-traveled by focus-group participants. Participants in the focus groups in central Phoenix and Scottsdale were familiar with State Route 51 (S.R. 51). Winter visitors reported recent trips on all Phoenix area freeways as well as Interstate 40 (I-40).

Although portable VMSs are frequently used on all of these routes, ITS technologies are not yet fully installed on the newer portions of the freeway system including segments of Loop 101, Loop 202 and S.R. 51. The heavy proportion of focus-group participants using the new Loop 101 and Loop 202 routes underscores the importance of responding to the needs of older drivers as ITS devices are deployed on the newer freeways in the West Valley and the far East Valley.

Peak Hour Freeway Travel

The majority of the focus-group participants limited their freeway driving to off-peak periods. Since most of them were not working on a regular basis, they had flexibility in

planning, particularly for their morning trips. Only a very few trips were reported in the morning peak for purposes including medical, shopping, or for driving someone else. Wisely, they generally chose to avoid the congested morning freeways and started morning freeway trips at 9 or 10 a.m. At the same time these mature drivers did not unnecessarily contribute to the morning congestion.

Nevertheless, overall, 28 percent of the freeway trips reported on the trip logs were made during peak travel periods when the drivers would have encountered ramp meters. There were, a considerable number of freeway trips reported in the evening peak, primarily for social or recreational purposes (33% of peak hour travel.) Eighteen percent of peak hour trips were for medical purposes and 19 percent for shopping. The drivers also reported that 9 percent of their peak freeway driving involved volunteering or driving someone else while 3 percent were for work trips and 18 percent for other or multipurpose trips.

The graph in Figure 10 indicates freeway travel in the evening peak. As is apparent, the oldest group of mature drivers was well-represented in the evening peak period driving. The winter visitors were less inclined to attempt freeway trips in either morning or evening peak hours. Among all of the winter visitors who kept trip logs, only two peak hour freeway trips were reported.

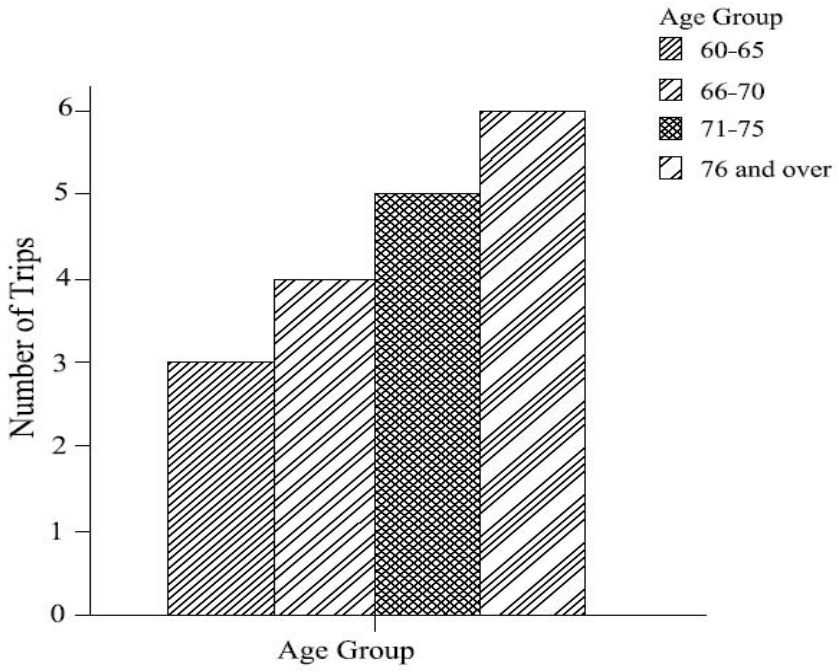


Figure 10. Freeway Trips in Evening Peak Period by Age

SOURCES OF TRAVELER INFORMATION

Focus-group participants were also asked on the survey whether they used some type of traveler information system before starting out on their trips. As figure 11 will point out, the overwhelming response among mature driver focus-group participants, regardless of age, was that they did not use any type of pretrip traveler information. This was true even for those who did travel the freeways at peak hours. Among those who did use traveler information, radio was mentioned most frequently. Four of the winter visitors mentioned using a radio, but like the year-round residents, most did not use any traveler information.

None of the participants were aware of the 511 system before being invited to the focus groups. (In fact, it was not widely marketed until spring 2004 after the focus groups were completed.) At almost every focus group session one or more participants noted in discussion that they regularly used MapQuest to provide directions before leaving home. Several participants also relied on an OnStar^{R} system for directions. Participants were concerned about congestion, road repairs, and road closures, but they were far more likely to access directions relating to their particular trip than they were to tune in to information about road conditions.

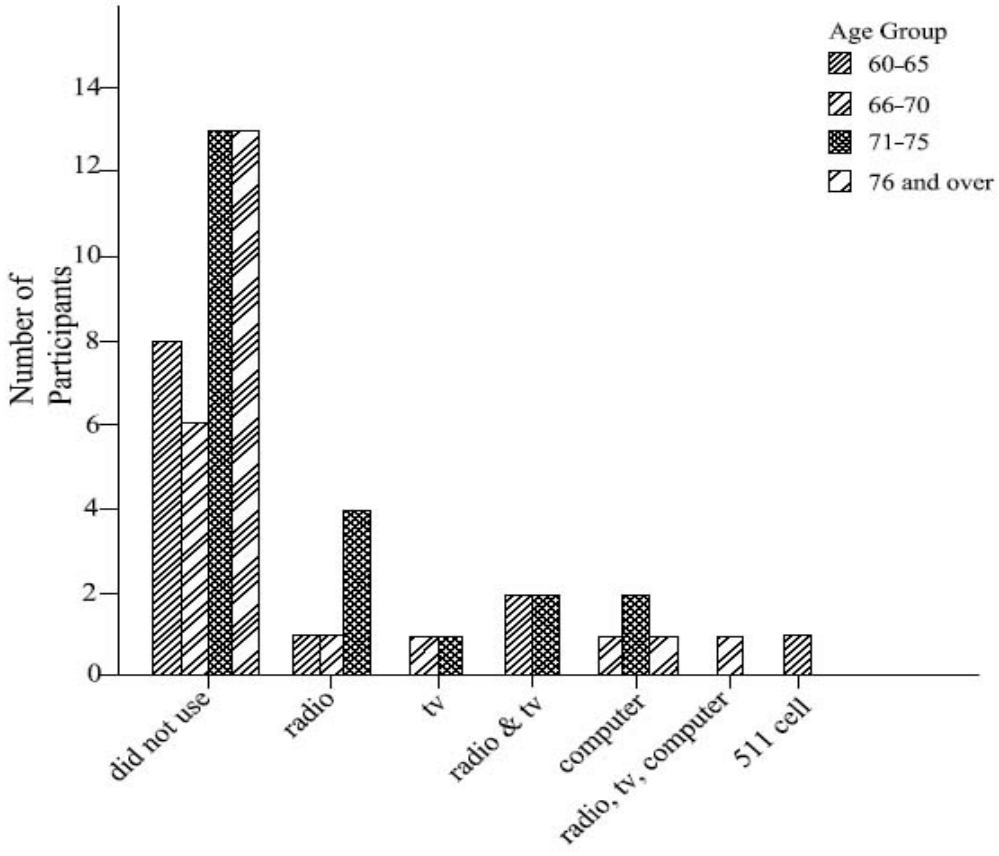


Figure 11. Travel Information by Age Group

CONTROL GROUP

In the control group focus session, the younger drivers indicated travel patterns and preferences that were similar to those of the older drivers. All would choose to drive on freeways even if there were an alternative way of reaching their destination on city streets. One of the participants, however, noted that the time of day would be a consideration in making that choice since it was "a good idea" to avoid congested periods. All of the younger drivers traveled regularly on freeways; half of them had also traveled on freeways outside of the Phoenix area, both in-state and along the west coast.

On the trip logs, the younger drivers reported that they made 35 percent of their trips on freeways, a proportion somewhat higher than that the 25 percent reported by older drivers. Still, these younger drivers also made the majority (60 percent) of their trips on city streets. They also reported that 5 percent of their trips were walking trips. Like older drivers, these younger drivers reported that the length of their trips ranged from less than a half mile to 10 miles, with a median trip length of 5 miles. As anticipate the trip purposes of the younger drivers reflected their work activity. Fifty-eight percent of all of the trips they reported on trip logs were work related and only 17 percent social, 10 percent shopping, 10 percent volunteering or driving someone else with 5 percent other. Another difference was that the younger drivers did not report traveling as a passenger in a car; while 12 percent of the trips reported by older drivers were as passengers.

PERFORMANCE ON THE TRAILS TEST

The overall performance of the focus-group participants on the Trails Test indicated a range in competency. In keeping with the literature, the performance of focus group participants on the Trail Test A did not seem to be affected by age. Both older driver participants and younger drivers in the control group completed Test A relatively quickly and easily. They had no difficulty in connecting the numbers sequentially with a single line without lifting their pencil from the paper. The median time for completion for both older and younger drivers was between 45 and 50 seconds. There were some older driver participants who completed the test in 35 seconds, and other older drivers who took as long as two minutes. Some of those who took longer commented that they had forgotten their reading glasses and felt like this was a kind of vision test. For the control group of younger drivers there was a much tighter range of completion times. The median was 44 seconds, and the range of completion times was between 42 and 50 seconds.

As anticipated, the mature driver focus-group participants found Trails Test B much more complex. The concept of connecting random letters and numbers in sequence was presented to the groups as a way of demonstrating the difficulty in carrying on two sets of activities at one time. Mature drivers had raised that point in all focus-groups, often in the context of a discussion of the problems associated with using cellular telephones while driving. Many of the older driver participants had considerable difficulty in completing Trails Test B. While one older driver focus group participant completed the test in 3 minutes 10 seconds, other participants took as long as 9 minutes. The median time was 5 minutes 45 seconds. On average, older drivers took about three times as long to complete Test B than Test A. The quality of the effort differed as well. A number of older drivers

resorted to connecting individual letters and numbers rather than maintaining a single sequence. One person maintained a running log of letters and numbers alongside the test sheet to be sure to get numbers and letters in order. Many of the older drivers left out letters and some did not fully complete the exercise. Some resorted to running their pencil over the sheet without connecting the letters and numbers in order. Testing instructions note that an observer can assist a participant by putting their pencil down on the next letter if they become lost. A number of the older driver participants needed this type of help.

The younger driver control group had far less difficulty completing Trails Test B. The median time for this group was 3 minutes 22 seconds, and the range was also fairly narrow from 3 minutes 11 seconds to 4 minutes 19 seconds. All of the younger drivers were able to keep their pencils on the page and connect letters and numbers in sequence.

The literature indicates that the challenges presented in Trails Test B are strongly associated with the aging process. Several older driver participants noted visual problems in tracking the letters and numbers; others appeared to have cognitive issues. Some had considerable difficulty in recalling the sequencing of the letters and numbers. Some resorted to simply connecting A to 1 and B to 2, rather than maintaining an overall sequence. The focus group in which almost all participants were over age 75 had the greatest difficulty in completing Trails Test B. Even with a lot of "help," one person took 9 minutes to complete the test.

ASSESSMENT

The study team took care not to associate Trails Test scores with individual participants in keeping with the pledge of anonymity. Nevertheless, the quality of observations and the experience relayed by the individual drivers generally coincided with their performance on Trails Test B. Those who had more difficulty on the test had earlier indicated that they restricted their freeway driving only to very familiar trips and that they had difficulty changing their driving patterns during road construction. Other older drivers who had trouble with Trails Test B made observations that seemed to wander from the subject at hand during their respective focus group session.

The focus of this study was on making freeways safer for mature, competent drivers. Obviously, not all mature drivers have the same level of comfort with freeway driving nor are all equally able to handle the complexities associated with freeway driving. The variation in performance on Trails Test B offered corroboration for that perspective.

5. MATURE DRIVER PERSPECTIVES ON ITS TECHNOLOGIES

As noted, the discussion agenda in all of the focus groups included four main topics– three of those related to ITS technology and a fourth dealt with response and expectations regarding advanced traveler information. The research team applied content analysis to the transcripts of each of the focus groups and used a common content analysis dictionary to note the key issues related to each topic. This dictionary, initially developed after a review of the transcript of the pilot project, was expanded to reflect the observations of the focus groups. Two researchers read each transcript independently, with a third researcher reading specific transcripts where there appeared to be a difference in coding. A discussion among the coders resolved any differences in interpretation. This approach not only helped to insure reliability, but also helped to assure that the divergent thoughts and ideas expressed in each group would not be overlooked.

The orientation and experience of participants in the individual groups, as well as the group dynamic, led to variation in emphasis and in levels of concern. Nevertheless, participants in the various groups raised a number of similar issues, thereby underscoring their broader importance to older drivers.

VARIABLE MESSAGE SIGNS

Mature drivers in every focus group noted the helpfulness of the large fixed VMSs posted above the flow of traffic in the center of the freeway. They saw them as communicating critical information to the traveling public. In the words of one mature driver, “Those signs—I find very helpful, and they are large enough that I can see them far enough away to pay attention.”

The content analysis dictionary has three sets of issues related to variable message signs:

- The importance of clarity (issues included shape, spacing, color, size, brightness).
- Location (issues included placement on highway and distance from incident).
- Meaningful information with guidance to driver (issues included simplicity of message, alternative routes, minimizing general alerts).

Other issues included benefits of repeating messages and standardization of messages.

The following topics are presented in an order that reflects the level of interest and concern of participants across the various mature driver focus groups. Saliency was noted in the involvement of multiple participants, each of whom added substantively to the discussion. The primary issue areas included both the presentation of the message, and the visibility and legibility of the sign.

The Message

- Signs need to be specific, concise, and relate to current driving conditions.
- Signs need to give enough prior notice for the driver to take action, given problems of reading while traveling at high speed.

- Signs and information should be repeated to assure appropriate driver response.
- Avoid use of signs for ozone alerts or encouraging seat belt use.

Visibility

- Concerns about glare.
- Blocking by other vehicles.
- Size of sign and letters.
- Need for increased alert to attract driver attention.

Message Review

Multiple participants in all focus groups zeroed in on the point that the messages conveyed on the signs should be specific and concise in order to be easily read and that the messages should relate to current driving-related issues. “Keep it simple.”

A number of the observations reflected recent experience with VMSs noting the weekend roadway closures required to resurface freeways with rubberized asphalt and other construction issues. This type of information appeared frequently over fall 2003 and spring 2004. Signs announcing weekend closures appeared early in the week and often included routes closed, reasons for the closure, and dates and times involved. It often took all three lines on the VMS to convey all that information. Route designators and the road direction affected were sometimes abbreviated along with the dates and times involved. This added to the confusion.

Participants in a number of focus groups volunteered their experiences in trying to read these signs. Given their challenges with visual acuity, they had difficulty reading and comprehending all that information as they drove by. Discussion moved to ways of simplifying these messages. A similar consensus emerged in several groups. The signs should focus on the impact on the driver, not on the explanation for the change in the traffic pattern. For example, a VMS could display basic information:

> “Route 51 North Closed”
> “Fri. 9 PM to Mon. 5 AM”

Other experience with VMSs related to warnings about congestion associated with traffic incidents. Again discussion focused on what was essential information that could be read quickly and with the least confusion. Several focus groups reached a similar conclusion: focus on what the driver is to do. For example,

> “Left Lane Closed 3 Miles Ahead”
> “Merge Right”

Representative observations included the following:

- “There’s too much information and not enough time to read it. It’s very confusing.”

- "They give you a little paragraph to read about it. If you are going 20 mph, that's great…"
- "If you're going at a good speed, it's impossible to react."
- "Depending on traffic, you can't take your eyes of the road more than two seconds if you're going 60–70 mph. The bigger the sign the better."
- "That sign, 'left lane blocked at 59th Avenue.' If I'm not familiar with that area, where is 59th Avenue? Tell me that the left lane is blocked one mile ahead. Give me information that I can use. How soon do I need to get out of that lane? Fifty-ninth Avenue might be a block ahead or it might be five miles. Tell me what it means to me. It doesn't mean anything to me."

Participants noted that messages should provide enough notice for the driver to respond, particularly if a lane change was required: "Those signs don't give you enough time. Cars are going zoom, zoom, going too fast on the freeway."

They felt that multiple signs would attract attention. In two groups, participants suggested augmenting the electronic signs with flashing lights. In all focus groups, participants noted that it is difficult to read any sign, even an electronic sign, while driving rapidly along the freeway. The situation is worse when the vision of the driver is blocked by a large truck or SUV: "When you are behind an SUV, you don't see the signs."

Participants went on to propose ways to enhance communication and minimize confusion. In four groups the mature drivers suggested posting the same message on several signs:

- "I think it's also placement of signage, that it's far enough in advance that it kind of warns you."
- "If they would give you another block or two before you need to read the signs then you would have enough time to get over."
- "We need prior warning."
- "They need to be repeated more often."

Two drivers suggested that flashing lights would help to attract attention to significant safety issues:

- "Do they have a flashing sign – warning sign? In New York you could see if it was fogged in or heavy snow. If it was flashing – it got your attention."
- "A blinking sign tends to capture our attention more."

In three groups the mature drivers felt strongly that the messages on the signs should be limited to two lines:

"I think the least lines that you have to read going down is better."

Participants in all groups commented that posting advance dates (e.g., 3/24 or March 24) for scheduled construction or maintenance was distracting. They preferred not posting such signs too far ahead of time, and simply referencing a day of the week (e.g., Friday).

Visibility Review

In every focus group discussion focused on the issues of glare and problems of definition; both appear to be major issues for mature drivers in the Phoenix area. Since most focus group participants reported that they traveled primarily in the daylight, bright sunlight was a primary issue. Several commented that they had had no difficulty reading electronic signs in places like Denver or Chicago where the electronic signs stood out against a gray sky, but they had considerable difficulty reading them in the Phoenix area:

- "From what I recall, signs in Phoenix, there are days that they are rather hard to read. I think it's an optical illusion because our sun is so bright here."
- "Either put brighter display or tilt the sign. Also, if it's an east/west roadway and you're traveling with the sun behind you, you might see it or you might not see it."

The need for increased brightness came up in every group, as did the importance of size. Several groups brought up the issue of color and spacing between the letters and words. In two groups, participants suggested that it was easier to read signs when the words were all grouped together, than to read large elongated signs with more than one line of print.

Summary

These issues of readability and concern about glare, brightness, and legibility of electronic VMSs are strongly reminiscent of the literature cited above on the challenges faced by mature drivers. As noted above, the color standard of yellow letters on a black background was specifically selected to respond to the need for contrast and was, according to the literature, most easily read by even the oldest drivers. Nevertheless, issues of glare and contrast are magnified in the Phoenix area as older drivers travel along freeways in the bright sunlight. The literature notes that older drivers can become almost blinded as they drive in bright sunlight that also washes out the color contrast on the electronic signs. These problems are magnified as driver's head west at sunset, and the trip logs indicate that about 25 percent of the focus-group participants do regularly travel on the freeways close to sunset. Electronic VMSs are intended to capture the attention of drivers and communicate significant information quickly. That assumes that drivers can read and comprehend quickly. As the literature notes, the aging process makes it more difficult to read quickly and reduces peripheral vision; hence the concern about reading elongated signs, with several lines of text is well placed.

PORTABLE ELECTRONIC MESSAGE SIGNS

Focus group participants agreed that the portable electronic signs caught their attention and were helpful in alerting drivers to temporary changes in driving patterns.

Four sets of issues emerged in all focus groups:

- Clarity (related to color and size).

- Location/Placement/Position/Visibility.
- Information accuracy, reliability and understandability.
- Multiple information phases on a single sign (The term "phase" refers to messages that are flashed in successive segments on a single sign because the full message does not fit onto a single sign. A phase is one segment of the message. Issues include speed of change, flickering, repetition of signs).

Other issues introduced in some groups included the need for advance warning, standardization, and repetition.

The issues generating the greatest interest among all focus groups again fell into two overall categories: the message and the presentation.

Issues related to the message being conveyed included:

- Problems with understanding abbreviations.
- Reliability of information.

Issues related to presentation, visibility and readability of sign included:

- Visibility.
- Placement of the signs.
- Contrast and glare.
- Problems with signs that have more than one phase.
- Issues about optimal timing for rotating phases on a two-phases sign.

The Message

Participants in all older driver focus groups felt very strongly that in order to be effective in communicating, these signs should show short messages relating directly to the driver. In almost every group, participants voiced strong concerns about signs that tried to present too much information and actually did not provide clear direction to the drivers. The younger driver group not only paralleled these concerns, but also proposed short, simple messages that would convey only essential points. Participants in almost all groups noted that portable signs often try to give too much information. They felt that there was no need to offer explanations, just direction to the driver. Several participants took the time to identify what they felt was essential information to convey on a sign: "Center lane closed. Merge right."

A related issue about too many words on a portable sign, was the use of abbreviations. A number of participants recounted experiences with trying to decipher the messages on signs referencing upcoming road closures or road repair. The use of abbreviations "E/B" for eastbound or "W/B" westbound also seemed confusing. This generated considerable discussion in all groups:

- "What does that mean? E/B – eastbound? What's S/R stand for?"
- (When a sign has both E/B and S/R on it…) "You've mixed the designators of the roads, state route and the direction Eastbound in one sign."

- "Going back to the SR 51 and EB 202, basically you've got two mixed things there. The mixed information, my first thought when I saw it, it didn't make sense."
- "I over-think. E/B 202 and S/R 51 – I spend the next half an hour trying to figure out what that means. How about south 51 and east 202 – that speaks!" (Actually SR 51 refers to state route, not south)

For these mature drivers, confusion introduced a distraction and subsequently a delayed response. In three groups participants suggested a term like "Rt.60 east." Others said: "Standardized wording would be helpful so that every time I see it, it says the same thing."

The nomenclature for specific highways was an issue. Some were comfortable with "SR 51," but the term "S/R 51" was unclear. While some people referred to the "Superstition Freeway" or "U.S. 60," the majority just knew that road was Route 60. Almost all participants felt that adding extra words on a portable sign was unnecessary and added confusion. They recounted similar problems with using road names as they traveled elsewhere. Although not unanimous, the majority of the winter visitor focus-group participants noted that they were unclear on most highway names and just used the numbers as a guide.

Multiple Phased Signs

All the mature driver focus groups included several participants who had problems with the type of electronic sign that flashes a single message in successive fragments because the message is too long to fit on a single sign. These signs are referred to as multiple phased signs. These participants were quick to relate personal experiences. Some felt that the signs changed too quickly and they were not able to read completely either phase:

- "It wouldn't be giving much of a message because it's flashing so fast that you can't possibly read them."
- "I can't read that fast. You see that and you can't read that….when you're traveling in your car, you don't have a chance to read it three times."
- "More time spaced out between each one individually. I don't know anybody that can (read it). It's not all old-aged stuff."

Others commented that they drove past the sign before they had time to read the second phase. Then, as they reported it, they kept wondering about the rest of that message and were distracted from total concentration on driving:

- "Depending upon how fast traffic is going at that time, a two page sign is lost."
- "You forget what you saw the first time. By the time you're looking at the second, you can't remember what it said either."

In four groups, several participants advocated having several signs that repeated the directions. That way the first sign would attract attention and the second one would

communicate the message. Others joined in the discussion and helped to make the point that it was most important to repeat the message on more than one sign to insure that all drivers understood the new directions.

In all mature driver groups participants underscored the importance of getting the message early and clearly, particularly when the message referenced need for a lane change.

Visibility and Legibility

Since portable signs are typically on the shoulder of the road, participants in all groups also recounted difficulty in seeing the signs if they were not driving in the right lane. In two groups this led to a discussion about the size of the portable signs as well as their height above the road.

The topic of brightness and clarity was raised again. This time discussion also included a reference to the spacing between letters and the sharpness of the letters. Several participants recalled trying to read signs where the letters seemed to run together. In almost every group, someone recounted difficulty in reading a temporary message sign in bright sunlight. One participant commented that these signs must be helpful for those who drive at night, but he limited his nighttime driving and he could not see them during the day.

Participants associated the portable message signs primarily with construction zones and that triggered discussion in three groups about the importance of sharing current, reliable information. A number of participants recalled reading message signs and changing lanes in response, only to find that there was no construction underway at that time:

- "When they had 19th Avenue closed and they were working on the 101 at Beardsley for so long, sometimes they [the electronic signs] are not on, so you think 'wow, they finally opened 19th Avenue,' and you get there…. No they didn't. Then they don't take them [the signs] down when the road is open. That's a pain. They are there for months."
- "Here, you come down the road and they've moved them [the signs] off to the side and it says the lane changes or the lane ends or there are workers present. You go out there and they are up all weekend, nobody's around. You get used to driving with these signs up and there's nobody there—no work being done—and all of a sudden they [the workers] are [there] and then they wonder why people don't slow down."

Summary

The issues raised regarding portable variable message signs in many ways reflect similar concerns to those raised regarding the fixed VMS signs. Clarity and brightness are an issue for older drivers. The visibility of these electronic signs is reduced since they are typically off to the side of the road and peripheral vision is considerably reduced for many older drivers. They are also harder to read since the surface available is smaller and

the tendency is to wedge in as much information as possible. A simple, concise message is a key to good communication. As noted in the literature, spacing between letters is important to reduce blur. The FHWA Highway Design Handbook also cautions about using double light columns for letters and urges not using more than two phrases on a sign (Staplin 2001). The older driver focus group participants found even two phrases to be difficult to follow. Reading speed is an issue and a partial message can lead to confusion. Multiple signs would not only address that issue but also strengthen the alert.

References to confusion and distraction are significant when relating to older drivers, particularly. It is essential that they concentrate on the driving function, and the literature notes that the aging process does make it more difficult to respond quickly and to multi-task. Hence it is essential to not only alert drivers with portable VMSs but also to communicate using a few well-chosen words to convey directional guidance.

RAMP METERS

Ramp Meters were generally perceived by participants in all focus groups as useful in merging into freeway traffic. They appreciated getting the green light to enter.

Five major issue areas emerged in discussion:

- Traffic flow issues, both positive and negative (on-ramps and freeways).
- Safety issues related to merging (acceleration issues).
- Driver behavior at ramp meters (competition with other drivers).
- Visibility (positioning of ramp meters and prior alerts).
- Timing of lights and time of day illuminated.

Ramp meters generated enthusiastic responses from almost all participants in the various focus groups. Discussions referenced all the above issues, but the topics that generated most discussion included:

- Concerns about acceleration from standstill to freeway speed.
- Problems with competition from other drivers at the merge.

In almost all focus groups, participants were positive about ramp meters and the idea of two lights, one focused on the first driver and one on the driver right behind. One of the winter visitor groups included participants from Minneapolis who were very familiar with the use of ramp meters and they recounted the complexity faced by drivers when the system was turned off for a period of time.

In one group participants suggested that the lights should be larger to make them easier to see. In several groups participants felt that having advanced warning about the fact that the ramp meters were operating would help. (Actually there is such advanced warning, but no one indicated having seen that.) In almost every group at least one participant brought up a positive experience with having two lights that alternated in letting drivers onto the freeways. Only one participant in one focus group brought up the issue of ramp meters backing up traffic on arterial streets and slowing up freeway entrance. The other participants in that group were visibly annoyed with his repeatedly returning to that point.

Acceleration Issues

There was more active and involved general discussion in a number of groups about the need to accelerate after stopping at the ramp meter. Several participants noted the difficulty in acceleration from a stop to freeway speed. Their comments seemed to reflect their experienced at tapered freeway entrances rather than at newer entrance ramps that are accompanied by a dedicated acceleration lane:

- "One drawback is the necessity to stop, because when you are stopped, you then have to try to access a high speed highway. If you came through it moving, you would be able to accelerate and get in a bit faster than from a dead stop."
- "The highway should give you a longer period of acceleration to catch up to traffic."
- "If the problem of acceleration is a problem from the light, then the on/off light should be moved further back from the highway to give you a longer period of acceleration time to catch up to the traffic."
- "If you had the light back here, you would have longer distance to gain speed, so in the future when they are planning these they might want to think about more distance."

Some drivers did acknowledge the helpful addition of the acceleration lanes at a number of the freeway entrances: "Entering the freeway is not tricky anymore since they added those extra lanes."

Driver Behavior

In almost every focus group, participants commented about the behavior of other drivers who seemed to regard the entrance ramps with two merging traffic lanes as an opportunity for a race to the finish line. Several participants noted that they had been cut off by other drivers who zipped around in front of them:

- "The alternating lights are good. You don't get in trouble that way. It's scary when you have someone zooming by you on the right when you're trying to merge."
- "Even with the light, when you get to the point where you've got to merge, if you've got somebody who's in a bad mood, I don't think it will help."
- "It's designed to give people access to the freeways. Now the battles take place before you get to them. You see people changing lanes, jockeying in lines, trying to get to the light first."
- "Racing to the light. You're here together and suddenly you are pushed off. More and more I use several of these ramps where there are actually two lights, left and right where you avoid that kind of squeeze."

Summary

The issues relative to ramp metering again reflect findings in the literature. Merging is documented as a complex task for older drivers. Judging the appropriate gap in freeway traffic flow is challenging given changes in the level of visual acuity, specifically dynamic visual acuity that accompany the aging process. Cautious older drivers tend to

wait until they feel confident in observing a gap in the traffic. That is difficult when the traffic is congested. Impatient drivers behind them become annoyed and cut ahead. The problems of acceleration in order to match the speed of the traffic flow once they do note a gap, reflects another challenge noted in the literature: the ability to respond quickly. The enthusiasm of older drivers for the ramp meters indicates their recognition of the important contribution that ramp meters can play in giving them a defined period of time in which to sense the flow of traffic without another driver pushing them from behind.

ADVANCED TRAVELER INFORMATION SYSTEMS

All focus groups were interested and intrigued by the idea of accessing up-to-date travel information on telephones. Since none of the drivers in the focus groups had used either the 511 telephone or computer screen prior to be invited to join a focus groups, much of the discussion regarding the 511 system was conceptual, rather than reflective of experience. The extent of this discussion in each focus group was in part an indication of potential interest in using such a system.

The content analysis included the following topic areas:

- Lack of knowledge about system.
- Helpfulness in trip planning
- Usefulness for enroute travel (clarity, speed, usefulness, safety of cell phone use).
- Cost – potential cost in the future .
- Responsiveness of Internet system (regularity of updates, prioritizing information).

In the context of the focus groups the following topics emerged repeatedly indicating interest and concerns among the mature drivers:

- Lack of knowledge about system.
- Concern with cell phone use while driving.
- Usefulness of 511 and potential for using AZ511.com for trip planning.
- The complexity of the AZ511.com site as it was in fall 2003 and early spring 2004, and a need for agreement on terminology.
- The need for visual clarity.

Since none of the participants was familiar with either 511 or AZ511.com before being invited to a focus group, it was not surprising that an initial focus for discussion was on reasons why they had not heard about these opportunities:

- “Is this one of their best kept secrets? How do they let the public know that this is available?”
- “If they don’t advertise it and get it out, feedback, find out where the mistakes are….they will never perfect it.”
- “I didn’t even know 511 existed. I had never tried it before.”

Participants in all focus groups thought that they would benefit from using AZ511.com for pretrip information about sections of the road that were under construction or otherwise congested:

- "That would be nice to use to find out where construction is. It would be good to use that for local travel—going to the airport, and there's an accident along the 202."
- "Where I think this information would be beneficial is if you were going from here to Flagstaff – weather conditions, highway safety, snow conditions."

Six focus groups briefly discussed the potential for using the telephone 511 system while traveling. This discussion became much livelier, however, when coupled with a discussion about safety in using a cell phone while driving. A similar thought pattern emerged in all groups, but it seemed more pointed in the fall 2003 sessions when the caller was required to use push buttons to access 511:

- "If you're driving and you have your cell phone and you're pushing 511?"
- "Are they encouraging us to use cell phones while we are driving?"
- "That's very difficult for me when you're using a cell phone. I hope you're not using it when you're driving down the road.

When shown a Power Point demonstration using slides taken from the AZ511.com site, as it existed in fall 2003 and early spring 2004, the participants responded negatively to what appeared to be a cluttered visual presentation. As one participant observed, "most people are going to be visual. For those of us who are not visual, the map will be confusing. If you give me a printout with words, it's much better for me." Others commented:

- "It looks very busy."
- "It's hard to use it."
- "Too many squares there."
- "Too many ranges. Too many things. By the time you read this map you might as well do something else."

Some felt the categories of information related to the state highway map were not clear: "Let me ask you, what does "except load" mean? Is that an oversize load, what is it?"

Summary

Participants were interested in a clear, user-friendly site. They were asked about priorities in terms of the information displayed. In all groups, the weather, road construction, road maintenance, and road closures were suggested as priority issues in checking AZ511.com online. Three groups summarized their priority by using the word "delay." The current source of traveler information for two groups was TV and newspapers for two others.

The limited discussion of traveler information reflected the limited experience of participants in accessing it. They could see the potential. Older drivers are, according to the literature, careful and try to avoid complex driving situations. The focus-group discussions about the traveler information system reflected those concerns. Participants said they would be interested in pretrip information that would help them avoid difficult driving situations, particularly on longer trips. This was a much stronger interest among these mature drivers than avoiding congestion on local freeways. Even though inclement weather is not a frequent problem on highways in the Phoenix area, these drivers thought about trips they made to Flagstaff where they might encounter snow. Several thought that information about high winds might be helpful on a trip to Tucson. The winter visitors offered very specific reports of the complexity of traveling in less than optimum conditions, particularly when pulling a mobile unit behind. If they had warning of problems ahead they could delay or reroute their trip.

Interest in information about road closures and construction was also presented in the context of avoiding challenging driving situations. Travel delays emerged as a topic for discussion in several groups, but these seemed to be less of a concern than the overall comfort of the drive. These mature drivers would not, apparently be regular users of 511 or AZ511.com, but they would be very interested in using it in planning trips or while traveling in other parts of the state.

6. MATURE DRIVERS AND TRAVELER INFORMATION

The value of a traveler information system can be gauged most effectively in terms of its usability to the traveling public. As noted above, the mature driver focus-group participants were largely unaware of the emerging state and national 511 traveler information system. The focus group sessions preceded the spring marketing effort for 511. Their comments were, therefore conceptual rather than specific in terms of interaction with either the telephone or computer-based system. On the other hand, the five mature drivers who participated in the heuristic evaluation of 511 and AZ511.com systems, had ample opportunity to observe that system and to propose modifications that would make both systems more usable.

As indicated above, five mature drivers participated in the heuristic assessment of the 511. All drivers were presented with the same scenario and asked to dial 511 on separate land-line telephones in individual cubicles in a quiet office. Users recorded their observations on a survey sheet that is included as Appendix F. Observers answered questions and prompted the users to move through the scenario. After all users had completed the scenario, the group assembled for a discussion. The common scenario was as follows:

> *You are planning a trip from east Mesa to downtown Phoenix where you plan to attend the symphony. You plan to travel on Route 60 and Interstate 10. Please use the 511 system to access information about road conditions on the way.*

USER REACTIONS TO 511 TELEPHONE SYSTEM

In general, mature drivers involved in the heuristic assessment expected the 511 system to provide instant information for their trip. They did not want to spend time getting extra instruction and training or finding out about places they did not immediately care about.

The voice-activated telephone 511 system first gives the users an opportunity to select information on roads, transit, airport, or the Grand Canyon. Next the user who has selected “roads” is asked to name a highway route of interest. Next the user is prompted to select a segment of that route that relates more closely to the portion of the road on which they are traveling. The user is also given the opportunity to select “quick reports” that summarize road conditions in their area.

Evaluators were frustrated with the system that seemed to be a bit “clunky” yet. The segment concept did not seem clear enough for them. Although there were lots of instructions (most said too much), they still didn't know what to say. When they tried different segment numbers, they still did not get information related to the far eastern part of Mesa, so they wasted time. The quick reports didn't seem to help them with the given scenario.

Although the scenario involved driving from east Mesa to the symphony in Phoenix, almost all of the evaluators got so hung up in trying to get to information about Route 60

that they did not even bother going on to get information on I-10. The evaluators were prompted at least try the "quick reports" and try to get information on transit. Frustration with voice recognition was evident. Some got angry at what seemed to be a waste of time. Some kept saying "60" over and over; one woman, a user in her 60s, put her head down on the desk. She could not get the voice recognition to work.

The following sample responses of several users to some key questions on the user survey reveal the nature of their observations related to the system.

1. After the prompts, select "roads." Did it correctly move you to roads?

Observer: All users got to "roads."

User 3: The introduction works OK. I got to roads.

If not, where did you end up?

User 2: I got information on Interstate 8 one time.

User 4: The main menu does not have a clear prompt.

Was there a clear prompt on when to say "60"?

User 1: It did not recognize "Route 60," and thought I said "I-8." I had to start over several times.

User 2: Did not recognize "Route 60," only "60" I tried several ways. When I said Superstition Freeway, it gave me different information from when I said 60.

User 3: Yes, but it should not rule out words like "interstate."

User 4: It gave me information that I did not need. I kept going back to the main menu. I tried to say "Route 60" three times. [Observer Note: user got very frustrated.] Then I tried to say "17" three times. I still could not get it to understand. I got to "8."

User 5: There was no clear prompt. I tried three times. It could not recognize me when I said "60." Each time I tried, the response was somewhat different. However, I kept being sent back to main menu. Finally I got through.

2. Were the directions on how to use the roads segments clear?

User 1: It did not understand me.

User 2: No, this was not clear; I had to have it repeat several times. I didn't understand the segments. I needed two different segments to come from east Mesa to Phoenix.

User 3: The information on segments was clear, but very long.

User 4: No, they gave me all sorts of information about things I don't need. It gave me information on I-10 west and a closure on Maricopa road. That isn't on my trip. I tried two times. The first time I did not get information on segments.

User 5: Not the first time. I had to get it to repeat.

Did it recognize your voice when you asked for the appropriate segment for the East Valley part of Route 60?

User 3: Yes

Was there any incident (accident or construction, etc.) on Route 60?

User 2: Yes, there was a problem, but I didn't recognize what they were saying about locations.

3. You also need information on Interstate 10 to get to Phoenix? Did you get to Interstate 10?

User 3: The first time I got to 8– maybe because I said "interstate." I got 10 on the second try.

Observer: Users 1, 2, 4, and 5 did not attempt.

4. The system will tell you that you could have the option of trying Quick Reports that will provide summary information on each of the subregions of the Phoenix area. Try to get a quick report on the East Valley. Did you get enough instructions on how to get a Quick Report on the East Valley?

User 1: I first got no information on quick reports. Instead I was directed to Tucson. After trying a couple times, it eventually worked.

User 2: It did not recognize me when I said "quick report." I could not get this information.

User 3: It took me several tries.

User 4: I tried several times and went back to main menu. I said "list" to get a list of quick reports, but didn't get a list. The person talked too fast, too much talk. I could not interrupt.

User 5: I got sent back to main menu. Finally I got it.

5. What type of information was included in the Quick Report? Would that information be helpful in planning your trip to the symphony?

User 3: Information about congestion. There was no problem on my route

User 2: The whole system is very slow. It just kept talking and I could not interrupt.

6. Next leave the roads part of 511. Try to get information on Transit. You want to know if there is a bus that will take you from Country Club Boulevard in Mesa to downtown Phoenix. What is the schedule? Is it on time?

Were you successful in getting to the transit section of the site?

User 3: Yes.

User 4: This was not clear. I had to say it twice.

Were the instructions on the transit site clear? What were you told to do?

User 3: Yes, Instructions were clear. I was told to call Valley Metro or say transfer. That connected me to Valley Metro.

Did you find out information about a bus from Mesa?

User 2: I did get to transit and got to Phoenix and did hear about how to transfer.

User 3: I went back to the main menu and that took me to transit. It did not offer any bus schedules. I got a telephone number to call for transit.

User 4: I ended up getting information about Tucson. It repeated a lot of information.

7. When would you use the system?

User 2: I would use the system to get information about road conditions on the way to Flagstaff. I would be interested in snow reports. I'd like to get the information about road construction about two weeks prior to making the trip.

User 3: This call was a real chore. I could have gone to the symphony and back in the time it took to make the call.

User 4: This really did not work for me. I could not get it to understand me.

User 5: Question, what if there are many people trying to access 511 at once? Would 511 become congested?

Summary

Frustration with voice recognition was evident, and all users felt that system did not seem to them to be ready for widespread use. Some got angry with what seemed to be a waste of time; one user became impatient and used the self-created voice command "stop" frequently (which actually seemed to work rather well). Some kept saying "60" over and over. One user, who was not able to make the call work at all, put her head down on the desk. Almost all users got so hung up in trying to get to Route 60 information that they did not even bother going on to get information on I-10.

On the positive side, one user began using the names of the freeways, such as the "Superstition Freeway" or "Red Mountain Freeway," and then the system gave the user information regarding road closures; clearly the highway names matched both the user's mental model and the system's capability in this case. The other respondents were not as successful as this user was.

The concept of segments was not clear to most of the users since it did not match their mental model of the highway system. Further, when they tried different segment numbers they still didn't get to the far eastern part of the Phoenix metropolitan area, so they wasted time. The quick reports didn't seem to help them with the scenario that was provided. They were urged to at least try the Quick Reports and the transfer to transit.

Users reported that they were more likely to use the system as a pretrip planning aid for longer trips. It is unknown if users would consider using the system for shorter trips had their experience with the system been more positive.

In summary, users believed that 511 is a good idea but they felt that the system still needs work. In particular, they believed that if they needed information quickly, this system was not responsive enough to provide it. “I could have been to the symphony in the amount of time that it took me to get this to work.” When asked if they would use the system again, they stated “Maybe…when it is perfected.”

Discussion and Recommendations

While the Arizona 511 system has the promise to make the highway traveling task easier, the present implementation of the interactive voice response system creates so many burdens for the mature driver user they will be unlikely to use the system more than once. The current evaluation’s results point to recommendations for improvement on at least five usability heuristic categories. Users should have more control and freedom, and a means to get help if required, at least until the system’s error rate is significantly reduced.

Among the above-mentioned commonly used heuristics, five were applied in assessing the 511 voice activated telephone system:

- Match between system and the real world.
- User control and freedom.
- Error prevention.
- Flexibility and efficiency of use.
- Help and documentation.

<u>Heuristic: Match between the System and the Real World</u>

Regain and retain a match with the real world; this means communicating with language that the users recognize from highways and maps. This further applies to the AZ511.com web site, which should have a cognitive match to the Arizona 511 telephone system.

- Consider designing the interactive voice response flow around real-world tasks and real-world mental models. For instance, users may know what their origin and destination cities are, but may not know what “segments” connect these cities. Design the system for minimal call time and error rate around these real-world scenarios. Consider the ability for the system to provide information on origin and destination travel with intermediary points.
- Segment information needs to be clarified and simplified. Users reported that it was long and confusing. For instance, if you are in east Mesa heading to Phoenix, you seem to need two different segments on Route 60.
- Quick reports need to be reassessed according to the most frequent, real-world user tasks.
- Consider using city names for transit. Users do not know about the names of bus companies (e.g., Valley Metro, SunTran).
- Users wondered if there were 511 signs posted on the highways. Once the 511 system is ready to be used and re-advertised, consider using roadway signs to raise traveler awareness of the system’s availability.

Heuristic: Error Prevention

- The basic voice recognition of the system should be improved. Only one user got to 60 on the first try. Others kept being sent back to main menu, particularly when they used "Route 60." Several people got information on I-8 when they said "Route 60." One user tried the system several times and got somewhat different prompts each time. Frustration built up after people kept being sent back to main menu or to information they had not requested.
- During major and minor system upgrades, make upgrades off line, conduct user tests, and then deploy the system.
- During system upgrades, retain the original hardware and software so that reversions can be made.

Heuristic: Flexibility and Efficiency of Use

- A touch-tone backup system should be provided to lend adaptability to the system (as well as to provide shortcut keys to expert users, discussed in the heuristic on user control and freedom). The touch-tone system should be compatible with the voice system, so that a verbal "17" can be entered from the same prompt as a numeric "17," and the same results achieved. (Touch-tone back-up was later added to the system)
- Make the system flexible to a user's tasks. For instance, users should be able to get just the Phoenix area without the whole state and then get state wide information if needed.
- Users suggested that a key for a better system was simplicity. Specifically, they expected the menu to be clearer, and the information to be clear but briefer.

Heuristic: User Control and Freedom

- Confident users wanted to be able to key ahead or interrupt if they did not need all the extra information.

Heuristic: Help and Documentation

- Consider providing a means to connect with a human if all else fails. As the system is improved, human operators should experience a dramatic decrease in calls requiring help from a human.

AZ511.COM WEB SITE

The same mature drivers were also engaged in interacting with the AZ511.com computer traveler information web site to get travel information related to the following scenario:

> *You are planning a trip from Mesa to Flagstaff, and you want to find out about road conditions before setting out.*

Four of the users interacted with the computer in groups of two; a setting intended to simulate a pretrip use of the computer "at home." The fifth user interacted independently with the AZ511.com site. An observer responded to questions and encouraged evaluators

to interact with all parts of the site. A talk-back discussion involving all users followed. (This study was repeated in July 2004 with an updated site. See Appendix G)

The users who viewed the site in March 2004 expected that it would offer them a quick assessment of roadway problems relating to the scenario of a trip to Flagstaff. Since all users commented that they had made the trip to Flagstaff, the scenario represented a real experience for them, and they were interested in finding out about potential traffic delays. They had difficulty, however, in navigating within the site, and also had difficulty with the legibility of material presented. The observer noted that all users took a long time to figure out the first page and kept staring at the screen until being prompted about the scenario. Although two of the users found the state map of highway conditions helpful, all found that the maps on the first page were too small especially since they were the main source of traveler information.

They wondered why so much space on the first page was devoted to a background discussion of AZ511.com. All found that the print was too small and that labels did not contrast sufficiently with the background. (This page has been changed.) They had difficulty identifying and selecting information specifically relevant to the scenario from the all the information provided on the site. All users felt that the web site as it appeared in March 2004 seemed "too busy." Three of the users did not understand that they were to select Maricopa County to begin their search for information. They could not read the county names; the labels were in gray and did not stand out on the colored county map.

All mature driver users found list of icons the statewide freeway conditions map confusing. The size of the text in the legend was too small, and they were not clear on the definitions for a number of the terms like "service level," "regulation," "parking," "except load," "high wind," and "activity." Once they clicked on icons of interest, like road closures or road construction, they found so many overlapping icons that they were unable to see route numbers and found it difficult to position the cursor on individual icons to get the pop-up frame providing information associated with it.

Several users wanted to combine the map of the "closures and restrictions" on the site with a type of MapQuest map focusing in on origins and destinations. They wished that the highways could be listed in alphabetical order so they didn't have to concentrate on the screen for a long time in order to locate the highway of interest. They also thought it might help to be able to print information on problem areas on the highways before they headed out on their trip.

The users were unable to see the camera views in March on the day of the heuristic evaluation, since the cameras were not turned on. None of them felt that they needed to see camera views of traffic conditions on Phoenix area freeways.

They were, however, all fascinated by the Phoenix area freeway Traffic Map showing the real time speed of the cars on various sections of the freeways. A few wished to be able to zoom into their own section of the metropolitan area to see it more clearly. They felt

that map gave them all the information they would need in planning a trip across the Phoenix metropolitan area. They just wanted to know where there was road construction, where roads were closed, and where the traffic was congested.

User Assessment

Overall the users were alert to the benefits of a web site that could provide information about road conditions and felt that would help in trip planning. In fact, almost all users regularly used the computer to provide them with directional information before starting out on a longer trip. However, they found that the site, as they used it in March 2004, included too much information and was difficult to use effectively and efficiently.

When a group of older drivers conducted a heuristic study of a revised version of the evolving website five months later in July 2004, they noted that the look of the home page of the site was much more streamlined. That assessment is included in Appendix G.

For older mature drivers, an effective site would be simple, clear, and easy to navigate, with sufficiently large maps and type in contrasting colors that they could read easily. These expectations reflect the basic principles of visual communication. In reality, a web site designed to address the needs of mature drivers will likely address the needs of a broader audience as well.

The observations of the mature driver users of the AZ511.com system in March 2004 can be categorized in terms of four of the heuristic principles associated with positive user interface that were noted above:

- Match between system and the real world.
- Flexibility and efficiency of use.
- Aesthetic and minimalist design.
- Help and documentation.

Heuristic: Match between System and the Real World

Much as they had with the 511 telephone system, the mature drivers addressed the Internet site with observations built on their real-world experience. They were very familiar with using highway maps to orient themselves on road trips. Hence when they were given a scenario involving a trip from Mesa to Flagstaff they were attracted to the state map on the home page of the site, but they found it difficult to see the full route of Interstate highways 10 and 17. The text was too small and the labels were difficult to read; hence they began looking for zoom features that would focus on their chosen route.

The highway conditions map departed from their real world experience, they found it hard to piece their trip together as a series of subunits associated with counties. (The map in the site that they used required users to zoom in on individual counties to get more detail rather than allowing them to zoom in on the specific highways of interest.) They became distracted with trying to read pop-up blurbs associated with an array of icons. None of the users persevered in completing a full trip preplanning session related to the trip between Mesa and Flagstaff. In contrast, the mature drivers' enthusiasm regarding

the Traffic Map of the freeway system in the Phoenix metropolitan area can be explained in part by the fact that it built on the familiar local map, adding new information about speed of travel. They could easily relate to that.

Heuristic: Flexibility and Efficiency of Use

The mature drivers had considerable difficulty in navigating through the site. Despite the fact that all of these users regularly used the Internet, they stared at the home page and did not know where to begin until prompted by the observer.

All observers noted that too much information was provided on the home page about 511 and not enough cues were introduced to guide the user to open the small map icons. The hierarchy of information did not appear to be related to answering questions posed by these users. Once they clicked on the state highway conditions map, it took a number of steps to move through the site to get information related to the scenario. The list of possible icons to select to find out about highway conditions seemed lengthy and the categories of information associated with the various icons were unclear. (This comment reinforced a similar point raised in a number of the focus groups.)

When the mature drivers clicked on an icon associated with a familiar concern, ("road closure" or "road maintenance" for example) they found that the icons clustered so closely on the map that they were unable to access specific information related to a specific location. Several of the users had difficulty positioning the cursor precisely enough to click on an individual icon and get the pop-up blurb giving information about the requested highway condition.

Although the icons provided with the map reflected the familiar international symbol found on highway signs, the mature drivers were unable to distinguish among them when they appeared on the state highway map or blow-up county maps. The mature drivers found it challenging to read either the text labeling the icons, or that included in pop-up informational blurbs. Again they commented that information provided in the blurbs was far more than they would really need as drivers who just wanted to know about highway construction sites that would delay their trip.

The fact that all users were distracted and none of them completed the scenario is indicative of issues with flexibility and efficiency of use.

Heuristic: Aesthetic and Minimalist Design

While aesthetics and flashing images can attract a user to a site, the primary purpose for a traveler information web site is to provide the traveler with information that will assist in trip planning. The assessment of all the mature drivers was that they would use a site that provided the information that they wanted in a simple and clear format. They found that the site they reviewed did not meet that heuristic. Their concern was not that the presentation was not interesting, but that they could not use it effectively and efficiently to provide the information that they wanted. Their comments related to inability to read

text and distinguish among icons were reflective of the low-resolution graphics, but they spoke more generally to the need for simplicity and contrast.

As noted in the literature, the aging process makes it more difficult for older persons to distinguish text imposed on a colored background; that was part of the issue here. The multicolored map with gray labels for counties and highways was difficult to read. The more general issue, however, is that the simplicity and sharp contrast offered in a minimalist design can be read and understood quickly by drivers of all ages who want to glance quickly at a traveler information web site before heading out on a trip.

Heuristic: Help and Documentation

The users reinforced the importance of this heuristic when they questioned where to begin with the site and how to access information. They were familiar with help bars on most software that they used and contact bars on informational web sites. They did not find help or guidance readily available on the AZ511.com web site that they used. This was not only a source of frustration, but also represented a missed opportunity for public education on how to use the 511 telephone number. The users commented that they did not know why they needed so much information on 511 on the home page. That seemed to distract from the basic information that they needed to gain traveler information.

Recommendations Related to Heuristic Evaluation

Heuristic: Match between System and the Real World

- The site should be based upon the travel information needs of the traveling public.
- The overall functionality of the site should be adaptable to the travel agendas of individual users offering users quick access information by imputing the origin and destination of their trip.
- A high-contrast highway map showing nothing but routes and major destination cities will allow users to orient themselves and note routes important to their trips.
- Users want to see only the areas that are closest to their own homes. Easy to use zone features can help. For Phoenix area residents, a link can connect the freeway congestion map with the basic highway map.

Heuristic: Flexibility and Efficiency of Use

- The objective is for the site to become more user-friendly. The functionality of a site geared toward serving individual users will alleviate the fragmentation from which the current site suffers.
- The site should be simple with clear guidance on how to navigate through it to find desired information quickly.
- Information not specifically related to pretrip planning should not clutter the site.
- The hierarchy of information should be clear and the number of steps required to access basic traveler information minimized.
- Font choice and letter size should be quickly readable. Combinations of upper and lower case letters are shown to be easier to read. (Green 2004)
- The categories of icons available on highway condition map should be greatly reduced and the definitions of each category evident to all site users.

- Simple geometric shapes in contrasting colors should replace the icon graphics.
- Users should be provided with a simple menu on the home page providing an early clear choice in terms of information to access.

Heuristic: Aesthetic and Minimalist design

- The site should emphasize visual and conceptual clarity.
- The development of an identity and aesthetics for the site should be secondary to the organization and presentation of information.
- The site should be simple to use and easy to read.
- The maps should be neutrally-colored to eliminate visual confusion and should be shown as large as possible. Users should be able to freely zoom into maps.
- Information associated with identified problem areas should be provided in short, easy to read blurbs that relate directly to the traveler (e.g., construction May 10–15, one lane blocked, and high-wind advisory).
- The size of type/text should be large enough that it is comfortable to read, and text should be a combination of caps and lowercase (most legible).

Heuristic: Help and Documentation

- Navigation through the site should be evident to users, but additional guidance on steps to using the site should be offered in a help button evident on the first page.
- The AZ511.com web site should have a link to a tutorial/training manual for users to learn how to use the 511 phone system. This link should include a simple step-by-step guide to the phone system that users can print to take along in the car.
- There should be consistency in the classification of information across both the 511 phone service and online service. At the very least, categories of information presented both on the phone and on the web site should be consistently labeled.
- Information regarding 511 could be accessed through a link on the first page.
- Newsworthy pieces on freeway expansion or major road closures (the type of information provided on variable message signs) could be linked to the site.

SUMMARY

In summary, the mature drivers who participated in the heuristic study of 511 and AZ511.com highlighted the importance of perceiving the operation of traveler information systems from the perspective of the ultimate user. The process allowed users to demonstrate their response to the information system as a whole and to note aspects that either were not operating effectively or were causing frustration. While users can volunteer a list of comments or concerns, the context for those comments is not always apparent. More importantly, these drivers were able to demonstrate what they expected from a system that would meet their needs. Those expectations can provide the challenges to be addressed as the systems mature. In fact, a number of the suggestions of these drivers were reflected in the evolving website that was reviewed in the second heuristic assessment in July 2004. Although older drivers represented only a relatively small proportion of the driving public, their concerns and expectations underscored key points that if rectified, would enhance the usability of these systems for all users.

7. ACCIDENT ASSESSMENT

Although the focus groups and the heuristic study provided an indication of the perceptions of mature drivers regarding challenges associated with freeway driving and the potential benefits associated with ITS devices, a parallel review of freeway accidents involving older drivers was intended to provide documentation of problem areas.

It is difficult to chart reasons for accident avoidance or to document the impact of signage on driver behavior. Hence the study team focused expressly on accidents associated with merging onto freeways from on-ramps. The literature had underscored this as being one of the most difficult maneuvers for older drivers. The expectation was that a substantial number of freeway accidents involving older drivers would occur at on-ramps. Given the problems of mature drivers cited both in the literature and in focus groups with observing gaps in traffic flow and accelerating quickly enough to get into the stream of traffic, the team expected to find reports of accidents consistent with slow moving vehicles and the reaction of other drivers trying to wedge in front of them.

Rear end collisions might be caused by other drivers running into slow moving vehicles, and sideswipes might be caused by other cars pushing ahead of them on on-ramps. Side-swipes might also be caused by older drivers who misjudged a gap in the flow of freeway traffic.

Ramp meters that are intended to stage drivers entering the freeway and keep freeway traffic moving, might also benefit to mature drivers with merging into traffic. That point was raised in all focus groups. Ramp meters are only deployed during peak traffic flow, but the trip logs reported that 28 percent of trips by those mature drivers on freeways actually did occur during peak traffic flow.

MATURE DRIVER ON-RAMP CRASHES 2000-2003

Using the ADOT accident data bank, the study team selected data related to crashes in 2000–2003 involving freeway drivers over age 65 and, more specifically, crashes occurring at freeway on-ramps. To establish a base for comparison parallel data was also assembled for accidents involving younger drivers in the 40 to 50 age group for the period 2000–2003. Licensed drivers in the 40 to 50 age cohort constitute 21 percent of all licensed drivers in Arizona, and they were associated with 17 percent of the all accidents reported in the Phoenix metropolitan area within those three years. In contrast, mature drivers include 15 percent of licensed drivers and were involved with 4 percent of all accidents in the Phoenix area. These proportions represent a tally of accidents and as such are useful for this study. They cannot, however, necessarily be regarded as an indicator of driver safety since they do not account for exposure levels. A substantial proportion of older residents hold onto their driver's licenses and do not use them and others drive only short distances. A better indicator of older driver safety would be the relationship between number and severity of accidents and miles driven.

A closer look at freeway accidents in the Phoenix metropolitan area from 2000–2003 noted that the actual number of older driver accidents occurring at on-ramps is rather low (115 over the three-year period). This type of accident has generally been fairly evenly distributed among on-ramps with one or two accidents occurring over the last three years at on-ramps for almost all freeways.

I -10

On I-10, for example, there were one or two accidents involving mature drivers over the three-year period at all on-ramps in the metropolitan area from Queen Creek Road south of Chandler to 99th Avenue close to the S.R. 101 intersection in the West Valley. The on-ramps at 7th Street and 35th Avenue seemed somewhat more challenging, with three crashes at each involving older drivers over the three-year period.

I-17

Similarly along I-17, there were one or two accidents at all on-ramps from 7th Street to Thunderbird Road. The on-ramp at 7th Avenue, however did appear to be more challenging for older drivers since there were five crashes at that on-ramp from 2000-2003. Seventh Avenue also was challenging for younger drivers age 40 to 50, who experienced a disproportionate number of crashes at that location.

S.R. 202 (Loop 202)

S.R. 202 was not extended into eastern Mesa during the full three-year 2000–2003 period, but there were one or two accidents at all on-ramps from 32nd Street to Scottsdale Road. The on-ramp at 44th Street that connects with State Route 143 (S.R. 143) seemed a bit more challenging for older drivers, since there were three accidents there over the period. There was only one on-ramp accident involving a mature driver, at the Sky Harbor Boulevard entrance ramp on the relatively short S.R. 143.

S.R. 101 (Loop 101)

On the relatively new S.R. 101 there were only four accidents reported involving mature drivers, one each at the on-ramps of Bethany Home Road, Thunderbird Road, Camelback Road, and Northern Avenue.

U.S. 60

U.S. 60 stood out with an accident pattern pointing to four on-ramps that seemed particularly challenging for older drivers. Although there were, in general, one or two older driver accidents at each of the ramps from Mill Avenue in Tempe to Ellsworth Road in Mesa in the period 2000–2003, there were larger clusters of older person accidents at the on-ramps in the eastern part of Mesa at Power Road (12), Greenfield Road (6), Gilbert Road (5), and Val Vista Drive (4). The 12 accidents involving older persons at the Power Road on-ramp over the three-year period was the largest number for any on-ramp on the freeway system. The map in Figure 12 indicates the median age of residents in neighborhoods in the Phoenix area. The clusters of older residents in both the far East Valley and the far West Valley are clearly evident.

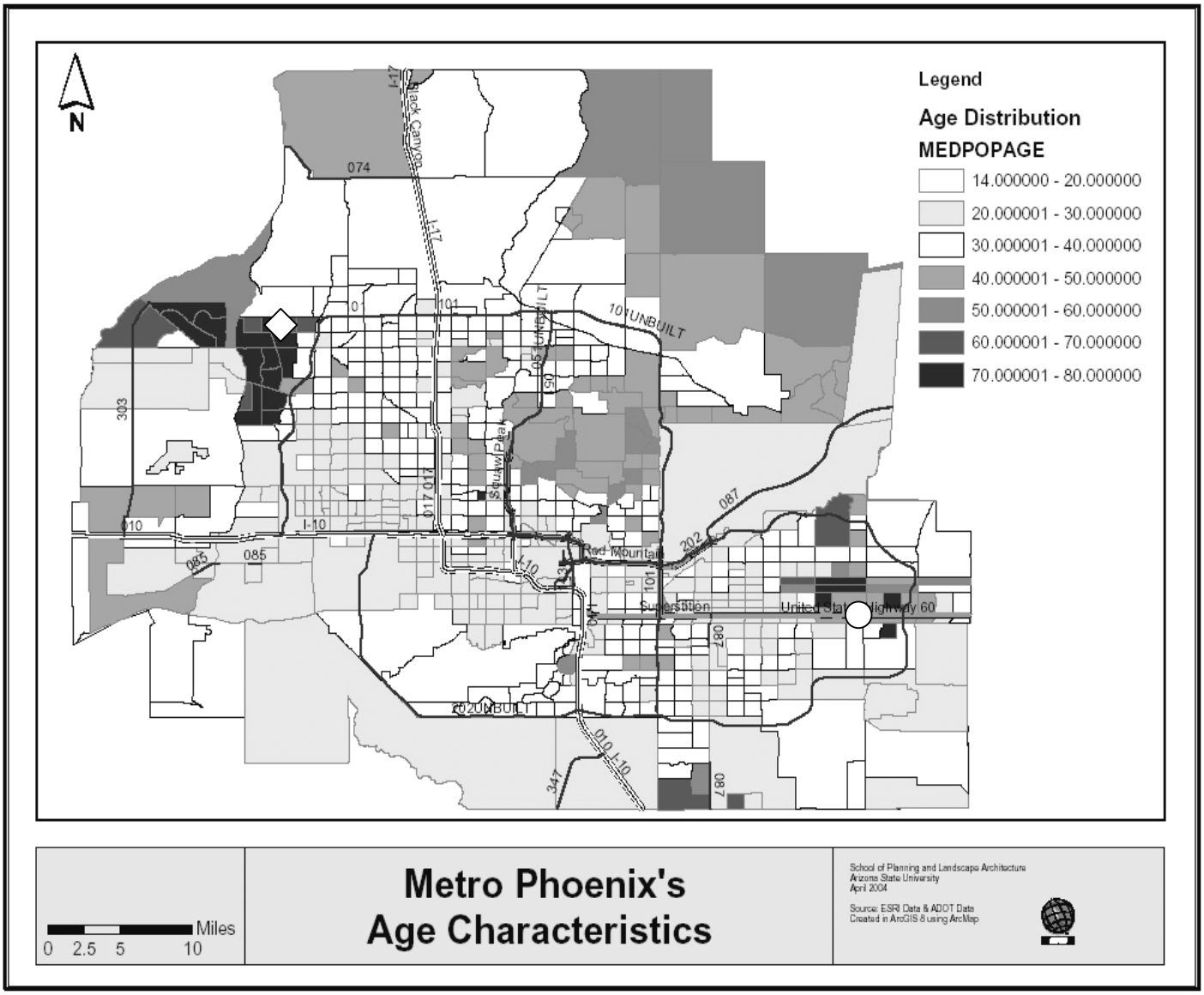


Figure 12. Metro Phoenix Age Characteristics

The Power Road exit on the eastern part of US 60 is shown with a white circle, while the Sun City area in the West valley is shown with a white diamond. Loop 101 and the future completion of Loop 202 will provide major access routes for these areas.

Assessment

A total of 161,341 accidents were reported on all Phoenix area freeways in the period 2000 and 2003. Of these, 6,406 (4 percent) were caused by mature drivers. Two percent (115) of all crashes involving older drivers occurred at freeway on-ramps, about half of those (59) occurring in peak hours when the ramp meters were turned on. The chart in Table 6 summarizes this data.

Table 6. Freeway On-Ramp Accidents Involving Drivers Over Age 65 from 2000 to 2003

	I-10	I-17	US 60	SR 202	SR 143	SR 101	SR 51	Total
Total On-ramp	25	16	45	10	1	14	4	115
Rush Hour Only	14	7	23	7	0	6	2	59
% of On-ramp Accidents in Rush Hour	56.0%	43.8%	51.1%	70.0%	0.0%	42.9%	50.0%	51.3%

In order to find out whether on-ramps and the merging process associated with them were specifically problematic for mature drivers, the study team also reviewed records of accidents involving younger drivers in the 40-to-50 age group at freeway on-ramps across the Phoenix metropolitan area.

COMPARISON WITH DRIVERS AGED 40 TO 50

Table 7. Freeway On-Ramp Accidents Involving Drivers Aged 40 to 50 from 2000-2003

	I-10	I-17	US 60	SR 202	SR 143	SR 101	SR 51	Total
Total On-ramp Accidents	134	89	0	53	11	74	65	426
Rush Hour Only	69	36	0	37	5	39	26	212
% of On-ramp Accidents in Rush Hour	51.5%	40.4%		69.8%	45.5%	52.7%	40.0%	49.8%

The comparative study of drivers in the 40 to 50 age bracket indicated that they were involved with 24,858 freeway crashes in the period (15.4 percent of all reported accidents). The proportion of their crashes at freeway on-ramps is, however, very similar to the experience of the mature drivers. Two percent of their accidents (426) were at on-ramps, and about half of those (212) at peak hours. Table 7 summarizes this data.

COMPARISON WITH ON-RAMP CRASHES 1996-1999

Mature Drivers over Age 65

In a further effort to note possible safety benefits associated with ramp meters, the study team also compared the records regarding crashes at on-ramps for the period 1996–1999, when there were far fewer ramp meters installed, with the parallel records for the period 2000–2003. The overall number of crashes involving older drivers actually declined from the period 1996-1999 to the period 2000–2003.

Despite an overall 43 percent increase in the number of crashes in all areas of the Phoenix metropolitan area and a greatly expanded freeway system, the number of accidents involving older drivers actually declined, from 7,722 to 6,406. This represented a decline from 7 percent of all reported accidents to 4 percent of all accidents.

The number of older driver accidents at on-ramps also declined from 194 to 115 (from 3 percent to 2 percent of all reported older-driver accidents). The number of peak hour on-ramp accidents involving older drivers also declined, from 83 to 59.

Drivers Aged 40 to50

Among the control group of drivers aged 40 to 50 the number of freeway accidents similarly declined in the period 1996–2003. Drivers in the 40 to 50 age group were responsible for 17 percent of all freeway accidents in the period 1996 to 1999 and 15 percent in the more recent 2000–2003 time period. Much like the experience of drivers over age 65, the proportion of all of their accidents that occurred at on-ramps declined from 3 percent to 2 percent, with only 1.1 percent occurring in the peak hour.

Tables 8 and 9 summarize the accident records associated with on-ramps for the two sets of drivers in the period 1996–1999.

The trend of decreasing numbers of on-ramp accidents is evident in Table 8, and the experience of the two groups of drivers is parallel, except in the case of U.S. 60 where the number of accidents involving mature drivers increased, specifically at the eastern part of the highway, where a substantial portion of older residents live. There were no accidents involving the younger cohort of drivers, age 40 to 50 years old

Table 8. Freeway On-Ramp Accidents Involving Drivers Over Age 65, 1996-1999

	I-10	I-17	US 60	SR 202	SR 143	SR 101	SR 51	Total
Total On-ramp Accidents	58	32	39	31	2	12	20	194
Rush Hour Only	25	12	20	13	0	5	8	83
% of On-Ramp Accidents In Rush Hour	43.1%	37.5%	51.3%	41.9%	0.0%	41.7%	40.0%	42.8%

Table 9. Freeway On-Ramp Accidents Involving Drivers Aged 40 to 50, 1996-1999

	I-10	I-17	US 60	SR 202	SR 143	SR 101	SR 51	Total
Total On-ramp Accidents	165	75	108	80	5	13	59	505
Rush Hour Only	56	47	60	36	1	8	34	242
% of On-ramp Accidents in Rush Hour	33.9%	62.7%	55.6%	45.0%	20.0%	61.5%	57.6%	47.9%

COMPARISON WITH LOCATIONS LISTED AS PROBLEMATIC: 1999-2002

Based on a review of accident statistics for 1999–2002, the ADOT study by Sharon Baggett ranked locations in terms of the number of accidents involving older drivers and those under age 65. (2003). Although the majority of the locations identified were at urban intersections, her study did also highlight a number of freeway locations. Several of the locations noted as problematic for older drivers were at on-ramp locations—specifically at 7th Street on I-10, and State Route 87, Alma School Road, and Gilbert Road on U.S. 60, and 32nd Street on S.R. 202. Most of those same locations were also indicated as complex for drivers under age 65; younger drivers also had difficulty at 7th Street and at Central on I-10.

Among those locations listed as problematic in the Baggett study, only Gilbert Road on the U.S. 60 continued to be challenging for mature drivers. There were five accidents involving older drivers in the period 2000–2003. Seventh Avenue on I-10 had three accidents at the on-ramp, a figure slightly higher than the one or two accidents. The overall reduction in the number of accidents at freeway locations that had been considered problematic for older drivers was most encouraging.

Along U.S. 60 the problematic areas seem to have moved further east. For example, the Alma School Road on-ramp, a location identified in the Baggett study as a major challenge for older and younger drivers in 1996–1999 with eight accidents involving older drivers and 21 involving drivers age 40 to 50, only had one accident with an older driver and no accidents involving a driver in the control group in 2000–2003. Gilbert Road continues to be problematic for older drivers. Val Vista Drive, Greenfield Road, and Power Road have not been areas of concern in 1996-1999, but registered 12, 8 and 4 accidents, respectively, involving older drivers in 2000-2003, and no accidents involving the younger control group.

Potentially this pattern of accidents involving older drivers reflects increased exposure in eastern Mesa with more development in the east, along with an increased number of older residents in the eastern part of Mesa. Power Road, with a multiplex theater, restaurants, and a shopping mall, is an obvious destination for those living further east. Given the type of trip purpose in coming to Power Road, accidents involving older drivers at Power Road were primarily in off-peak when the ramp meters were not on.

ASSESSMENT OF CRASHES AND DEPLOYMENT OF RAMP METERS

It is not possible to associate the general decline of accidents on the on-ramps directly with the installation and operation of ramp meters. During this same period dedicated acceleration/deceleration lanes were also introduced at a number of freeway entrances. Nevertheless, the overall reduction in accidents at on-ramps is impressive.

Ramp meters were not installed at many of the on-ramps along the freeway system in the period 1996–1999, and accident rates at almost all on-ramps for older and younger drivers were much higher than for 2000–2003.

During the period 2000–2003 ramp meters were installed at all on-ramps on I-10 north of Chandler Boulevard. On I-17, ramp meters were operational from Grant Street to Peoria Avenue. Ramp meters were not operational at the 7th Avenue on-ramp, one of the more complex locations for both sets of drivers. On S.R. 202 ramp meters were installed and operational at all ramps as far out as Scottsdale Road. On S.R. 101 ramp meters were installed and operational at Camelback Road, Bethany Home Road and Northern Avenue on-ramps during the 2000–2003 period, but not at Thunderbird Road. No ramp meters were installed on S.R. 143 during this period. On U.S. 60 there were ramp meters operational between Mill Avenue and Power Road. Potentially the proportion of older driver accidents will begin to decline at on-ramps on the eastern part of the area, much as they have declined in other parts of the freeway system.

To put these observations into context it is helpful to note a 1996 report by the Highway Safety Information System (HSIS), titled “An Analysis of Older Drivers on Freeways.” This report, based on accident data bases from five states in the period of 1988–1991, matched freeway accidents involving drivers aged 66 and older and with those involving drivers age 31 to 45, and looked at a number of factors including precrash maneuvers of drivers (1996).

The study found that 11.8 percent of accidents involving older drivers involved precrash maneuvers with merging or changing lanes as compared to 8 percent of the younger drivers. Older drivers were cited five times as often as younger drivers for failure to yield. Nevertheless, the difference between older and younger drivers involved in multiple vehicle accidents involving lane changes at entrance or exit ramps was very small, 15 percent and 14 percent, respectively.

Older drivers were over represented in single-car accidents where they were attempting to merge or change lanes and subsequently ran off the road. The HSIS report recommended additional studies of ramp and mainline geometries and characteristics that contribute to freeway merge problems, and studies of traffic control devices that could be used to minimize problems with merging in transition areas (HSIS 1996). Potentially the ramp meters are one form of traffic control device that are assisting older drivers with merging.

8. CONCLUSIONS AND RECOMMENDATIONS

PROJECT SUMMARY

Although a substantial proportion of mature drivers voluntarily refrain from freeway driving, there is a sizable number who do regularly use the urban freeway system. This number is expected to rise as members of the baby boom generation, who have extensive experience with urban freeway driving, join the ranks of mature drivers. Scattered urban development patterns make freeways a vital link between residential and recreational opportunities, shopping centers and even medical facilities. Individual retirees are able to group their longer-distance trip purposes so that they do not drive on the freeway system every day of the week. Nevertheless, about 25 percent of the project participants in 11 focus groups with drivers over age 65 reported freeway trips on trip logs for the two days before their group meeting. Twenty-eight percent of those trips were during peak hours.

For Phoenix-area focus groups held between fall 2003 and spring 2004, participants were selected to represent mature drivers who regularly drove on the freeway system, since the intent was to solicit observations regarding responsiveness to ITS devices from those with recent experience with them. Most demonstrated through their well-framed comments that they were alert, responsible drivers. For example, a number shared their observations on experiences in changing lanes, a maneuver that the literature points out is particularly challenging for older drivers. Several said that when they were unable to get over to the right lane to exit on time, they just drove to the next exit and turned around. Group discussions reinforced the concept of driving in the middle lane where they could travel at a consistent speed, but also exit on time. Several noted that they used the freeways for regular trips, and they were very familiar with particular stretches of freeways.

All but one participant agreed to take the Trails Test, a test widely used to assess both vision and the mental agility required for multi-tasking. Results of the test indicated that although the older drivers were slower in response to Trails Test B than were members of a control group (aged 40 to 55), most were able to complete the test successfully. Several participants, however, found the multi-tasking required on Trails Test B to be very challenging. The aging process clearly affects individuals differently, and age is not itself an indicator of competence in addressing the multiple tasks involved in driving.

Overall, these older freeway drivers were very positive in their assessment of ITS innovations such as VMSs and ramp meters, and felt that they enhanced their driving experience. They did, however, provide a number of specific observations that would enhance their usefulness. The suggestions generally related to accommodating aspects of the aging process reflected in the literature. Many of their observations related to problems with dynamic visual acuity—complexity in distinguishing letters while moving—as well as problems with observing contrast, seeing clearly, and peripheral vision. Several participants also indicated that it took them longer to identify gaps in the traffic flow and to move their foot from the brake to the accelerator after stopping. Those concerns also were reflected in observations about the speed of other drivers on the road,

and frustration in dealing with impatient drivers behind them. The following observations and suggestions relate to the specific technologies included in this study.

FIXED VARIABLE MESSAGE SIGNS

The older drivers were enthusiastic about large fixed VMSs centrally located above the lanes of traffic on the urban freeway system. In all the focus groups, participants commented about their difficulty in reading the standard highway signs. The signs near the Phoenix airport that have white letters on a brown background came up in almost every session as an example of a standard sign that is hard to read. Some of those signs are faded by the sun and are difficult to read while negotiating an already complex roadway system. Some participants also noted difficulty in reading the white on green signs that are used nationally on the interstate system. In contrast, the large VMSs with fiber-optic yellow letters on a black background were relatively easy to read and caught their attention.

Participants did, however, have suggestions that they felt would make the VMSs even more helpful. Comments fell into two major categories—the content of the message conveyed and the signage itself.

The Message:

- The message should be specific and directional relating to current travel.
- The message should be simple and concise, avoiding extra explanations.
- The message should suggest an alternative, if the road is blocked or closed.
- Post more than one sign with same message to the reinforce message.
- Post message well in advance of the problem area.
- Avoid use of signs for alerts or providing general information such as ozone alerts, or urging use of seat belts, or indicating, “have a nice day” (Amber Alerts, however, are a useful exception.).
- Avoid posting future road closure or maintenance signs too far ahead of time.
- On signs noting future road closings avoid using numerical expressions to convey dates (e.g., 4/20).
- Choose abbreviations carefully to avoid confusion.

The Sign:

- Brightness and high contrast is essential especially given glare in bright sunlight.
- Provide only two lines of information on an elongated sign.
- Center message in middle of sign, if possible. (Three lines are relatively easy to read if lines are short and centered.).

These suggestions are certainly in keeping with the standard FHWA guidelines and do not differ substantially from the practice in use for the VMSs on the Phoenix urban freeway system. Alerting the driver well in advance of the required action is clearly a goal, although it is sometimes difficult to achieve with fixed message signs. Posting key information on multiple signs is a practice in the Phoenix metropolitan area. Participants

agreed that that approach is most helpful in alerting attention as well as giving several opportunities to read, absorb, and respond to key information.

Although VMSs do allow for three lines of information, participants in all focus groups reported difficulty in reading, absorbing, and responding to messages that extended over the three lines. Even reading and responding to two full lines was challenging if the message included abbreviations for route designators or numerical expressions for dates. All agreed that the VMSs should convey only essential directional information requiring driver response. Short messages could be centered on the sign, minimizing the need to read across lines.

Given the challenges in reading messages while driving and the impact of the VMSs in attracting their attention, the older drivers were not in favor of using the VMSs for alerts regarding ozone. They pointed out that they were already on the highway before they saw such a sign, so there was not much they could do about ozone. "Amber Alerts," however, seemed to be a good use of the VMS, since “they seemed to work.”

The paramount problem faced by these Arizona older drivers in regard to VMSs, as with standard signs, is glare from bright sunlight. The fiber-optic signs were easier to see, but participants underscored the importance of sharp contrast and clearly delineated letters.

PORTABLE MESSAGE SIGNS

Focus-group participants appreciated the portable, trailer-mounted electronic signs since they caught their attention and offered directions. Participants recounted their experience with these signs at construction sites where they found that these signs were much easier to follow more than the standard painted highway signs. They did, however, have many suggestions regarding both the message and the deployment of these signs.

The Message:

- Provide simple, concise message avoiding extra words of explanation.
- Avoid using abbreviations for route direction or for route identifier (e.g., Rte 51 North is clearer than S/R 51 N/B).
- Avoid giving advance dates, and use days of week instead (e.g., Friday, rather than 4/23).
- Focus on required driver response (e.g. Merge Right).
- Avoid using more than one phase in signs.
- Use multiple signs, to catch attention and reconfirm message.

The Sign:

- Brightness and contrast are essential to compensate for glare.
- Use letters with sharp resolution
- Elevate the sign as high as possible to be seen across multiple lanes of traffic.
- If mounted separately from the message, flashers help attract attention to the sign.

Several of the issues with the portable signs were similar to those with the fixed signs. The smaller surface on the portable signs made the caution about conveying only essential directional information and avoiding unfamiliar abbreviations even more significant. Older drivers also found it difficult to read more than one message phase on portable signs and suggested using multiple signs.

The placement of portable signs on the right side of the freeway is unavoidable in freeways without a median, but it is difficult to see them across several lanes of traffic. The mature drivers urged that they be placed as high as possible on the trailer. Flashers within the message field are distracting, but some participants felt that flashers mounted above the sign would help to attract attention, a point that corresponded with a recommendation in the FHWA Highway Design Handbook (Staplin 2001). The sign placement issue reconfirms the caution about the length of message.

RAMP METERS

Overall, the mature drivers were enthusiastic about ramp meters and their potential for helping them merge into the flow of traffic. Although they made more freeway trips at times of day when ramp meters were not operational, almost all participants were familiar with the ramp meters, indicating that they also traveled in peak periods. More of their concerns related to interaction with other drivers, than to the operation of the ramp meters themselves.

Although this study cannot directly relate a reduction in accidents at most on-ramps in the Phoenix area to the introduction of ramp meters, it is true that the proportion of accidents involving mature drivers has declined at many on-ramp locations that were problematic in the past. Accident levels for a control group of younger drivers age 40 to 50 were also reduced at most of the same on-ramps. The only locations where the proportion of accidents involving mature drivers increased, those at the eastern end of U.S. 60, may possibly be attributed to demographics. Locations at the eastern end of the U.S. 60 freeway are home to a substantial proportion of older residents, a factor that would relate to higher exposure levels.

Issues Related to Ramp Meter Devices:

- If there are two approach lanes on a ramp, it is essential to have a separate set of signal lights associated with each.
- The double set of signals—one for the front driver and one for the driver behind is a major benefit.
- Lights should be large enough and bright enough to be seen by all drivers.
- Clear, easy-to-read signage warning that the ramp meters are operational would help.
- Space between the ramp meter and entrance into the traffic flow is essential to give drivers adequate space for acceleration after stopping at ramp meters.

Issues Related to Other Drivers:

- Mature drivers are more deliberate and slower to gauge gaps in traffic. Younger drivers whipping around in front of them on the on-ramp or competing to get to ramp meter is unsafe, frustrating, and confusing.
- Dedicated new acceleration/deceleration lanes combined with the ramp meters help to reduce these concerns.

TRAVELER INFORMATION SYSTEMS

Since the focus groups and the heuristic test both addressed issues related to mature driver use of the 511 telephone and the AZ511.com web site, observations from the two sources are combined in the following recommendations. Overall, the mature drivers were enthusiastic about a source of information that would assist them with pretrip planning, particularly on longer trips. Since they were generally able to rearrange their trip to avoid travel in congested periods, they did not anticipate using enroute telephone-based travel information except as they encountered problematic roadway conditions while on a longer trip. These mature drivers underscored the importance of simplicity, clarity in directions, and close association with the real world for either telephone or computer-based ATIS. Much like busy commuters, they wanted information quickly and easily, without putting forth a considerable amount of effort. Recommendations fell into two categories: suggestions for enhancing the 511 dial-up system, and suggestions for enhancing the web site.

Dial-up: 511 Telephone

The 511 telephone system is evolving both in Arizona and in other parts of the country. Arizona has joined a relatively small number of states in using voice recognition . Voice recognition software is being refined, and 511 users in different states note complexities with using voice recognition that parallel comments of Arizona users. The comments of the mature drivers paralleled those of other drivers who called the ADOT 511 comment line and of the younger driver control group. They were intrigued by the concept and looked forward to using it more completely when it was more fully refined. Observations clustered standard user-interface heuristics.

<u>Response to User Interests and Needs:</u>

- The system needs to be simple to use with a clear, simple menu with a minimum of instructions.
- The system needs to minimize call time.
- Information flow needs to be presented from the perspective of users, focusing on points of origin to points of destination, rather than a highway-oriented approach.
- Information regarding use of segments should be simplified, so users can focus on areas of concern to them.
- Using terms familiar to users leads to quicker and more effective use (while helpful in zooming in on relevant information, route segments are unfamiliar to users and explanatory information too extensive).

Provide for Flexibility Among Users:

- Familiar, confident users should be able to move ahead through the system and interrupt explanatory material if they are familiar with the system.
- Additional information should be available to those who need it (as a fall back position a person should be available to respond to queries).
- Use of the help line would decline as more users become comfortable with the system.

Preventing Errors

- Developing fully responsive voice recognition is complex (a fall back key pad system is needed to prevent frustration).
- Major upgrades to the system should be made off-line to avoid discouraging current confident, regular users.

Web site: AZ511.com

The site should respond to real-world needs for travel information. The mature drivers, all of whom were familiar with using the computer to get trip directions, were most interested in accessing pretrip information about road repair, or high winds, for example. They wanted the site to be simple to use and identify problems that would impact a trip.

Their concerns related to several heuristics of usability. The overall theme was that the site should be user-friendly and functional in terms of serving individual users. This would offer the site a clear focus and avoid fragmentation.

Focus on the user:

- The site should be simple with clear guidance on how to navigate through it to find desired information quickly.
- The overall functionality of the site should be adaptable to the travel agendas of individual users, offering users quick access to information by imputing the origin and destination of their trip.
- Users should be provided with a simple menu on the home page providing clear choices in terms of information to access.
- The hierarchy of information should be clear and the number of steps required to access basic traveler information minimized.
- Font choice and letter size should be quickly readable. Combinations of upper- and lower-case letters are shown to be easier to read.
- The hierarchy of information should be clear and the number of steps required to access basic traveler information should be minimized.
- The site should feature a high-contrast highway map showing routes and major destination cities, allowing users to orient themselves.
- The map should allow users to zoom into specific areas of concern, such as their own neighborhoods. This would both enlarge the text, and provide a focus for the users.

Legibility:

- The maps should use colors to eliminate visual confusion, and should be shown as large as possible.
- The categories of icons related to highway conditions should be greatly reduced, and the definitions of each category made evident to all site users.
- Simple geometric shapes in contrasting colors should replace icon graphics.
- Information associated with identified problem areas should be provided in short, easy to read blurbs that relate directly to the traveler (e.g., construction May 10–15, one lane blocked, and high wind advisory).
- The size of type/text should be large enough that it is comfortable to read, and text should be a combination of caps and lowercase (most legible).
- Users in the Phoenix area should link to the map showing real-time highway congestion.

Help and Documentation

- Navigation through the site should be evident to users, but additional guidance on steps to using the site should be offered in a help button evident on the first page.
- The 511 site should have a link to a tutorial/training manual so users can learn how to use the 511 phone system. This link should include a simple step-by-step guide to the phone system that users can print to take along in the car.
- There should be consistency in the classification of information across both the 511 phone service and online service. At the very least, categories of information presented both on the phone and on the web site should be consistently labeled.
- Explanatory information regarding 511 could be accessed through a link from the first page.

The following conceptual images (Figures 13 and 14) illustrate the above principles as applied to a possible web site.

Figure 13 shows a minimalist design with a focus on a highway map. Function and usability are the emphasis, rather than an attempt to capture attention. Since mature drivers, and potentially others as well, approach the site for information on a specific trip, there is a scroll bar to indicate a range of possible origin and destinations. Incidents that impede smooth travel on the urban freeway and interstate system are presented in a few easily distinguished geometric shapes. Each shape represents a category of issues that contribute to travel delay and would impact trip planning. Lettering is in mixed case, which is easier for older persons to read quickly. Information on AZ511.com and on using the telephone 511 is available on a separate page. News on road closures can be linked. The highway speed map for Phoenix is also shown on the first page. A click will select and enlarge it. Other highway speed maps could later be added for Tucson or other cities.

Figure 14 represents a “zoom-in” on a portion of the map and shows the selected icons and accompanying blurbs that briefly note key information relating to delay on the specific trip selected by the user.

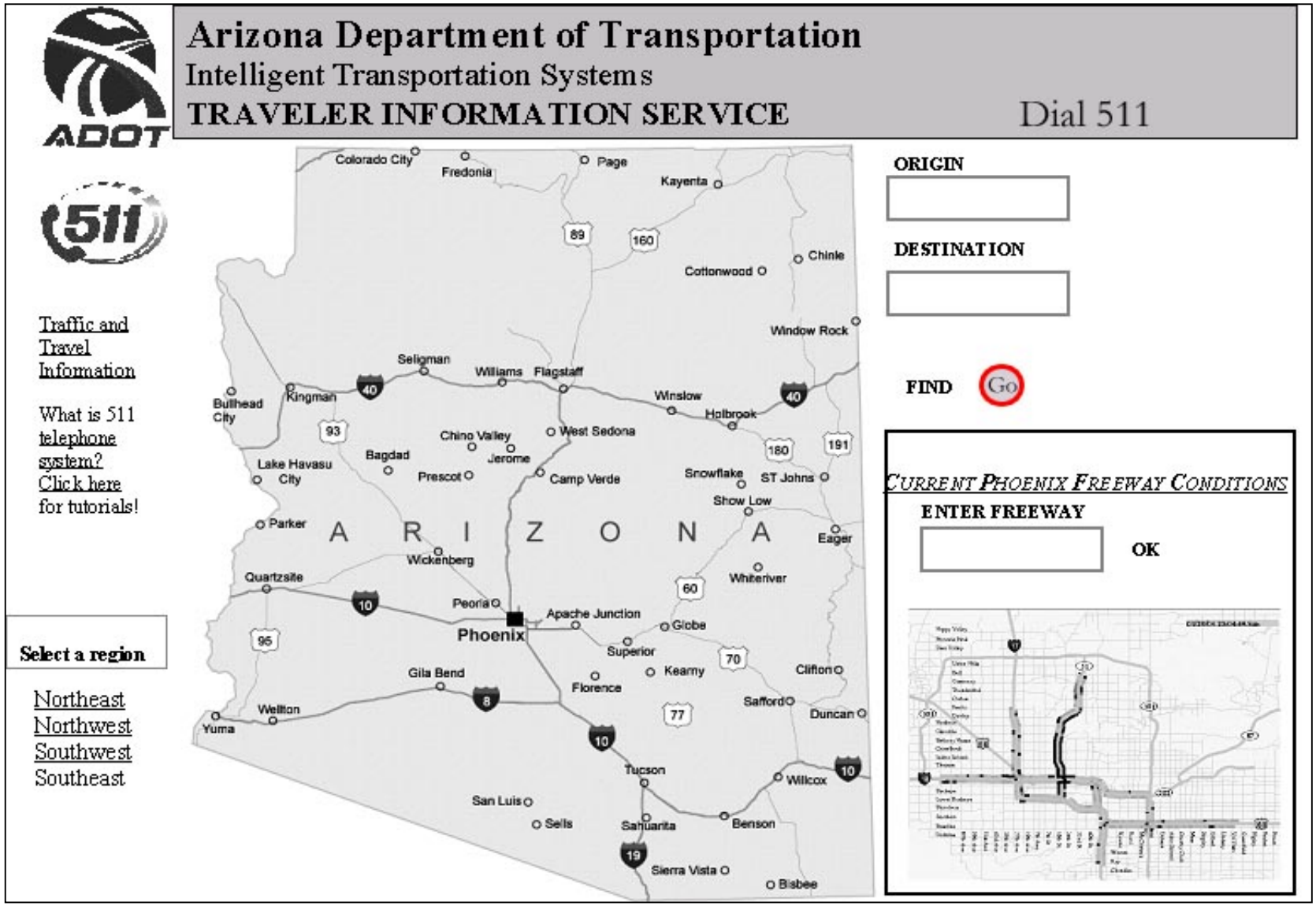


Figure 13. Concept for AZ511.com Web site Home Page

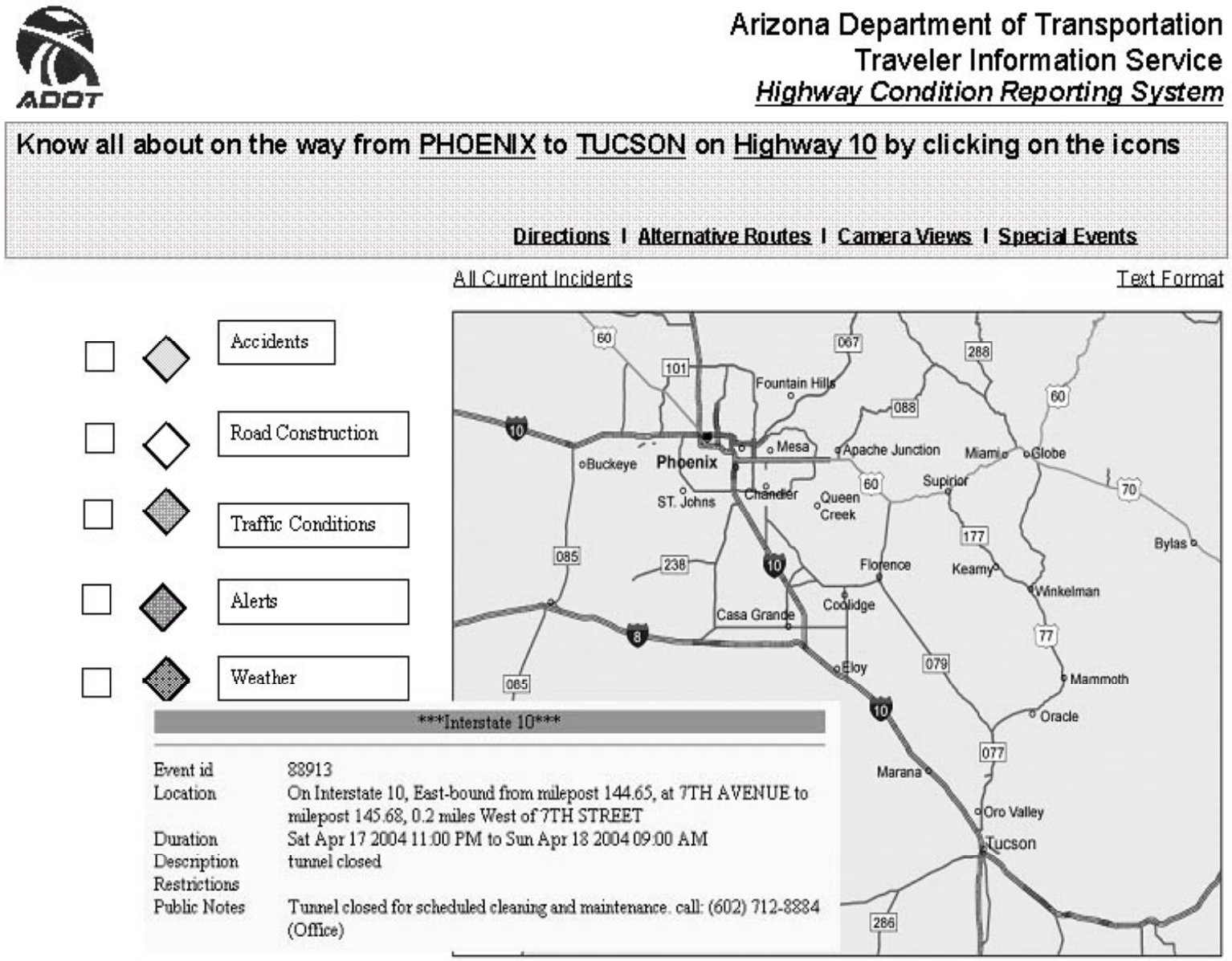


Figure 14. Concept for AZ511.com Road Conditions Web Page

This analysis was completed before a revised AZ511.com web site went live on April 16, 2004, after both the conclusion of the focus-group sessions and the initial heuristic session. In June and July, a follow-up evaluation was conducted, and those findings are included in Appendix G. Further revisions of the site are planned on an ongoing basis.

There is no attempt to critique the evolving site, but rather to provide a set of guidelines that can direct future development of the evolving traveler information web site. A site responding to these guidelines would present road conditions in a way that could be quickly grasped not only by mature drivers but also by users of any age wanting to find out quickly about travel delays that would impact their trips.

SUMMARY

In many ways, the ITS technologies reviewed in this study do respond to needs of older, mature drivers. Older drivers with declining visual acuity and diminished agility in response need advanced notice of road hazards to accomplish lane change or merging maneuvers. ITS technologies can play a significant role in attracting the attention of older drivers and offering timely alerts. Fixed VMSs feature large fiber-optic displays using negative contrast yellow-on-black lettering. Portable fiber-optic VMSs can both attract attention and provide key directions for motorists. Ramp meters offer older drivers a valuable four-second gap to assist with merging onto the freeway, and ATIS can offer valuable information for trip planning.

Increased sensitivity to the needs of mature drivers can make these technologies even more effective. The mature drivers in the project's focus groups recommended a focus on simplicity of message, clarity in presentation, and sharpness of image. They emphasized that VMS messages should be limited to essential directions for drivers. They should be presented in a few well-chosen words, and avoid unfamiliar abbreviations. Although the reason behind the message is of interest to motorists, the primary objective is to insure that drivers respond appropriately. For example:

- The standard four-part message (Staplin 2001) —What happened? Where? What is the effect on traffic? What should the driver do? —can be reduced to just one essential point: "What should the driver do?"

- "Truck Overturned SR 51 at Indian School / Expect delays / 3 lanes closed. Merge right" can be reduced to a short message presented in two lines at the center of the VMS—"3 lanes closed / Merge right."

Maximizing visibility and legibility with portable message signs would involve elevating them to the maximum level in the trailer, limiting the message to the action step, and using multiple signs rather then multi-phased signs. Ramp meters linked to acceleration lanes offer real promise in assisting with the merge and reducing the potential for rear end and sideswipe accidents associated with hesitation in entering the freeway.

For ATIS, the aim should be to convey key information, in a minimum number of steps or screens, thereby making the system fully usable by those drivers with declining hearing, decreasing visual acuity, or limited dexterity.

None of these concepts or principles offers a significant change in direction or policy in deployment of ITS technologies. In fact, they correspond to guidelines provided by the FHWA in *The Highway Design Handbook for Older Drivers and Pedestrians* (Staplin 2001). What these concepts do suggest, however, is to consider the perspective of older drivers when deploying ITS technologies. Older drivers represent an increasingly significant proportion of the driving public. The objective is both to maximize the benefits that come with alerting drivers with electronic signs and signals, and to minimize confusion caused by drivers straining to read or comprehend the message they present.

Relatively low cost changes in application can make ITS technologies more effective in communicating with mature drivers, and can help to enhance their driving performance. Focusing on enhanced visibility and legibility for older drivers will also enhance communication with other drivers. In effect, highways made safer for mature drivers, become safer for all drivers.

APPENDICES

APPENDIX A

FOCUS GROUP SCRIPT

WELCOME

INTRODUCTIONS

AGENDA SETTING

Our focus today is on enhancing the safety of mature drivers, particularly as they travel on freeway and major arterial streets. One way to increase safety is to focus on the highways themselves. In recent years there has been a major effort to use technologies to increase the efficiency and safety of existing freeways and major arterials.

We are particularly going to look at two technologies that you may have noticed—

- **Electronic message signs**
- **Ramp meters.**

We are also going to look at ways of providing

- **Current** (almost real time) **traveler information**.

Our hope is that this group can come up with some suggestions that can help in making these more effective in meeting the needs of mature drivers, in particular.
As we well know, that will also help all drivers.

TECHNOLOGIES

FIXED VARIABLE MESSAGE SIGNS

Let's turn first to variable message signs. Show photo of variable message sign.
This kind of sign is permanently fixed –usually suspended over the freeway

Have any of you seen this type of sign in the Phoenix area?
On what highway?

What type of message did it convey?

Can you offer other examples?

Were they helpful is providing guidance to you as you were driving along?

Did any of you see a sign that was difficult to read? Please describe it?

Did reading the sign cause you to slow down considerably or look away from the highway?

When you saw the sign that said (*FILL IN WITH WHAT THEY SUGGESTED*), what did you do?

Did anyone see this type of variable message sign in other cities that you have driven through?

Were they similar to those used locally or different? Please describe them for us.

What suggestions would you have to make these signs on in our area even more effective?

PORTABLE ELECTRONIC MESSAGE SIGNS

There is another type of electronic sign that is now used on major arterials as well as freeways—portable electronic message signs.
Sometimes they are displayed before a construction zone.
Here is a slide showing several of these signs.

Has anyone seen one of those?
Where was it? -- On a freeway or a major arterial street? On the shoulder of the road?
What type of information did it tell you?
What did you do when you saw the sign?
Did you need to slow down to read the information?

Can you offer other examples?

Did you ever see a sign like this that was difficult to understand? Please describe it.

Feel free to share your experience from driving in locations outside the Phoenix area also.

Were the construction signs you saw displayed alone or were there striped barrels or reflector lights associated with them? Were there flashing lights?

Did those help you get the message?
Did they add confusion?

Would you say that these electronic signs are more helpful than the more traditional orange painted construction signs? In what ways?

What suggestions would you have to make these signs even more effective in communicating to the driver?

RAMP METERS

Do you find it difficult to merge onto a freeway from an on-ramp?

What would you say causes the difficulty? (Hard to see traffic from ramp? High speed of traffic on the freeway? Etc.)

Have you entered a freeway when a ramp meter was turned on?
(Show picture of ramp meter.)
What freeway? What time of day?

Did you find that the ramp meter was helpful?

Do you have some suggestions for making the ramp meter even more useful?

TRAVELER INFORMATION

As you know, on the survey connected with the trip log, we asked whether you checked any type of traveler information before taking trips in the last two days.

What **sources** of traveler information would you say you use most often? Why?

For what type of trip would you be most likely to check traveler information?
Where do you check traveler information—Before you leave home? On the way to some destination? Before you start your return trip?

What type of traveler information would be most helpful to you as you plan your trip?

AZ511.com

ADOT provides a considerable amount of updated traveler information on its web site. Have you checked that? If not, why not?

Show images taken from web site.
What information would be most helpful?
What suggestions would you have for making this source even more useful?

511 Dial-Up

Arizona is one of a growing number of states that are now introducing a new 511 telephone system to get traveler information. The number will be soon used nationwide.

Have any of you tried to dial 511?
For what type of trip?
If not, why not?

Assuming that you were heading out onto a freeway, what type of information would be helpful?

Now that you know about 511, would you be likely to use it?

Do you have suggestions for making it even more helpful?
What type of information would be more helpful?

Where would you access 511—from a home phone? A cell phone?

Do you take a cell phone with you when travel? Do you use it when driving?

ADDITIONAL SUGGESTIONS?

Do you have any additional suggestions regarding ways of making freeway driving safer for mature drivers?

THANK YOU SO MUCH FOR TAKING TIME TO BE WITH US TODAY.

APPENDIX B

TRIP LOG

(Compressed sample: copy provided to participants was larger and easier to read.)

	Morning						Afternoon						Evening				
Trip Log Date:_____ _	**Before 7 a.m.**	**7:00-7:59 a.m.**	**8:00-8:59 a.m.**	**9:00-9:59 a.m.**	**10:00-10:59 a.m.**	**11:00-11:59 a.m.**	**12:00-12:59 p.m.**	**1:00-1:59 p.m.**	**2:00-2:59 p.m.**	**3:00-3:59 p.m.**	**4:00-4:59 p.m.**	**5:00-5:59 p.m.**	**6:00-6:59 p.m.**	**7:00-7:59 p.m.**	**8:00-8:59 p.m.**	**9:00-9:59 p.m.**	**10:00 p.m. & later**
Trip Purpose																	
Work																	
Medical																	
Volunteer or drive someone																	
Shopping																	
Banking																	
Social/Recreation																	
Other																	
Return Home																	
Approximate Trip Length																	
Less than 1/2 mile																	
1/2 to 1 mile																	
1.1 to 5 miles																	
5.1 to 10 miles																	
10.1 to 20 miles																	
over 20 miles																	
How Traveled																	
Walk																	
Car passenger																	
Bike																	
Bus																	
Drive on freeway																	
Drive on local streets																	

APPENDIX C

TRIP LOG SURVEY

(Copy as distributed to participants was part of a booklet with trip log and directions for filling in trip log.)

Thank you for keeping the trip log. Please bring this with you to the focus group meeting.

1. Were the last 2 days fairly typical for you? Yes__ No___
If not, what other types of trips do you make on freeways each week?
_____
_____

2. Do you work full time outside the home? Yes___ No___

3. Do you work part time outside the home? Yes___ No___

4. Which freeways have you driven on in the last month?

_____

5. Would you choose to drive on a freeway if there were another choice of road? Yes___ No___

   That depends on the time of day____
   That depends on whether I am in a hurry to get to my destination____
   That depends on circumstances relating to the specific trip___

6. Have your traveled on interstate highways outside the Phoenix metropolitan area in the last six months? Yes___ No___
   Where did you travel to in those trips? _____

7. Have you voluntarily limited your driving in any way in recent years?
   Yes___ No___

   If so, in what ways? _____

8. Did you use traveler information for any trip that you made this week?
   Radio___Television___Computer___511 Call__ None__

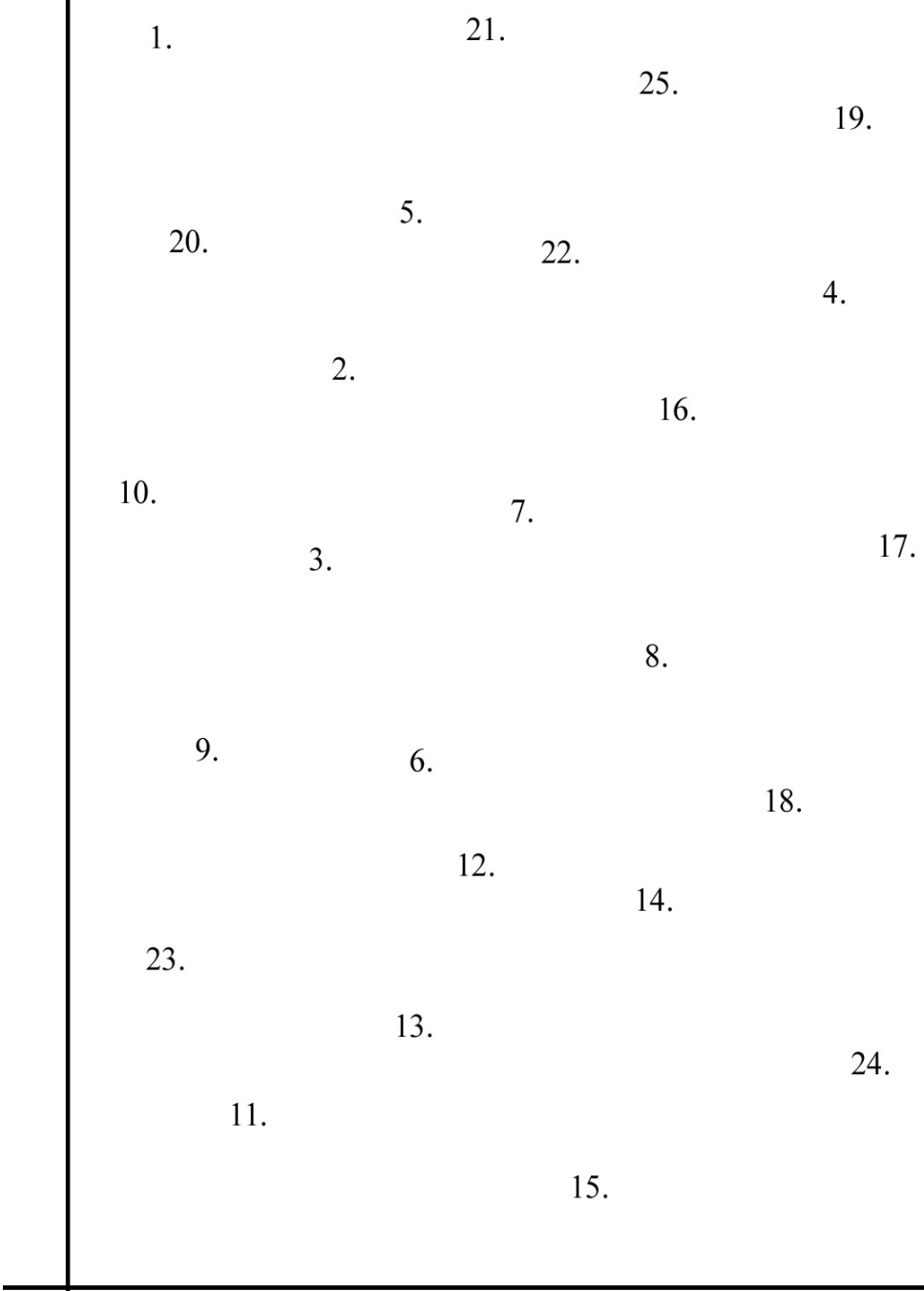
9. What is your age group? 60-65___ 66-70___ 71-75___ 76 and over___

Thank you. All answers will remain confidential.

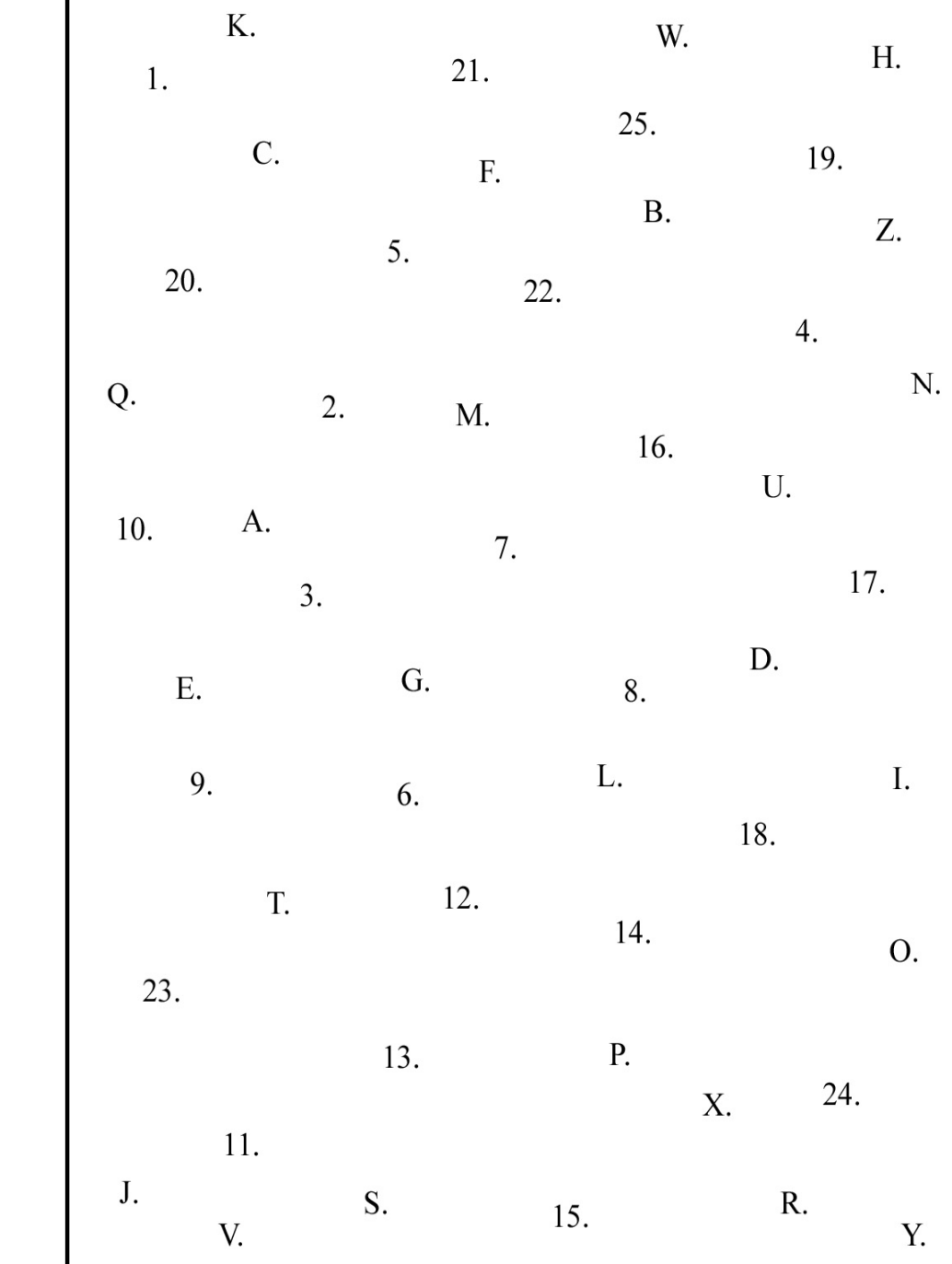
APPENDIX D

TRAILS TESTS

TRAILS TEST A



TRAILS TEST B



APPENDIX E

CONTENT ANALYSIS DICTIONARY

(List of terms used by focus group participants in referencing ITS technologies)

VARIABLE MESSAGE SIGNS

- **Helpful/Useful**
- **Clarity**
  - Directional
  - Shape
  - Spacing
  - Color
  - Size
  - Brightness (need compensation for sun glare in specific)
- **Location/Placement/Visibility**
  - Center
  - Higher placement/Overhead
  - Flashing message (for high alert)
  - Lighting the signs at night
  - Distance from incident
  - Blocking by other vehicles
- **Information**
  - Meaningful
  - Specific/No Excess
  - Alternate routes for closures
  - Limited number of lines
- **Multiple signs/Repetition of same sign**
- **Warning**
- **Standardization**

PORTABLE VARIABLE MESSAGE SIGNS

- **Clarity**
  - Color
  - Size
- **Location/Placement/Position/ Visibility**
  - Height
  - Speed of vehicle
  - Traffic lane of car vs. side of road the sign is on
  - Distance from incident
  - Blocking by other vehicles

- **Information**
  - Accuracy
  - Reliability
  - Specific/No Excess
  - Abbreviation - confusing
- **Multiple information pages on one sign**
  - Speed of change
  - Flickering/Blinking/Flashing
  - Timing
  - Repetition of signs
- **Advance warning**
- **Standardization**
- **Repetition**

RAMP METERS

- **Traffic flow - negative**
  - Bottle neck
  - Difficult going from 0 to 60 (backs up traffic)
  - Safety in merging
  - HOV lanes at on-ramps (potential for accident)
  - Merge after ramp meter
    - Potential for competition
    - Visibility low at night
- **Traffic flow – positive**
  - Good for freeway merging
  - Helpful in rush hour
- **Visibility**
- **Positioning of ramp meter**
  - Pushed back
  - Prior warning signs
- **Timing of lights**
  - Too fast, too slow, about right
  - take into account volume of traffic on freeway not ramp
- **Size of lights**
- **Times when meters are operational**
- **How managed—automatic timer or by someone in control room?**

TRAVEL INFORMATION

- **Unfamiliar with sources (511 or AZ511.com)**
- **Helpful**
  - Trip planning
  - Emergency

- **Usefulness to en route travel**
  - Concern 511 usage while driving (cell phone)
  - Punch in numbers versus letters
  - Update – Need to be current
  - Needs clarity in message
  - Speed of message
  - Safety hazard
  - Compatibility with other systems (OnStar™)
  - Alternate route suggestions
- **Prioritizing Information**
- **Roaming Charge/Fee**
- **Online 511 system**
  - Fuzzy
  - Layman terminology
  - Terminology descriptions
  - Usefulness on the road?
- **Source of Information**
  - Radio
  - Internet
  - TV
  - Newspaper
- **Useful Information**
  - Weather
  - Road Construction
  - Road Maintenance
  - Road Closures
  - Accidents
  - Delays
  - Lane restrictions

APPENDIX F

HEURISTIC ANALYSIS 1

511 TELEPHONE SYSTEM REVIEW SCRIPT (March, 2004)

Please dial 8-511 ('we have to dial 8 to get an outside line)

SCENARIO:

You are planning a trip from East Mesa to downtown Phoenix where you plan to attend the symphony. You plan to travel on Route 60 and Interstate 10. Please use the 511 system to access information about road conditions on the way.

1. Listen to the initial introduction.
Does it effectively introduce you to the 511 system main menu?
Does it provide enough information to get you started?
Does it provide too much information at the start?
Are instructions clear?

2. .After the prompts select *Roads*
Did it correctly move you to roads?
If not, where did you end up?

3. Were the directions on how to use the roads section clear?
Was there a clear prompt on when to say "**60**"?
Did it recognize your request for information on route 60?
If not, what happened?
Did you try more than once to get route 60?

4. When you get to route 60, are instructions clear on what to do next?
Was the discussion of segments clear?
Did it recognize your voice when you asked for the appropriate segment for the East Valley part of route 60?
If not, where did it send you?
Did it take you more than one try to get to information on the right part of highway 60? What happened?

5. Was there any incident (accident or construction etc) on Route 60?
Was discussion of the problem (if any) clear?
If there was a problem, did it tell you what road to take as an alternative?

6. You also need information on *Interstate 10* to get to Phoenix.
Was the prompt to say "**10**" clear?

Did it recognize you when you told it 10 or Interstate 10?
Did it take you right to Interstate 10?
If not, where did you go?
Did it take you more than one try to get information on Interstate 10?

7. Was information on the segments of Interstate 10 clear?
Were you successful in getting information on the segment that includes Phoenix?
If not, what happened?
Did you try more than one time?

8. Was there any accident or construction on Interstate 10?
Was the information helpful?
Did it tell you what to do to avoid the problem area?

9. The system will tell you that you have the option of trying *Quick Reports* that will provide summary information on each of the sub regions of the Phoenix area.

Try to get a **quick report** on the East Valley.
Did you get enough instructions on how to get a quick report on the East Valley?
Did it tell you what sub region the East Valley is in?

Did you get a quick report on the East Valley?

What type of information was included in the Quick Report? Would that information be helpful in planning your trip to the symphony?

When would the quick report information be helpful to you as a traveler?

10. Next leave the *Roads* part of 511 and try to get information on *Transit.*

Let's assume you want to know if there is a bus that will take you to Phoenix from Mesa. What bus should you use to go from Country Club Boulevard to Phoenix? What is the schedule? Is it on time? Where should you go to find out about that?

Were you successful in getting to the transit section of the site?
Were the instructions on the transit site clear?
What were you told to do?
Did you find out information about a bus from Mesa?

11. Then end the call.

VII. Group discussion.
What were your overall thoughts about the 511 telephone system?

Are there particular parts of the system that need attention?

What would you recommend?
Would you use the system again?
For what type of trip information?

AZ 511.COM WEB SITE

1. Look at the section that includes the state map first.

You want to take a trip from Phoenix to Flagstaff. What type of road condition information would you want to know?

- Can you find out that information from this site?
- Are directions clear?
- How would you begin?
- After checking icons, is it clear what you need to do next?
- Did you get the information you needed? What type of information do you need to know?
- Is the information provided just about right? Too much? Too little?
- Is the site easy **to use**? If not, why not?
- Is it easy **to see**? If not, what would make it easier to see?
- Would you suggest any other changes?

2. **Would you use this site again? If so, for what type of trip**?

3. Look next at the congestion map of the Phoenix area.
Assume that you are looking at this to see if there are any major road delays between you home in East Mesa and the symphony in down town Phoenix.

- Are there any delays? Is it clear where those are?
- What would you do to avoid a major freeway delay?
- Is that map helpful? Do you have suggestions for making it easier to use?

Do you have any overall suggestions that would make the web site more effective?

Thank you for joining us today!

APPENDIX G

HEURISTIC ANALYSIS 2 (July 2004)

ADOT's 511 traveler information system is continuing to evolve. Following this project's initial heuristic review of the 511 dial-up and the AZ511.com website by a group of five older drivers in March 2004, both the telephone dial-up system and computer website were modified considerably. A number of the changes to the 511 dial-up system suggested by the group of older drivers were incorporated, as were changes suggested by callers on the comment line. The most important change was adding a back-up touchtone system for the caller to use if the voice recognition system did not recognize his or her stated requests. A number of changes were also made to the AZ511.com website, and a second heuristic study of the site seemed to be warranted.

APPROACH

A group of six older drivers (user/evaluators) conducted the second heuristic evaluation of the site on July 1, 2004. Three of these older drivers had participated in the earlier heuristic test in March. The others had not interacted with the site before. The group included two women and four men. All were retired from Arizona State University, but several continued to contribute their time or work part time at ASU. All had used computers in their job assignments and all continued to use MapQuest for trip directions. None had personally used AZ511.com to access road condition reports.

A control group of five younger drivers (aged 35 to 45), who are current ASU employees, participated in a parallel heuristic study of the same version of the AZ511.com website on June 30, 2004. The objective in involving the control group was to determine whether there would be significant differences between the observations of the older drivers group and those of a group of middle-aged drivers who regularly commute to work. These younger drivers use the computer and access the Internet as part of their job assignments. They also said that they regularly use MapQuest for travel directions. All of these younger drivers had seen variable message signs on the freeways announcing the AZ511.com system during the week of June 28 to July 4; one had tried it and recommended it to family members. One other younger driver had used the telephone 511 system and found it helpful.

Both sets of drivers used the same two scenarios that were used in the heuristic study in March. They were observed by graduate student assistants as they accessed the web site on ASU office computers. As in March the older driver evaluators interacted with the computer in groups of two, simulating the experience that they might have at home in trip planning. Three of the younger drivers accessed the site independently and the remaining two in a group of two.

- Scenario One: You are living in East Mesa and plan to travel to downtown Phoenix. Access AZ511.com to find out about any traffic problems that would impact your trip.

- Scenario Two: You plan to take a trip from Phoenix to Flagstaff over the July 4 weekend. You plan to leave July 1. Access AZ511.com to find out information that will help you to identify any road conditions that would affect your trip.

Two graduate assistants (observers) were familiar with the AZ511.com website, and they watched the users (older drivers) as they negotiated the site first in response to scenario one and then in response to scenario two. The observers noted the responses of the users to a prepared set of questions as well as their body language and also recorded the users' informal observations. Following the sessions with the computer, the older driver users participated in a group focus session directed by the project manager. They discussed their overall comments regarding the AZ511.com site and suggestions for possible modifications that would enhance its usability. The younger driver control group members followed the same procedure.

The primary emphasis in this report will be on the heuristic study involving the older mature drivers. The younger driver control group will be referenced only for comparative purposes.

DESCRIPTION of AZ511.com WEBSITE IN JULY, 2004

The users in the July 2004 heuristic study addressed a home page that was greatly changed from the version observed during the study conducted in March. In July a splash page featured three large bubbles—one with a picture of traffic, another with a picture of a camera, and the third with a picture of someone sitting at a traffic monitor. These bubbles rolled into place as the user entered the address AZ511.com. A large oval marked "Enter" was indicated within a color bar on the left side of the page. Upon pushing the word "Enter" the user moved to the home page from which he or she could select information on traffic speed on Phoenix area freeways, road closures and restrictions, cameras, or a discussion of related ADOT programs and services.

The early July version of the site included both the colored state map and counties that the users saw in the March heuristic test, and a new site with a state road conditions map showing major highways against a neutral single color background. The new site also included a horizontal bar with pull-down menus that would let the user refine his or her area of interest. One could select from pull-down menus labeled: "Quadrants", "Cities," or "Quick Reports." These pull down menus directed users to blow-up maps for sub-state regions (Quadrants), for cities in Maricopa County or Pima County (Cities), or for sub-sections of Maricopa County or Pima County (Quick Reports). The July users tried both the old and the new state Roadway Conditions map. The list of icons associated with the state Roadway Conditions map remained the same over the full course of the study.

HEURISTIC STUDY 2 INVOLVING OLDER DRIVER USERS

Scenario One: Driving from Mesa to Phoenix

Prior to starting the interactive session with scenario one the older drivers were each asked what information would be most important to them in planning their trip to

Phoenix from East Mesa. Their list included: location of accidents, lane closures, and obstructions affecting traffic flow.

Accessing the Internet site

All of the mature driver users successfully pressed "Enter," although one team found it difficult to find the Enter button. It was on the left side of the screen and colored brown, the same color as the splash page color bar. Once they got to the home page several teams had difficulty selecting the designator that would get them to information that would help in planning the trip from Mesa to Phoenix. One team clicked on the traffic image bubble and then clicked on "Closures and Restrictions." That took them to the state Roadway Conditions Map. Those that clicked on "Road Conditions" on the menu bar on the left side of the screen went directly to the Phoenix area freeway Traffic Map. Another team clicked on the camera link inadvertently and then clicked back to the browser.

Expectations and Observations regarding the Traffic Map

None of the older drivers expected that their search for roadway conditions in the Phoenix area would take them to a traffic speed map for the area. One of the older driver users wondered why the menu bar did not reference a freeway congestion (speed) map. Several users were not sure what the colors on the Traffic Map meant when they first saw it. They pointed out that there was no caption on the map in addition to the word "Traffic." There is a legend that explains the significance of the colors, but the users had to scroll up to find that since the legend did not fit on the screen at same time as the map. One user found the font and letter width in the legend difficult to read.

Several users wondered how current the map was. There is a clock at the top of the legend. One user team eventually found that, but they found it hard to read. A second team did not find the clock until the observer pointed it out.

Utilizing Cameras

The users were told in the prepared script that the site provided access to cameras showing the roadways, and they were asked to try to access the cameras. They quickly discovered that the real time video was not yet functioning. Several still cameras were working, but the list of cameras did not indicate which ones were functioning. Several users commented that the cameras seemed to be an extra feature that was tied to the rest of the website. One asked, "Why would you click on the camera bubble?"

The users had difficulty accessing the still cameras efficiently. One team of respondents tried unsuccessfully to find a link to cameras on the tool bar off the traffic map. Then they went back to the home page and clicked on the bubble that showed a camera.

Linking Cameras to the Traffic (speed) Map

One user team saw a red spot indicating a very congested point on the Traffic Map. They then went back to the screen that listed the location of cameras and tried to guess which camera matched that red spot on the map. When the observer pointed out that they could "mouse over" the Traffic Map and click and see camera images associated with several

locations, they were enthusiastic. The users wondered why there were no instructions that would alert them to that feature. Another team thought of adding little camera icons at locations where it was possible to see a camera image.

The third team found the camera links after being prompted by the observer; they wanted to know what direction the cameras were pointing in and at what time the still photos were taken. At the time they accessed the site there was no time stamp associated with the images. These users saw what looked like a congested area on the speed map, but the camera image associated with that location showed a fairly open highway.

Acquiring Information from the Traffic Map

Once older users became comfortable with the Traffic Map and were able to orient themselves and observe the color changes associated with increased congestion, they then tried to identify those locations. The current map shows the mountains in the area in relief and also labels major intersections. Those features helped with orientation. For these older drivers who had lived in the Phoenix area for years, those cues were sufficient to provide a general orientation. They did wonder whether the names of major cities could be included in the background to assist others less familiar with the area. Another user thought noting key exits would be helpful in identifying and hopefully avoiding areas with major traffic congestion.

As these users became more familiar with the Traffic Map, they wanted to use it to access more detailed information. One user team tried to find a link between the Traffic Map and the Roadway Conditions Map. They saw a red spot on the speed map and tried to find out the reason for that delay. However, they did not find a direct correlation between a "spot of red" on the traffic map and an icon and explanatory pop-up report on the Roadway Conditions Map.

Another user found the Quick Reports link associated with the Roadway Conditions map. He found that very helpful and wanted to have that linked with the Phoenix Traffic Map. With this combination he thought he could note traffic congestion on a freeway, find out the cause for that delay, and plan an alternative route as needed.

Others thought that it would be helpful to have some type of flashing icon to note accidents on the Traffic Map. Accidents frequently generate fairly short-term traffic delays. That could be important since, as the users noted, a traffic bottleneck marked in red on the traffic map before they left home might clear up before they got to that spot on the freeway.

Scenario Two: Driving To Flagstaff

You are traveling from Mesa to Flagstaff over the July 4 weekend and want to find out about possible travel delays.

Navigation

Several of the older driver users had difficulty trying to navigate the site to respond to scenario two. One female clicked first on the traffic bubble and then went to the search bar where she typed Flagstaff. That did not work, so a male respondent suggested just type "F." Since the search bar was not yet functioning, they then went to the sidebar where they tried first clicked on road conditions and got the traffic map again.

Another team also had difficulty. A female user tried all of the menu items on the left panel of the home page before she was prompted by a male user to click on "Roadway Conditions." That got them to the Traffic Map, and from there they clicked on "Restrictions and Closures." That got them to the state map.

Contrast between the Old and New State Roadway Conditions Maps

Since the original state Roadway Conditions Map with colors for each county came up as a first option on July 1, all users looked first at that site. They made observations much like the group in March about difficulty piecing together a trip from Mesa to Flagstaff by selecting blow-up maps for three different counties along route 17. They had difficulty following route 17 as they moved from one map to the next and did not see Flagstaff labeled on the map. Several noted the differences in the size and detail of the road designator and city labels in the different counties, and all had considerable difficulty reading the route labels.

The New State Map

When prompted to look at the new state Roadway Conditions Map that was also available on the site, all users commented that it was a great improvement over the older map. They felt the map size and clarity was much better. They liked the city labels on the map, although some thought the font could be clearer. One user felt that more cities like Payson and Winslow should be labeled. He pointed out that these cities are key destinations and landmarks.

Several suggested labeling state highways as well as the interstate highways since you might, for example, take highway 89A to Flagstaff. They noted that the highways were marked with different colors on the new map. This made it much easier to follow I-17. Several wanted a legend to explain the different colors.

Quadrant and Quick Reports "Blow-Ups"

Like the March users earlier, these older users wanted to zoom in on key locations along the way from Phoenix to Flagstaff. They really liked the idea of being able to click on "Quadrants" (blow-up images of sub-sections of the state) once that feature was pointed out to them by the observer. One user noted that this was much better than clicking on counties. Another user pointed out that there were more than 4 quadrants listed. It took a bit of guesswork to find out which quadrant pertained to the trip since there was no highlighting to indicate what portion of the state was included in each quadrant.

With prompting, the users also tried the Quick Reports related to the Phoenix area and really liked that concept. They felt that more detail was needed, however, for orientation. They suggested adding names of major streets or major landmarks. They also wanted the Quick Reports to indicate traffic accidents on major city streets. They pointed out that there was no point in exiting a freeway to avoid congestion only to find another traffic jam on parallel city streets. One user wanted this feature to link with the Traffic Map.

Road Condition Reports: Icons

The roadway conditions icons and the related pop-up reports had not changed since March. The comments of these users were, therefore, very similar to those in March. When the first team of users reached the state map, all the icons were checked and illuminated. The first impression was of a very busy map with too many little icons showing. Again they noted that too many of them overlapped particularly in the Phoenix area. One team figured out how to click off the unwanted icons and leave a more manageable number. Another team did not know how to click off unwanted icons until the observer pointed that out. That same team of users also did not know they could click on an icon to get the detailed report until the observer also pointed that out. They noted that there were no instructions on the site. When the third team accessed the same computer as the first team, they found all the icons were clicked off and they did not know to click on the ones they wanted until prompted by the observer. The definition for each of the categories of icons was also troublesome for these users, much as it had been in March.

Since there were several forest fires in the state on the July 4 weekend and road closures had been discussed in the news, one of the teams wanted to find out if the fires would delay a trip up north. They tried to figure out what icon would relate. They tried clicking on a variety of icons such as “Lane Restrict,” “Delay,” and “Road Closure.” Only with prompting from the observer did they find information on forest fire delays listed under “Obstruction.” That team suggested reducing the number of categories of icons, and using more general categories of icons such as: delay, closures, hazards, and other issues. They felt that that would not only make it simpler to use the map, but it would also simplify the map’s visual appearance.

Another team wanted to know about road closures and restrictions on the Phoenix area freeways. Since all the icons on the state map were illuminated, their first step was to try scrolling over four or five different icons to try to find out which ones related to the freeway closures. They did not try to work with the tool bar to limit the number of icons on the map and did not know that they could experiment with Quick Reports.

Ironically none of the older driver users pressed the “All Events” bar, which lists all highway closures and restrictions along with time and duration and provides all the road condition reports. When an observer asked why they did not push the All Events bar, a female user said she thought that it would list social events and baseball games that might generate traffic jams. One male respondent thought that if he clicked on it, all the icons that he had just clicked off would light back up again.

PARALLEL HEURISTIC STUDY WITH YOUNGER DRIVER CONTROL GROUP

Site Navigation

The younger drivers' experience was very similar to that of the older drivers. They had no difficulty entering the site, but had similar mixed experience with navigation when seeking information about the trip from Mesa to Phoenix. Two drivers clicked on "Roadway Conditions" on the left side of the home page and got to the Traffic Map; two clicked the traffic bubble and "Closures and Restrictions" and went to the state map; and a fifth driver tried the search bar with no success. Once reaching the Traffic Map two of the younger driver teams had considerable difficulty in finding the legend and determining what the map was actually showing and commented that there were no directions or captions on the map. Several wanted more zoom features. One younger driver, who was new to the area, had trouble orienting herself on the Traffic Map. She thought city labels would help.

Cameras

Much like the older drivers, these younger drivers did not find the camera feature helpful. One of them said that the cameras were "unnecessary," since they provided little extra information. When prompted about cameras, they all went back to the home page and clicked on "Camera Images" on the left menu bar. They commented that it would be helpful to link cameras with congestion hot spots, but none of them realized that they actually could "mouse over" the Traffic Map and associate the camera images with the map until the observer pointed that out. They also noted that the camera images were not stamped with a time and date.

Road Conditions Map

In terms of Scenario Two—the trip to Flagstaff—the younger drivers wanted to know about road closures, lane restrictions, accidents and delays. Much like the older drivers, they had difficulty following the trip to Flagstaff on the older state map where they had to click on the counties. They also much preferred the new map since it showed the whole trip and had a solid color background. They also wanted to zoom in on an area to find out more and clicked on the map rather than trying the tool bar and the list of Quadrants.

Two of these younger users did not know that the icons were interactive and they could click them on and off and get specific traffic reports until prompted by the observer. When they did click on the icons, they found the information on the pop-up reports helpful. Like the older drivers, one of these drivers tried clicking on a number of different icons to find out about forest fires before the observer pointed her to the "Obstruction" icon. Several of these users echoed the older drivers' call for fewer categories of information, since the definitions were not clear to them and so many categories seemed to overlap.

OLDER DRIVER USER ASSESSMENT

Much like the older driver users who reviewed the earlier version of the website in March, both these older drivers and their younger counterparts who reviewed the site at the beginning of July were enthusiastic about a website that would provide information about road conditions and would help in trip planning. They were well aware that the site that they saw was still evolving. The three older users who had reviewed the site both in March and again in July noted a number of modifications that had increased its usability, and also noted that there were indications that additional enhancements were underway. Gone was the cluttered look and excess information that they had commented on in March and the Enter button was a very welcome change.

Evolving Site

Those who had not used the earlier version were more frustrated by the "teasers" that they found on the evolving site. These "teasers" included: a search bar that was not operational, references to real time video cameras that were not available, references to information on camera direction that was not turned on, a substantial list of cameras that were not available, the suggestion of information on city road conditions that were not fully operational, and the large sections of the freeway system on the map that did not yet show speeds.

Roadway Conditions Map

Once they got into the new state Roadway Conditions Map, the repeat users found that a number of the features that they had suggested earlier for increasing usability were now included: the single color state map, colored highways, and the Quadrant and Quick Reports blow-ups. However, communication still seemed to be an issue. There was very limited guidance on site navigation, no captions on the maps, and no instructions informing users on how to access the interactive aspects of either the local or state maps. The older drivers, who had not used the site before, did not know that a number of interactive features were available, or how to use them.

The younger drivers in the control group experienced similar problems with navigation and in making use of the various interactive features on the site. However, while the older drivers continued to "play around" with the site and eventually found much of the information they needed, several of the younger drivers became frustrated when they could not get information quickly and efficiently. They said they would probably not take the time to use the site in the future. One more optimistic younger driver commented, however, "I'm sure I could make that work for me with some more practice. I was already beginning to feel more comfortable with it."

ASSESSMENT IN TERMS OF HEURISTICS

As is apparent, a website designed to communicate effectively with mature older drivers will likely address the needs of a broader audience as well. The observations of the July group of older mature driver users can be categorized in terms of the same four heuristic principles associated with positive user interface that were referenced with regard to the earlier heuristic exercise:

- Match between system and the real world
- Flexibility and efficiency of use
- Aesthetic and minimalist design
- Help and documentation

Heuristic: Match between System and the Real World

Connecting a new system to the real world experience increased its usability since users can build upon the familiar, learn new information efficiently, and remember how to use it again at another time. This is particularly important for older persons. The mature drivers who participated in the heuristic study in July were very familiar with the Phoenix area freeway system and had regularly used state highway maps to orient themselves on longer road trips. Hence they had no real difficulty in orienting themselves on the local area freeway map. The familiar mountains presented in relief on the map further assisted with orientation. Several did comment, however, that the Phoenix area hosts many winter visitors and tourists, and finding some way of labeling major area cities like Mesa and Phoenix might be helpful for them.

The older driver users enthusiastically welcomed the changes represented in the new state Roadway Conditions map. Now they could follow the whole route of I-17 at one time and easily read the label for Flagstaff. The map looked much more like the familiar state highway map. They noted that the new map showed routes in different colors, but those colors were not the same as those on standard highway maps. They did not see a legend.

They wanted a zoom feature and tried clicking on the new map as they would with MapQuest. That did not work, but when they were directed to the tool bar and "Quadrants," they were very enthusiastic. They thought that breaking up the state into regional units was much more realistic than counties. Several users, however, had very different ideas about what part of the state should be assigned to the various sub-regions (north central, central, etc.). All users pointed out that there were many more than four state quadrants on the list of choices.

When the older drivers asked for a zoom feature for the Phoenix area, the observer pointed out that Quick Reports were also available on the same brown tool bar. The districts included in the Quick Reports (East Valley, Phoenix, etc) corresponded with familiar sub-areas in the Phoenix metropolitan area and promised to give a closer look at travel restrictions and delays close to home. Several enthusiastically commented that this was just they type of information they were looking for. To increase orientation, however, the users wanted more local streets labeled. They also wanted more local incidents reported.

The list of icons on the left side of the state highway road conditions map had not changed since the earlier heuristic study in March. These users had the same problems as those in March in trying to determine what concerns were associated with each icon. The real world experience of these drivers differed and so did their suggestions for cataloging information. One of the older drivers, a professional librarian, suggested starting with a

limited number of categories and then stepping down to more detailed points in sub-categories. She felt that would be a more efficient way of presenting information about roadway conditions. These older drivers were primarily concerned about potential travel delays. A broad category of "delays" could have a number of sub-sets of causes for that delay—road maintenance, road restrictions, etc. These drivers felt if they clicked on a single icon marked "delay," they should be able to access all information regarding travel delays on a proposed route. Sub-sets of causes for delays could be available for those concerned about those issues.

Heuristic: Flexibility and Efficiency of Use

The revised web site that the users accessed in July certainly had more flexibility than the earlier version that users had explored in March. The July version offered the users a variety of approaches to accessing both roadway conditions and traffic information.

The Enter button took these users to a page where they could select Traffic or Roadway Conditions. Built in redundancy provided a variety of options for accessing information. Users could choose from a menu, a set of pictorial bubbles, or a colored band at the bottom of the page. The problem was that taking the various options did not lead directly to the same information.

While a click on Roadway Conditions on the menu brought up the Traffic Map, a click on the bubble brought up two options: Traffic, and Closures and Restrictions. Clicking Traffic led to the Phoenix area Traffic Map, while clicking on Closures and Restrictions led to the state highway map. To a first-time user concerned about possible travel delays between Mesa and Phoenix, it was not apparent that either of these terms would bring up a speed map for the Phoenix freeway system or a state highway roadway conditions map.

The new state Roadway Conditions Map also provided a number of options, indicating increased flexibility. The users could click on a set of desired icons relating to various travel limitations on the state. There were also a variety of options for a closer look at a specific area of interest. One could select a sub-state region (Quadrant), a city within Maricopa or Pima counties, or get a Quick Report for a subsection of either of the major urban areas - Phoenix or Tucson.

Efficiency in using these various options was impeded, however, first by not knowing about their availability and second by confusion about how to access them. Website efficiency can be measured in part by minimizing clicks and layers needed to find key information, as well as by minimizing time needed to absorb and use that information. The site did not provide instructions on how to use any of its key features, leaving users to browse and find the options themselves, rather than directing them quickly to key information.

Unfortunately, users who are in a hurry to get travel information could miss out on some very helpful dimensions of the site. For example, users would not know to mouse over the speed map and click for camera images. Although the mature driver users continued

to request more zoom features, they did not think to click on the brown toolbar above the state map to find the various options for a closer look. While clicking on a map is intuitive for someone who is a regular user of MapQuest, clicking on such a toolbar is not. Simple instructions would clearly make the site more user-friendly. The option of clicking next to icons to turn them on or off was also not apparent. Again, a simple instruction would be valuable.

Efficiency is also reduced by a lack of common definitions for the icons associated with the state map and the overlap between the categories. There are also some issues of definition with Quick Reports and Quadrants.

The new Traffic Map with the menu along the side was a clear enhancement both in terms of aesthetic and usability. Showing the mountains in relief also contributed to increased orientation of users. Certainly the new state Roadway Conditions Map was a major step toward minimal, functional design. The older driver users found that solid color background and clearer labels of both the highways and cities made it fully functional. Although there were some concerns about fonts used on the Traffic Map and the new state map, the primary concern was for labeling and appropriate legends. The time bars on both the Traffic Map and the Roadway Conditions Map are helpful in announcing real time, but are not easily read by the older drivers. Captions for the maps noting the frequency of updates would help to meet that need.

Issues with visibility and with distinguishing among the yellow icons on the state road conditions map continue. This is particularly difficult in the Phoenix area where icons cluster and website users are unable to sort them out efficiently. Since the default option on the road conditions site appears to be leaving all icon choices checked, the impression for someone opening the map for the first time is one of clutter and confusion rather than usability. Since each of these mature users only accessed the Roadway Conditions Map in one session, they did not benefit from another new feature that automatically opens for each user, the same screen (Quick Report, Quadrant, or state map) that he or she had selected in the previous session.

As in March, the users continued to have difficulty positioning the cursor precisely enough to click on an individual icon and get the related pop-up report.

Heuristic: Aesthetic and Minimalist Design

The mature drivers who reviewed the site in March commented that they would use a site that provided the information that they wanted in a simple and clear format. The new site attracts attention, but users wondered if communication was really furthered by a number of the new aspects in the design.

For example, the users wondered about the function and value of the popup color bands on the menu page of the website (see next page). The bubble balls are relegated to the top of the page to accommodate those bands that provide little additional information.

Concept for Color Bands with Instructions

One possibility would be to use those bands more effectively to convey key instructions on use of the website, as the above concept indicates. The suggestion is that more information should be displayed immediately on the screen. The first level of available information (traffic, closures & restrictions, still images, live video, and camera locations) should be continually displayed rather than popping up when clicked by the user. The second level of information (descriptions of the information being linked to) should be visible when the user "mouses over" them.

The Enter button was certainly a welcome change in this version of the site, but the lack of color contrast and positioning the button off to the lower left on the splash page raised concern. The following figure suggests an alternative location of the Enter button that responds to the users' difficulty in seeing it. This makes the whole page, or at least a large area on the page, a "clickable" link to the home page so users can quickly access the site.

Concept for Splash Page with "Enter" Clearly Indicated

Heuristic: Help and Documentation

This is an area that needs attention as the site evolves. The website did not provide instructions or even cues that would guide the users. During the second heuristic test the older drivers generally wandered through the site, clicking along to find out what features were available. As noted above this adds to inefficiency, but it can also lead to confusion and frustration.

When lost within the site, the users quickly went to the scroll bar to request help. Then they found that it was not yet functioning. The types of searches attempted by the older driver users varied considerably. Some tried to locate a city or route on a map. Others tried to find out which icon would show highway impacts of forest fires. One tried to find a list of road closures in the Phoenix area. Still others wanted guidance on where to find the speed map or how to use features on the new road conditions map.

Labels and simple instructions would add considerably to site usability. When the older drivers looked at the Traffic Map, they did not know what it was until they had scrolled up to the legend. They had difficulty finding, reading, and interpreting a clock especially since they did not know they were looking at a real time map. There was also no indication to users that they could mouse over the speed map to see pop-up notes giving key addresses and links to cameras.

On the Roadway Conditions map, a simple instruction like "Select and click desired icons" would offer clear guidance. This instruction, and starting with a default of no clicked icons, would help users to build a meaningful and a less-cluttered map. Simple instructions are also needed to guide users to try the tool bar with the options of "blowup" images of quadrants, cities, or quick reports areas. The user needs a simple instruction like "For a closer look at state or urban regions select and click options on the above brown tool bar."

Common definitions are essential for efficient navigation. The terms Quadrant and Quick Reports are becoming more familiar to users of 511 dial-up, where they offer users a closer look at a portion of the state or of an urban region. These terms are now associated with blowup images of the state Roadway Conditions Map on AZ511.com. The link between the two 511 media types offers an opportunity to better inform users and make them more comfortable with moving between the two forms of ATIS.

The terms do, however, need clearer definition in the context of a stand-alone interactive state roadway conditions map. Since it is possible to click on more than 4 sub-state regions, the term "State Sections" is more accurate than quadrants; it also will link them with the state map. The term "Urban Quick Reports" might help distinguish the blow-up maps available for sub-sections of Phoenix and Tucson from those available under the "cities" option on the same tool bar.

The users' definition of the word "event" clearly differed from that of the site designer. Some sort of simple instruction would help. ("Click for a list of all selected reports.")

The categories of information associated with the icons on the road conditions map continue to confuse users who find that the definitions for the various icons overlap. This issue was apparent among the younger drivers in the control group as well as the older drivers. A hierarchy of categories could direct users to a smaller group of icons representing overarching themes like travel delay or road maintenance. Subgroups could also be identified within the overarching categories.

A REVIEW OF OBSERVED RESPONSES TO RECOMMENDATIONS GENERATED FROM THE FIRST HEURISTIC EVALUATION

Heuristic: Match between System and the Real World

The site should be based upon the travel information needs of the traveling public:

- The overall functionality of the site should be adaptable to the travel agendas of individual users offering users quick access information by imputing the origin and destination of their trip.

  This remains a goal, but the new state Roadway Conditions Map is a helpful step in this direction.

- A high contrast highway map showing nothing but routes and major destination cities will allow users to orient themselves and note routes important to their trips

  The new state Roadway Conditions Map is a helpful response.

- Users only want to see the areas that are closest to their own homes. Easy to use zoom features can help. For Phoenix area residents a link can connect the freeway congestion map with the basic highway map.

  Although costly zoom functions are still not available, the new Quick Reports, as well as cities and quadrant "blow-up" options, are major steps forward as long as drivers know how to access them. The menu available at the side of the Traffic Map provides a helpful link, but more attention is needed to associating red congestion spots on the Traffic Map with explanations in the Quick Reports.

<u>Heuristic: Flexibility and Efficiency of Use</u>

The objective of the adaptable interface is for the site to become more user-friendly. The functionality of a site geared toward the purpose of serving individual users will help to alleviate the fragmentation from which the current site suffers:

- The site should be simple, with clear guidance on how to navigate through it to find desired information quickly.

  This still needs attention.

- Information not specifically related to pre-trip planning should not clutter the site.

  This has been addressed by grouping additional information that can be accessed using the Programs and Services bubble. The older drivers who clicked this bubble were, however, unable to sift through this material or read the small fonts used in the assortment of information available there.

- The hierarchy of information should be clear and the number of steps required to access basic traveler information should be minimized.

  Direct access through the menu bar is helpful. The other access options still need attention since they require selections among options for which definitions are unclear.

- Font choice and letter size should be quickly readable. Combinations of upper and lower case letters are shown to be easier to read.

  There are positive changes on the menu bar. Changes are still needed in terms of icons and roadway condition report pop-ups.

- The categories of icons available on highway condition map should be greatly reduced and the definitions of each category evident to all site users.
  This still needs attention.

- The icon graphics should be replaced by simple geometric shapes in contrasting colors.
  This still needs attention.

- Users should be provided with a simple menu on the home page providing an early clear choice in terms of information to access.
  The menu bar on the home page is much improved but choices available through the bubbles are not yet clear.

Heuristic: Aesthetic and Minimalist Design

- The site should emphasize visual and conceptual clarity.
  The visual clarity has been improved but conceptual clarity still needs attention.

- The development of an identity and aesthetics for the site should be secondary to the organization and presentation of information.
  This still needs attention.

- The site should be simple to use and easy to read.
  Legibility has improved, but guidance in navigation needs more attention.

- The maps should be neutrally-colored to eliminate visual confusion and should be shown as large as possible. Users should be able to freely zoom into maps.
  The new state Roadway Conditions Map is a major improvement. The usefulness of the blowup images in the Quadrants, Cities, and Quick Reports can be a less costly solution to the zoom, but only if there are clear instructions on how to use them effectively. They do not work intuitively.

- Information associated with identified problem areas should be provided in short, easy to read blurbs that relate directly to the traveler (e.g. construction May 10-15, one lane blocked, or high wind advisory).
  This has improved but still needs attention.

- The size of type/text should be large enough that it is comfortable to read and text should be a combination of caps and lowercase (most legible.)
  The legibility of labels on the Roadway Conditions Map is a major improvement as are options on the menu bar.

Heuristic: Help and Documentation

- Navigation through the site should be evident to users, but additional guidance on steps to using the site should be offered in a help button evident on the first page.
  This still needs attention. The Enter button helps but is not easy to find without a contrasting background color. A search bar is evident, but not yet functioning. That will be a major step forward in this direction.

- The 511 site should have a link to a tutorial/training manual for users to learn how to use the 511 phone system. This link should include a simple step-by-step guide to the phone system that users can print to take along in the car.
  Use of common terms between 511 and AZ511.com is a helpful step as is the use of common urban regions selected for Quick Reports. There still is no "how to" guide available.

- There should be consistency in the classification of information across both the 511 phone service and online service. At the very least, categories of information presented both on the phone and on the web site should be consistently labeled.
  This is underway.

- Explanatory information regarding 511 could be accessed through a link from the home page.
  The 511 logo appears on the Splash page, but it is not interactive. There is no clear source of information on 511 and how to use it.

- Newsworthy pieces on freeway expansion or major road closures (the type of information provided on variable message signs) could also link to the site.
  This information is available, but not immediately obvious to users. Users don't want to search for this key information.

SUMMARY

In summary, the mature drivers who participated in the heuristic study of the AZ511.com Internet site in July (particularly those who participated in the earlier heuristic study) were encouraged that the site is evolving toward increased usability. Legibility of the state Roadway Conditions Map is greatly enhanced. The introduction of blow-ups both for state sub-regions and for specific urban areas are major steps forward. With additional information flowing in from city traffic operations centers, the blow-ups on cities will help to meet the needs of the broad base of drivers who travel daily on city streets.

More effort is needed to enhance communication so that users will be able to take full advantage of these enhancements. The older driver users did not find a number of potentially helpful options without the aid of an observer. They were frustrated when the approach they tried independently or the selections that they made did not lead to desired information. Their experience was mirrored by the control group of younger drivers, for whom speed in use was a key consideration in interacting to the site. Activation of the

search bar will certainly help, but adding simple captions and instructions will greatly enhance usability.

In many ways the usability of the site can be gauged in terms of the efficiency and relative ease with which the drivers can find desired information. The effectiveness of the site can be gauged in terms of the appropriate decisions regarding travel plans. With appropriate travel information older drivers might opt for less congested and less stressful routes or reschedule trips to another time of day.

The expectation is that satisfied users will visit the site again. Increased attention to instructions and communication will not only increase the efficiency of older users, but others as well. The expectation is that increased usability will entice drivers to consult the site regularly before venturing out onto the highways.

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