Improving Mature Driver Safety
Task 6: Final Report with Recommendations

Submitted to:
PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

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August 2, 2010

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Introduction

National statistics show that older drivers will be increasingly exposed to crash risks because older adults are the fastest-growing segment of the U.S. population, and future generations of older drivers are expected to drive more miles per year and at older ages compared with the current older-driver cohort. The U.S. Census Bureau projects that the population of adults aged 65 and older will more than double, from 35.1 million people (12.4 percent of total population) in 2000 to 86.7 million people (20.7 percent of total population) by 2050.[1]

Drivers aged 65 and older currently make up almost 17 percent of Pennsylvania's licensed driving population. By 2020, the number of Pennsylvanians over 65 will increase 21 percent from recent levels, with a concomitant increase in the total number of mature drivers *and* their percentage of the total driving population.[2]

Certainly, the issue of an aging driving population is important in all states, but mature driver issues are particularly important in Pennsylvania. Compared to other states, Pennsylvania has the fourth largest state population, has one of the largest networks of roadways to maintain and modify, and is a largely rural state -- with citizens requiring transportation options.

There are a number of important issues when examining the issue of mature drivers and mobility – particularly age-related physical and behavioral changes that affect one's ability to drive. Recent research from a variety of sources (e.g., National Highway Traffic Safety Administration, Federal Highway Administration, American Association of Motor Vehicle Administrators, AAA Foundation for Traffic Safety, National Cooperative Highway Research Program [NCHRP], and others) clarifies the current, and future anticipated, characteristics of this mature driving population. The Older Adult Drivers fact sheet (Centers for Disease Control and Prevention; www.cdc.gov/ncipc/factsheets/older.htm) summarizes some of these elements:

- physical vulnerability -- mature drivers injured in motor vehicle crashes are more likely than younger drivers to die from their injuries;
- fitness to drive -- age-related changes in vision, cognitive functions, and physical impairments are increasing concerns;
- driving behavior -- mature drivers wear seat belts more often than any other adult age group, tend to drive when conditions are safest, and are less likely to be DUI when driving (note that Pennsylvania crash statistics for 2009 reveal that drivers age 65 and older were only slightly more likely to be belted than their younger counterparts).

Among older drivers, frailty begins to increase from about the age of 60. Because of increasing frailty, when older adults are in crashes, as drivers or passengers, they are more likely to be

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[1] General Accounting Office, *Older Driver Safety: Knowledge Sharing Should Help States Prepare for Increase in Older Driver Population,* Report to the U.S. Senate Special Committee on Aging, GAO-07-413, Washington, DC, April 2007
[2] Pennsylvania Department of Aging, website: http://www.aging.state.pa.us/aging/cwp/view.asp?A=560&Q=254754

injured or killed than younger people. Slower reaction time, reduced flexibility, hearing and vision limitations, and medical issues related to aging are implicated in older driver crashes. Yet even as these physical impairments or conditions may negatively affect mature drivers, other factors positively affect these same drivers. For example, older drivers have better driving records than other age groups. They have the benefit of many years of driving experience to apply to driving decisions. They have a particular motivation to retain driving privileges; that is, to sustain mobility. Mobility provides independence, convenience, autonomy, reliability, and supports an active lifestyle.

With an aware, motivated older driving population, education and training have been shown to enhance safety, sustain driving privileges, and retain cherished independence. A number of states through their Department of Transportation (DOT) or Department of Motor Vehicles (DMV) have created excellent learning venues specifically tailored to older drivers. National organizations such as AARP, AAA and others are also vital sponsors and stakeholders in the nation's driver education and training infrastructure. Community programs to support and facilitate mobility and transportation alternatives are critical links to maintain quality of life for older citizens. Learning from successful practices is an important consideration to promote safety for mature drivers.

Roadway design/technology engineering and licensing/enforcement practices are also critical components of mature driver safety. In *NCHRP Report, 500 -- Guidance for Implementation of the AASHTO Strategic Highway Safety Plan Volume 9: A Guide for Reducing Collisions Involving Older Drivers*, one of the key objectives is to "improve the roadway and driving environment to better accommodate the special needs of older drivers." Recommended improvements include advance warning signs, improved delineation and channelization, increasing size and letter height of roadway signs, all-red clearance intervals for signalized intersections, left turn aids (e.g., signalization, turning lanes), and improved traffic control in work zones. In addition, advances in vehicle technology such as seat positioning, hand controls, enhanced mirrors, and automotive electronics (vision enhancement, collision avoidance) hold promise for improved safety. Although prime responsibilities for new vehicle technologies rest with automobile manufacturers and regulatory bodies, state DOTs and DMVs have a significant role in outreach and promotion of technology improvements for older driver safety, including via Intelligent Transportation Systems initiatives.

Licensing practices allow competent older drivers to keep their driving privileges, and temporarily or permanently rescind privileges of those who lack capability or competence. Every state has policies concerning older driver practices such as license renewal, restriction, revocation and restoration, medical screening and the use of Medical Advisory Boards, knowledge and skills testing, and associated enforcement practices. Maximizing opportunities to use these systems to enhance older driver safety is a challenge for every DOT and DMV.

PennDOT's Mature Driver Improvement Program, the Physician Reporting system, and the Mature Driver Reexamination Program all have proven to be effective tools to allow competent mature drivers to retain their driving privileges, and to intervene and suspend privileges for those who cannot drive safely. Other community-based initiatives seek input from the mature driver population and others who are concerned about mobility and transportation options. PennDOT

continually makes roadway design safety improvements, many of which are intended to benefit mature drivers (e.g., clearview font and sign visibility enhancements, wider pavement markings), and offers mobility alternatives such as the Shared Ride and Free Transit programs.

In light of PennDOT's substantial and multi-pronged investments in safety improvements and initiatives, assessment of their benefits in the context of a comprehensive evaluation of the mature driver population is timely and has the potential to guide future investments. This report summarizes this evaluation, including findings of an extensive literature review (Task 1a), a survey of practices of other states (Task 1b), analyses of PennDOT's databases (Task 2), proceedings of a Mature Driver Symposium (Tasks 3 and 4), and improvement recommendations and implementation plans that followed from these tasks (Tasks 5 and 6). Figure 1 shows the flow of project activities. A summary of each major task area is provided below.

TASK 1a: Literature Review

A literature search on factors that influence mature driver safety was conducted. The search included such literature domains as gerontology, psychology and human factors, safety and crash prevention, engineering and roadway design, adult education, and law enforcement, in domestic and international books, journals, and technical reports. A full report is available separately. Bullet points below summarize some of the highlights and major findings.

Sources
- PsycInfo (American Psychological Association)
- Web of Science
- Transportation Research Board (TRB) Research in Progress Database
- TRB Transportation Research Information Services (TRIS)
- PubMed
- ProQuest-CSA
- Google
- … and more, both domestic and international

Citations
- Summary of findings: 21 topics & subtopics
- Abstracts included for 543 studies & reports

Abilities that Decline with Age
- **Physical abilities**: strength, flexibility, range of motion, and reaction time
- **Perceptual abilities**: night vision, movement perception, and glare sensitivity
- **Cognitive abilities**: speed of information processing, memory, spatial visualization, and parallel processing (tasks that require divided attention or attention switching)

Declining Abilities and Driving
- To compensate for slower cognitive processing, older adults reduce driving speed
    - Exercise helps to maintain strength, flexibility, range of motion, and reaction time
    - Drivers with chronic medical conditions have greater risk of violations and crashes
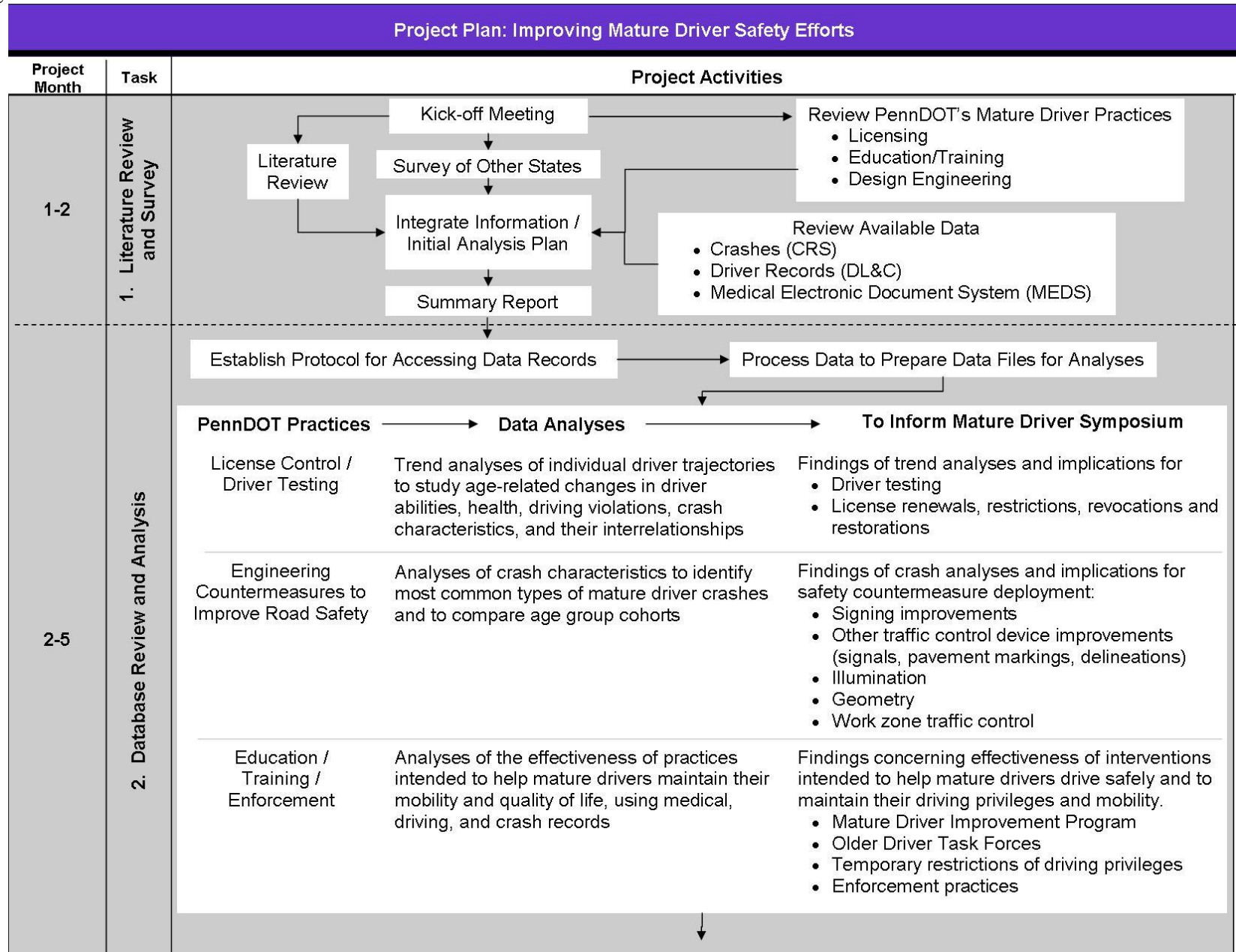
Figure 1.

Project Plan: Improving Mature Driver Safety Efforts

Project Month	Task	Project Activities

1-2 — **1. Literature Review and Survey**

- Kick-off Meeting
- Literature Review
- Survey of Other States
- Integrate Information / Initial Analysis Plan
- Summary Report

Review PennDOT's Mature Driver Practices
- Licensing
- Education/Training
- Design Engineering

Review Available Data
- Crashes (CRS)
- Driver Records (DL&C)
- Medical Electronic Document System (MEDS)

2-5 — **2. Database Review and Analysis**

Establish Protocol for Accessing Data Records → Process Data to Prepare Data Files for Analyses

PennDOT Practices → Data Analyses → To Inform Mature Driver Symposium

PennDOT Practices	Data Analyses	To Inform Mature Driver Symposium
License Control / Driver Testing	Trend analyses of individual driver trajectories to study age-related changes in driver abilities, health, driving violations, crash characteristics, and their interrelationships	Findings of trend analyses and implications for • Driver testing • License renewals, restrictions, revocations and restorations
Engineering Countermeasures to Improve Road Safety	Analyses of crash characteristics to identify most common types of mature driver crashes and to compare age group cohorts	Findings of crash analyses and implications for safety countermeasure deployment: • Signing improvements • Other traffic control device improvements (signals, pavement markings, delineations) • Illumination • Geometry • Work zone traffic control
Education / Training / Enforcement	Analyses of the effectiveness of practices intended to help mature drivers maintain their mobility and quality of life, using medical, driving, and crash records	Findings concerning effectiveness of interventions intended to help mature drivers drive safely and to maintain their driving privileges and mobility. • Mature Driver Improvement Program • Older Driver Task Forces • Temporary restrictions of driving privileges • Enforcement practices

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Figure 1 cont'd.

Project Plan: Improving Mature Driver Safety Efforts (cont'd)		
Project Month	**Task**	**Project Activities**

6-7	3. Mature Driver Symposium Materials	**Prepare Mature Driver Symposium Materials**
		• Agenda
		• Findings of Literature Review, Survey of other States, and Data Analyses concerning:
		  • License Control / Driver Testing
		  • Engineering Countermeasures to Improve Road Safety
		  • Driver Education, Training, and Enforcement

8	4. Mature Driver Symposium	**Support Activities for Mature Driver symposium** • Present findings of Tasks 1 & 2 • Assist in leading discussion of findings • Document discussions and implications for recommendations
9-10	5. Draft Report and Recommendations	**Prepare draft report summarizing Tasks 1-4** • Summary of project activities • Recommendations addressing license control / testing, engineering countermeasures and roadway improvements, and driver education / training / enforcement • Implementation plan for recommendations
10-12	6. Final Report with Recommendations	**Final Reports with Recommendations** • Summary of project activities • Recommendations addressing license control / testing, engineering countermeasures and roadway improvements, and driver education / training / enforcement • Implementation plan for recommendations • Guidelines and suggestions for evaluating the effectiveness of safety countermeasures deployed • PennDOT Research Executive Summary • Oral presentation with annotated PowerPoint slides

- Although physician reporting systems generate some controversy, their use reduces crashes

Mature Drivers and Crashes
- Crash incidence for older drivers is predicted by:
  - previous crashes
  - driving exposure
  - night driving
  - past moving violations
  - cognitive and vision deficiencies
- Older drivers crashes are more likely to be:
  - angle collisions
  - left-turn collisions
  - intersection collisions
  - daylight hour collisions
- Older adults in crashes, as drivers or passengers, are more likely to be injured or killed than younger people

Mature Drivers & Safety Countermeasures
- Countermeasures to assist older drivers:
  - roadway geometry
  - signs
  - signals
  - pavement markings
  - lighting
  - work zones
- Most countermeasures for older drivers have benefits for the entire driving population

Effectiveness of Mature Driver Training Programs
- Studies promote the value of education programs that encourage community, family, and social services involvement with older drivers
- Education should target men and women differently (e.g., men resist behavior change and exhibit riskier driving)
- Evidence that physical and visual perception retraining improves driving skills encourages further research
- Older drivers who attend education programs are more concerned with maintaining mobility than evaluating their own driving safety

Mature Drivers and Mobility
- For older adults, mobility is central to quality of life, identity, and independence
- Despite increasing frailty, many older adults continue to drive; self-rated health influences driving cessation more than actual medical conditions or perceptual limitations
- Driving cessation is a transitional process; many older drivers self-regulate (no night driving, shorter trips, etc.)
- Aging drivers may need help transitioning to ex-driver from family members, physicians and other front-line professionals, and policy makers

Problem Drivers
- Age-based programs to identify problem drivers have no safety benefits; community-based referrals are effective (family, friends, physicians)
- States with medical reporting (mandatory and voluntary) revoke the licenses of many reported drivers, and crashes are reduced

Vehicle Adaptations and Advanced Technology
- Vehicle designs and technologies are rapidly evolving, challenging drivers to adapt, particularly older drivers
- Advanced automotive technologies (e.g., navigational displays) can improve safety and mobility if designed in accordance with the abilities of older drivers

Transportation Alternatives
- Even when people can no longer drive themselves, they often avoid public transit, perhaps due to the fixed routes of these services
- Door-to-door transportation may be the only acceptable alternative for many ex-drivers, although this presents a significant challenge for public policy

TASK 1b: Survey of Other States

A survey/questionnaire to collect information from other state Departments of Transportation (DOTs) and Departments of Motor Vehicles (DMVs) was conducted. The purposes of this survey were to identify successful mature driver practices used by other agencies directed toward: (a) improving safety and mobility, and (b) reducing crashes and fatalities.

PennDOT determined that the DMV Survey would be distributed via the American Association of Motor Vehicle Administrators (AAMVA). AAMVA requires that surveys have no more than three or four questions. To accommodate this requirement, the DMV Survey was conducted in two parts, a short Part 1 survey via AAMVA, followed by a longer Part 2 survey distributed to Part 1 respondents. The DMV Survey Part 1 was distributed by PennDOT via AAMVA on October 1, 2009. Distribution of Part 2 of this survey began on October 13, 2009. The DMV survey addressed strategic planning for older drivers, older driver outreach, and licensing practices. The DOT Survey was distributed by PennDOT via AASHTO-RAC on October 14, 2009. This survey addressed strategic planning for older drivers, countermeasures implemented to improve older driver safety, and use of crash data to determine locations for countermeasure installation.

The response rate for the DMV Survey Part 1 was 47% (30 completed surveys out of 64 distributed, to the 50 U.S. states, the District of Columbia, and 13 Canadian provinces and territories). The response rate for the DMV Survey Part 2 was 66% (29 Part 2 surveys were distributed and 19 were completed). The response rate for the DOT Survey was 38% (50 surveys distributed and 19 completed surveys).

A full report is available separately. Bullet points below summarize some of the highlights and major findings of this report.

Policies
- National and state policies addressing older driver issues are receiving greater awareness due to increasing life expectancy and greater numbers of older drivers
- Federal legislation requires all state DOTs/DMVs to have a strategic highway safety plan; mature driver issues are not specifically required
- PennDOT's strategic highway safety plan addresses older road user safety and mobility
- Federal guidelines are helpful, yet such tools are truly guidelines and are used at each state's discretion

Planning
- Planning activities within DMV/DOTs *and* coalitions with partner organizations are important. Pennsylvania and 15 other states/provinces (of 24 survey respondents) have:
  - other mature driver planning activities in lieu of or in addition to addressing mature driving issues within their strategic highway safety plans
  - coalitions(s) to address safe mobility for older citizens

Engineering Countermeasures
- Most engineering safety countermeasures benefit the entire driving population, not only older drivers
  - Survey respondents reported the greatest barriers to implementing countermeasures:
    - Lacking staff with expertise to implement
    - Lacking funding to implement
    - Actual or perceived lack of importance of the issue
- PA has implemented most of the countermeasures in the FHWA *Design Handbook for Older Drivers and Pedestrians*

Successful Practices of Other States
- Confidential reporting of impaired drivers by physicians, family members, and law enforcement
- Maintaining good relationships among the medical community, law enforcement, DMV licensing and safety staff
- Medical program based on impairment, not age; mandatory reporting of "severe and uncontrollable impairments"
- Comprehensive information available to mature drivers and families – licensing, mobility options, education, brochures

TASK 2: Review and Analysis of PennDOT's Databases

Background

The researchers drew upon the research literature, practices of other states determined by the Task 1 survey, and information obtained about PennDOT's practices concerning mature drivers to formulate research questions about the effects of various factors on mature driver safety. These questions were tested using quantitative data obtained from the following three sources:

1. **Driving records**: Pennsylvania has nearly 1.5 million licensed drivers aged 65 and older. PennDOT's driver records database contains information for these drivers, and these records describe many years of individual drivers' histories, including license classes, license renewals, violations, associated points, and sanctions (and dates of each transaction). Note that PennDOT only records *convictions* for violations, which we refer to as violations or violations committed. In fact, drivers commit violations that are not detected by law enforcement, and not all violations charged result in convictions. The reported numbers thus understate actual violations. PennDOT provided driver records for all drivers with a driver license number ending in '5'. This dataset contained records for approximately 1.6 million drivers. After extracting drivers with current (for the 1996 – 2008 period) and valid licenses, the dataset contained records for approximately 870,000 drivers. A random sample of 100,000 drivers was drawn from this group to provide a more manageable dataset for several of the analyses that were undertaken.

2. **Crash records**: Crash records include details such as the date of crash, number of vehicles involved, crash characteristics such as location, time of day, weather, type of crash (e.g., left turn, right turn, angle, hit fixed object, rear-end collision), and driver actions (e.g., following too closely, speeding, failure to stop, improper lane changes). PennDOT provided all crash records for the 1997 – 2008 period.

3. **Medical records**: The Medical Electronic Document System (MEDS) includes details of reported medical conditions such as seizure disorders, loss of consciousness problems, vision deficiencies, and loss or impairment of limbs. PennDOT provided all MEDS records from 1997 through July 2009.

   Pennsylvania's Medical Reporting Criteria

   Physical Criteria:
   - Visual acuity less that 20/70 (after correction)
   - Seizure disorder
   - Unstable diabetes
   - Vascular insufficiency with any of the following in the past 6 months: syncopal attack, vertigo, paralysis, vision changes, loss of consciousness for unknown reason
   - Loss or impairment of joint or extremity

- Rheumatic, arthritic, orthopedic, muscular, vascular or neuromuscular disease expected to last longer than 90 days
- Use of any drug or substance that is known to impair skill or function

Mental Criteria:

- Cognitive Impairments
- Inattentiveness to the task of driving because of, for example, preoccupation, hallucination or delusion
- Contemplation of suicide, as may be present in acute or chronic depression or in other disorders
- Excessive aggressiveness or disregard for the safety of self or others or both, presenting a clear and present danger

All records were identity-masked (i.e., name, address, SSN, etc., were omitted). A database was created to organize and store all relevant information for a given driver, so that data could be extracted in formats suitable for statistical analyses. Analyses were conducted to answer several specific research questions that collectively elaborate the general theme of mature driver safety (a separate report is available with full details of the review and analysis of PennDOT's databases).

After the linking the various data sources, the following analytic approaches were used to address the primary research questions:

Descriptive Statistics and Frequency Distributions: Initial analyses of driver, crash, and MEDS records included descriptive statistics and frequency distributions. For these analyses, a random sample of 100,000 drivers (the 100K sample) was drawn from the driver records dataset, and a data file was created that included the driving, MEDS, and crash records for these drivers. These analyses: (a) provided the researchers with a deeper understanding of the databases; (b) revealed age-related trends in reported medical conditions, driving violations, and crashes; and (c) helped to identify any anomalies in the data (e.g., apparent gaps in records or other missing data, coding of variables that may have changed over time).

Survival Analysis: This analytic approach was used to test time-dependent relationships between driver age and reported medical conditions on risk of violations and crashes during the period 1997-2008. Survival analyses were conducted using data for all drivers with (and without) reported MEDS conditions. These analyses allowed the researchers to examine the effects of age, medical conditions, and their interactions on driving safety.
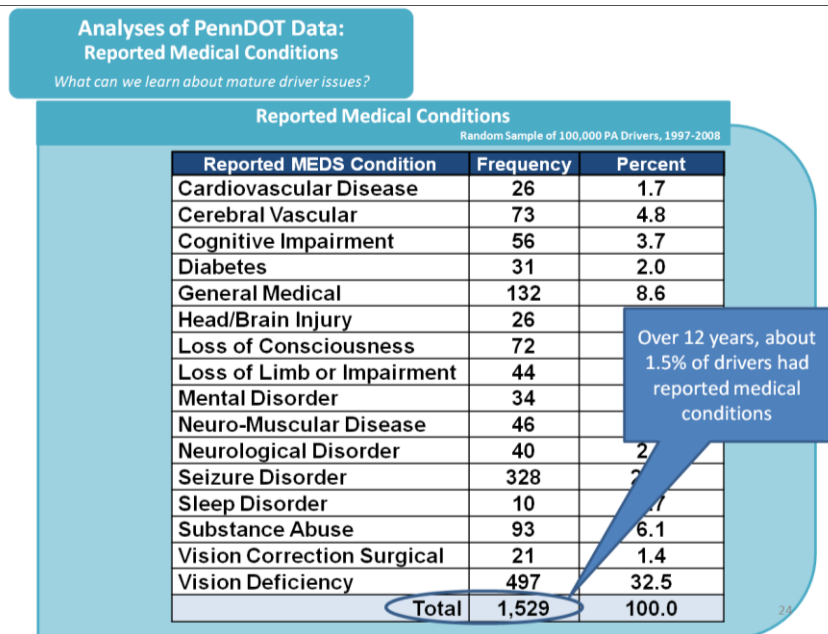
Crosstab Analysis: These analyses allowed the researchers to examine factors associated with mid-block and intersection crashes, including driver age, injuries to drivers and others involved in crashes, illumination conditions, types of collisions, driver actions, direction of movement of vehicles, presence of traffic control devices, and others. Crosstab analyses were conducted using records for crashes that occurred during 2008. These analyses revealed characteristics of crashes that were particularly associated with

older drivers, and provided insights into engineering countermeasures that could mitigate these crashes.

**Selected Findings**

Analyses of Medical Conditions

Frequency distributions related to reported MEDS conditions for the 100K sample of drivers are shown below. Because several conditions have very similar labels, some were grouped into categories. The chart shows the numbers of reported drivers for each type of medical condition and the associated percentages. The most commonly reported MEDS condition is *vision deficiency* (32.5% of the total), followed by *seizure disorder* (21.4% of the total). Among the least commonly reported Meds conditions were *cardiovascular disease* (1.7%), *head/brain injury* (1.7%), *vision correction surgical* (1.4%), and *sleep disorder* (0.7%).

Analyses of PennDOT Data:
Reported Medical Conditions
What can we learn about mature driver issues?

Reported Medical Conditions
Random Sample of 100,000 PA Drivers, 1997-2008

Reported MEDS Condition	Frequency	Percent
Cardiovascular Disease	26	1.7
Cerebral Vascular	73	4.8
Cognitive Impairment	56	3.7
Diabetes	31	2.0
General Medical	132	8.6
Head/Brain Injury	26	
Loss of Consciousness	72	
Loss of Limb or Impairment	44	
Mental Disorder	34	
Neuro-Muscular Disease	46	
Neurological Disorder	40	2
Seizure Disorder	328	2
Sleep Disorder	10	7
Substance Abuse	93	6.1
Vision Correction Surgical	21	1.4
Vision Deficiency	497	32.5
Total	1,529	100.0

Over 12 years, about 1.5% of drivers had reported medical conditions

A series of survival analyses addressed the questions of *whether* and *when* medical conditions, crashes, and violations occurred. Survival analyses are particularly well-suited to studies of events that unfold over time and account for drivers for whom the event did not occur. Survival analyses were conducted to estimate the likelihood of occurrence of medical conditions according to driver age at the time of the report of the medical condition, gender, and the interactions between age and gender. It should be noted that the incidences of reported medical conditions (base rates) were low, so a higher likelihood of occurrence does not imply large numbers of reported cases. A general pattern emerged for *any medical conditions, cognitive impairment, general medical condition, cerebral vascular*, and *vision deficiency*. These medical conditions became increasingly common with age. For the conditions of *seizure* and *substance abuse*, no age cohort effects were found; older drivers were *not* at greater risk for these conditions than their younger counterparts. Findings concerning gender were all significant and positive, indicating that males were more at risk of all medical conditions than females. The

strongest gender effect was for *substance abuse*; males were almost four times more likely to be reported as having substance abuse problems than females.

As detailed in the full report, gender by age cohort interactions were tested to determine whether drivers with particular combinations of characteristics are especially likely to experience the event. An example analysis is shown in the figure below, which depicts the effects of an age by gender interaction on the likelihood of having been being reported for any medical condition. As shown, as time progressed from the beginning of the observation period (January 1, 1997) through the next 12 years, drivers in older age cohorts, particularly males, were increasingly likely to have a reported medical condition (of any type) compared to their younger (age 39 - 64) counterparts.
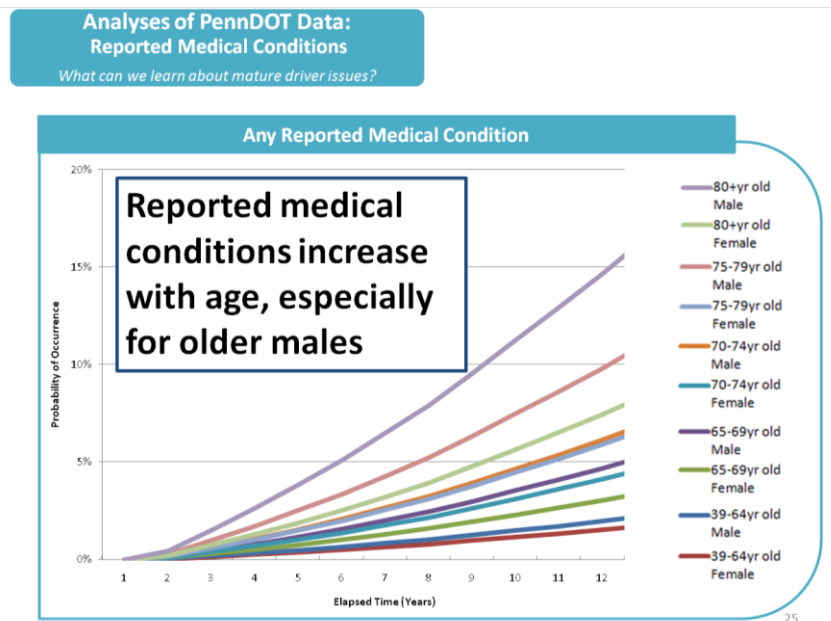
Analyses for Crashes

The following chart presents the numbers of drivers with crashes in 2008 broken down by driver age (at the time the crash was reported). In addition to observed frequencies, for each age cohort the percent of the total crashes and the cumulative percentages are reported. Drivers involved in most crashes (about 80% of the 178,911 drivers involved in crashes in 2008) were under age 55. Among older drivers, the percentages of crashes decreased steadily for each successive age cohort. With increasing age, drivers were increasingly less likely to be involved in a crash. Note that because annual miles per driver are not recorded, it is not possible to adjust these statistics to determine a crash probability *per miles driven*.

With increasing age, older drivers account for increasingly smaller proportions of crashes

Drivers with Crashes in 2008

Driver Age Cohort	Frequency	Percent
< 55	143,847	80.4
55-59	10,621	5.9
60-64	7,878	4.4
65-69	5,287	3.0
70-74	3,855	2.2
75-79	3,165	1.8
80-84	2,581	1.4
85 +	1,575	0.9
Total	178,809	100.0

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Survival analyses were conducted to examine the effects of age and gender (and their interaction) on the likelihood of crashes during the period 1997-2008. For example, the figure below shows the driver age by reported vision deficiency interaction for 4-way intersection daylight crashes for the older (age 65 and older) cohorts with vs. without vision deficiency compared to their younger (age 64 and younger) counterparts. The probability of an intersection daylight crash was substantially greater for older drivers with vision deficiency than for the other cohorts. Approximately 9% of older drivers with vision deficiency were involved in an intersection daylight crash by the end of the observation period. This is substantially greater than the 5% of older drivers without a vision deficiency who were involved in this type of crash. Vision deficiency also increased the likelihood of a crash for younger drivers, but this effect was not nearly as large as for older drivers.

Crashes 1997-2008

Intersection Daylight Crashes x Driver Age & Vision Deficiency

Vision deficiency almost doubles the likelihood of an intersection daylight crash among older drivers

Older with Vision Deficiency

Younger with Vision Deficiency

Younger No Vision Deficiency

Older No Vision Deficiency

(y-axis: Probability of Occurrence, 0.0% to 10.0%; x-axis: Elapsed Time (Years), 1 to 12)
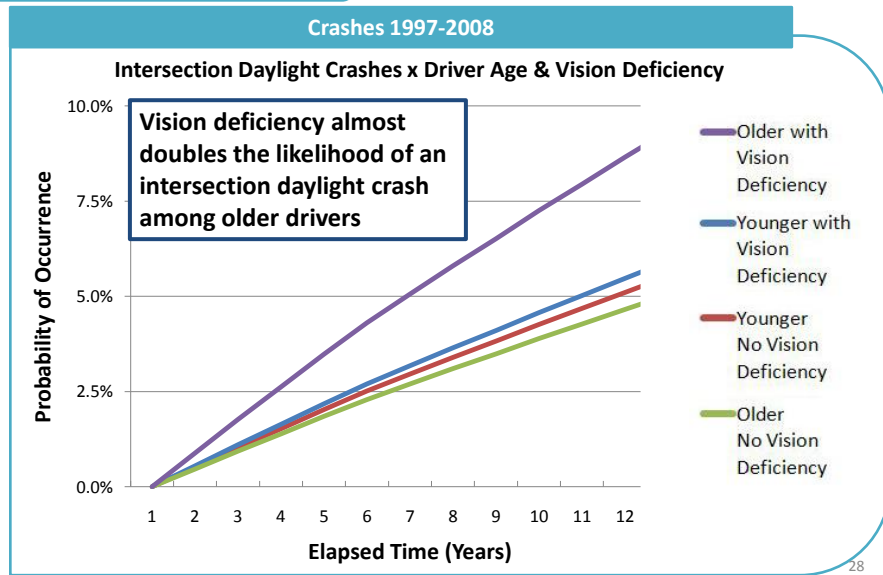
A series of crosstab analyses were conducted to examine associations between driver actions and types of crashes. Crosstab analyses were conducted using records for crashes that occurred during 2008. These analyses (summarized in the figure below) revealed characteristics of crashes that were particularly associated with older drivers, and provided insights into engineering countermeasures that could mitigate these crashes.

Driver Actions and Types of Crashes

Driver actions common among
Younger Drivers (under 65)

Crash types common among
Younger Drivers (under 65)

Driver actions common among
Older Drivers (65+)

Crash types common among
Older Drivers (65+)

contribute to

- Improper or careless turn
- Proceed w/o clearance
- Run stop sign
- Run red light
- Improper entrance to highway
- Speeding

- Rear-end
- Head-on
- Angle
- Sideswipe
- Hit fixed object
- Hit pedestrian
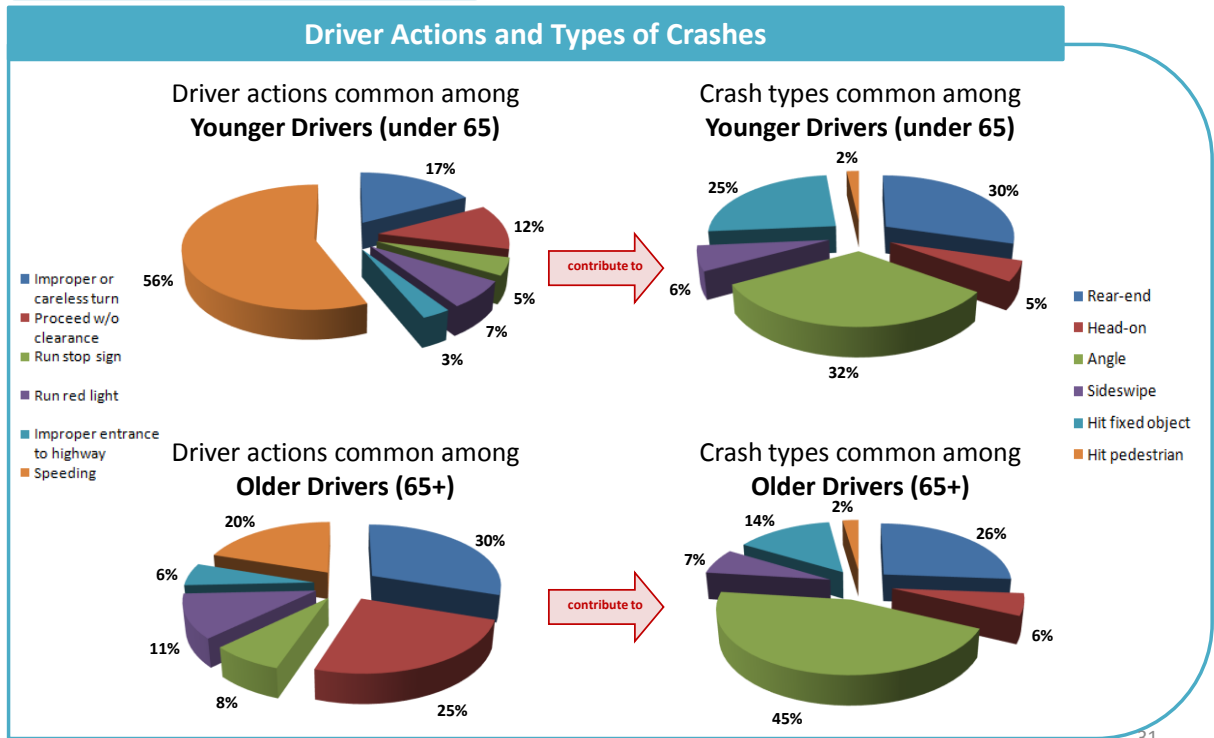
Based on the data shown above, countermeasures that address particular issues (e.g., turning movements at intersections, judgment of gaps at intersections, traffic signal head placement and conspicuity, stop sign placement and conspicuity, pedestrian and crossing location visibility) may help reduce the incidence of crashes among older drivers.

Analyses for Violations

The chart below presents the numbers of drivers for several major categories of violations and the associated percentages. The most common violation type was *speeding* (41.6%).

All PA Drivers' Driving Violations in 2008

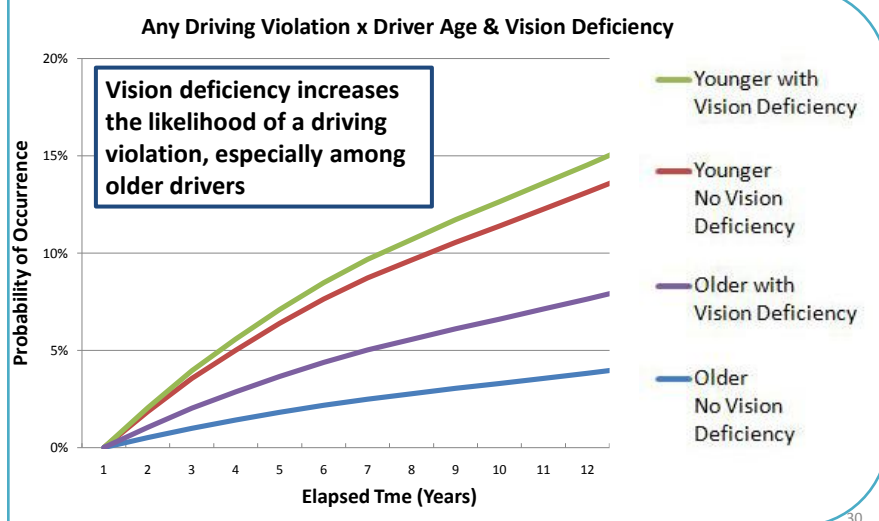| Violation Category	Frequency	Percent
License Restriction	11655	19.6%
Failure to Stop-Yield	7552	12.7%
Speeding	24663	41.6%
Improper Driving	8422	14.2%
DUI	7045	11.9%
Total	59337	100.0%

Speeding is by far the most common driving violation

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Survival analyses revealed that younger drivers were more likely to commit a driving violation during the 12 years of observation (1997-2008) than older drivers. Vision deficiency also increased the probability of a driving violation, especially for older drivers (4% of older drivers without vision deficiency violated, whereas 8% of older drivers with vision deficiency violated; see figure).

Analyses of PennDOT Data:
Medical Conditions & Violations
What can we learn about mature driver issues?

Violations 1997-2008

Any Driving Violation x Driver Age & Vision Deficiency

Vision deficiency increases the likelihood of a driving violation, especially among older drivers

Younger with Vision Deficiency

Younger No Vision Deficiency

Older with Vision Deficiency

Older No Vision Deficiency

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TASKS 3 & 4: Support Activities for the Mature Driver Symposium

An important component of the research project was the Mature Driver Symposium. Goals of the Symposium were to:
- Inform participants of the evidence and current practices concerning mature driver issues
- Promote a constructive dialogue with participants to yield actionable insights and potential avenues of progress
- Gather suggestions from participants to inform a set of actionable recommendations and improvement strategies and plans

Symposium highlights included presentations by invited speakers and breakout sessions with facilitated discussions among participants. Breakout session topics were:

- Aging, Medical Issues, & Driving Skills
- Crashes and Safety Countermeasures
- Mobility, Quality of Life, & Driving Cessation
- Policies and State Practices

A working lunch featured a keynote speaker and opportunities for informal conversation and networking. Of approximately 70 individuals invited to attend the Symposium, there were 63 attendees representing a diversity of backgrounds, interests, and expertise.

A full report is available separately. It summarizes Symposium planning and preparation activities, the Symposium itself, and Symposium outcomes.

TASKS 5 & 6: Final Report with Recommendations

This report combines the discussions and suggestions from the Mature Driver Symposium and the data-driven research that was conducted in Tasks 1 and 2 to arrive at recommendations for PennDOT's review. Implementation plans are also considered.

PennDOT's attention to mature driver safety is directed toward the dual objectives of maintaining mobility of Pennsylvania residents as they age and improving safety for all users of Pennsylvania's roads. Our recommendations and implementation plans address these topics: (a) older Pennsylvanian mobility needs and options; (b) medical condition reporting and driving skills assessment; (c) mature driver policies and practices; (d) engineering safety countermeasures; and (e) data and metrics. Within each topic area, broad recommendations are presented along with background explanation and supporting rationale. Also provided are specific sub-recommendations that offer practical suggestions and address (where possible) such issues as the effectiveness, use, resources, and/or time required to implement the recommendations.

OLDER PENNSYLVANIAN MOBILITY NEEDS AND OPTIONS

Recommendation 1: *Clarify the current and track changes in the ongoing mobility needs and actions of older citizens.*

Older drivers tend to self-regulate their driving, reducing miles driven and restricting driving to daylight hours and good weather conditions as they get older. However, many older individuals continue to drive beyond the point when they can do so safely because they need to carry out activities of daily living, they may have few acceptable transportation alternatives, and they may overestimate their capacity to drive safely. Assumptions underlying programs such as Free Transit and Shared Ride are that older drivers will use these alternatives if they are aware of them. To help increase the effectiveness of these programs and to aid in creating other strategies to enhance older citizen safety and mobility, it would be beneficial to have a reliable and current understanding of older citizens' mobility needs, preferences, choices, and actions. Specifically:

   1a. Conduct Older Pennsylvanian Mobility Surveys on an ongoing basis, by partnering with AARP, AAA, Seniors for Safe Driving, and other organizations that provide driver improvement courses or other services to older citizens, and by partnering with PennDOT districts via Safety Press Officers, task forces, etc. Surveys should include both focus groups and questionnaires – note that questionnaires should be based on findings of focus groups, addressing topics such as:

   i. Modes of transportation used in a typical week, frequency of use of each mode, and usual purposes of travel using each mode.
   ii. Perceived availability, accessibility, acceptability, adaptability, and affordability of alternatives to driving, including Free Transit and Shared Ride Programs, transportation provided by family members, friends, or community services (church groups, senior centers), and any other alternative to driving used at least once per month.
   iii. What an older driver would do for mobility if driving were no longer an option.
   iv. Whether older citizens have planned for their future mobility needs, and, if so, how they expect their needs to be met.

   1b. Upon license renewal, request that drivers age 65 and older complete a brief Mobility Survey that asks about modes of transportation used in a typical week (including personal vehicle), awareness of and opinions about transportation alternatives, whether options currently available meet their needs, and plans for meeting their future mobility needs.

   1c. Conduct these surveys and focus groups on an ongoing basis, and compile responses to create an annual "Mobility Needs and Actions of Older Pennsylvanians" report for use in planning and resource allocation decision-making.

   1d. As applicable, make the annual "Mobility Needs and Actions of Older Pennsylvanians" report available to PennDOT partners.

Recommendation 2: *Work within PennDOT to explore a range of possible alternative transportation options for older individuals.*

When older individuals are no longer able to drive safely, many seek alternative sources of transportation. A report commissioned by AAA noted that many older Americans cannot access ordinary forms of public transportation, and profiled 236 Supplemental Transportation Programs available throughout the U.S. that fill the gap between personal and public transportation (The Beverly Foundation [2001]. *Supplemental Transportation Programs for Seniors*. AAA Foundation for Traffic Safety.). We recommend evaluating current and potential future transportation alternatives against the criteria outlined by Molnar and colleagues: "…the effectiveness of a transportation service is the extent to which it is available, accessible, acceptable, adaptable, and affordable" (Molnar, L.J., Eby, D.W. & Miller, L.L. [2003]. *Promising approaches for enhancing elderly mobility*. Ann Arbor, MI: University of Michigan Transportation Research Institute.) Although Pennsylvania's current programs, such as Shared Ride and Free Transit, benefit many individuals, these services can be further enhanced, as can other transportation options available to seniors. We therefore recommend 1) a close examination of possible alternative transportation options – partnering with community agencies, volunteer groups, and businesses as needed – to identify new and document the current formal and informal programs that can supplement the existing options for older Pennsylvanians, and 2) that PennDOT, in conjunction with partners, employ a variety of communication strategies and materials to inform this segment of mature drivers. Older individuals who are unfit to drive may remain on the road because they feel they have limited mobility options. By enhancing the effectiveness of transportation alternatives, these individuals will choose to stay off the road, which should result in fewer violations and crashes involving older drivers.

2a. Partner with other PennDOT offices, community agencies, volunteer groups, and businesses (e.g., Mature Driver Symposium participants noted that some businesses such as supermarkets respond to the needs of regular customers by providing transportation) to identify a range of formal and informal programs that can supplement the existing options for older Pennsylvanians. Potential partners can be identified by Older Pennsylvanian Mobility Surveys (see Recommendation 1) that will document transportation alternatives available to seniors.

2b. Create a task force to guide the examination and evaluation of current and possible future alternative transportation options for older individuals.

2c. Partner with other PennDOT offices and PA organizations to publish and widely distribute these program options. Consider formats targeted to the various audiences that will use this information.

MEDICAL CONDITION REPORTING AND DRIVING SKILLS ASSESSMENT

Recommendation 3: *Expand the reach of programs for drivers, their families, medical professionals, and law enforcement that allow for timely and accurate reporting of information on drivers' medical status.*

A general trend of declining functioning of physical, cognitive, and perceptual abilities occurs with age, but these effects are not the same for everyone -- many mature drivers have a high level of physical, cognitive, and perceptual functioning. A decreased range of motion, slower reaction times, cognitive slowing, visual impairments, and a diminished ability to process visual information from the driving environment (a lowered "Useful Field of View") are all factors that may lead to an increased likelihood of crashes.

Empirical evidence and analysis of Pennsylvania driving records indicates that drivers with a broad range of medical conditions, including vision deficiency, cognitive impairment, seizure disorder, and other chronic diseases are at increased risk for crashes and driving violations. Evidence also suggests that as drivers' abilities decrease, they become more selective in when and where they drive, and eventually, when the perceived risks become too great, many voluntarily cease driving altogether.

PennDOT currently has programs in place that educate drivers about risks associated with decreased physical, cognitive and perceptual abilities. PennDOT also employs methods to obtain, compile, and take action on information about drivers' medical conditions, primarily from physicians and law enforcement.

To enhance mature driver safety, "driving health" should be monitored/assessed by drivers themselves, family members and friends, health care professionals, law enforcement, and PennDOT. Key to both PennDOT's actions and drivers' own decisions is the availability and provision of accurate and timely information about medical conditions and corresponding changes in driving ability. We recommend that the reach of existing medical information capture systems be expanded in at least seven ways which are detailed in the following subpoints of this recommendation.

> 3a. For a two-year pilot test period, require a subsample of drivers age 70 and older to report on their current health at license renewal by including a medical condition checklist in the license renewal procedure. PennDOT should review and follow-up on these reports according to the procedures currently used for the mandatory medical condition reporting process. The primary goal of this pilot test will be assess the extent of possible underreporting of medical conditions under current practices, by identifying through self-reports drivers with reportable medical conditions who were not otherwise identified. The age 70 criterion is used by several other states for similar purposes. The Maryland Motor Vehicle Administration (MVA) uses a 16-item medical condition checklist at time of license renewal – this may provide a model of practice. If the pilot test reveals evidence of substantial underreporting of medical conditions, consider adopting a self-report of medical conditions checklist as standard practice for older drivers.

3b. Supplement the current process that allows for concerned family members and close others to report at-risk drivers with a web-based portal accessed via PennDOT's DMV website, so that PennDOT may follow-up with the re-exam process. Resources for family members (such as pamphlets at physician offices) would allow family members to be more active in monitoring driving skills, encouraging cessation, and finding transportation alternatives. Due to confidentiality and verification requirements, this is a longer-term objective.

3c. Expand the scope of PennDOT's re-exam program by lowering the *oversampling* age range to drivers age 75 and older. In addition, use daylight intersection (4-way, T, or Y) crashes during a calendar year by drivers age 75 and older as a trigger for a re-exam notification during the following year. According to PennDOT crash records, during 2008 there were 3,619 daylight intersection crashes involving drivers age 75 and older. According to PennDOT's current re-exam process, 22,800 drivers age 45 and older receive re-exam notifications each year, with oversampling of drivers age 80 and older. If the total number of re-exam notifications per year is to remain constant, adding the crash criterion to the notification selection process would require substituting drivers selected by the crash criterion for an equal number of drivers selected by the current process. These groups (crash criterion drivers vs. non-crash criterion drivers) could be compared to determine whether they differ in responses to or outcomes of the re-exam notification process, and if these differences warrant continuation of the crash criterion for re-exam selection.

3d. Remove barriers that hinder law enforcement's ability to flag potentially at-risk drivers for medical follow-up by providing the possibility to submit reports directly in the Traffic and Criminal Software (TraCS) system (or other systems in use locally), for example, by including a check box with justification (e.g., poor gap judgment) for PennDOT follow-up. Modification of these systems will become more feasible as electronic reports fully replace paper documents. Create a brochure or other information resource for use by law enforcement agencies to increase awareness among officers of the need for medical reporting, their role in educating the public, understanding of their role in the reporting process, and understanding of the steps that PennDOT takes when receiving notification.

3e. Promote voluntary cessation of driving by working with independent groups to develop and implement a self-testing system (e.g., web-based or at kiosks located at senior centers, AARP and AAA offices, and shopping malls) that provides drivers with feedback about the status of their basic abilities important for driving (such as attention, task-switching, visual acuity, useful field of view, contrast sensitivity, and reaction time) and information that would allow individuals to make informed decisions about their current driving abilities and develop plans for driving cessation. Emphasize that these assessments are only for information purposes for drivers – results are not available to nor used by PennDOT for license renewal purposes. Implementation can build on available computer-based assessments, such as the *Driving Health Inventory with UFOV*.

3f. Develop a set of specific guidelines (including definitions of medical conditions) for physicians to use in their mandatory medical reporting. Health care professionals are a critical line of defense in dealing with mature drivers who have diminished physical,

cognitive, and perceptual abilities, yet many health care professionals do not know about criteria for reporting a medical condition to PennDOT. Use venues such as state medical conventions and continuing education webinars for health care professionals to provide additional education about reporting unfit drivers.

3g. Encourage and require a broad range of medical professionals (including physicians, pharmacists, eye doctors, dentists, etc.) to provide reports on potentially at-risk drivers. Primary care physicians may use the Mars contrast sensitivity test, in conjunction with basic assessments of visual acuity, as a tool to screen for potential visual problems and referral to an eye care professional for a closer assessment and determination of visual fitness to drive. See Appendix A for further discussion of vision and driving.

Implementation of these systems will increase PennDOT's ability to promote safety though more accurate and timely actions that remove high-risk drivers from the road, *and* increase individuals' own capability for identifying themselves as at-risk drivers and for making thoughtful decisions about driving cessation.

POLICIES AND PRACTICES

Recommendation 4: Enhance and broaden the available offerings for effective educational opportunities for mature driver safety. Such offerings are to target mature drivers as well as the array of participants and organizations associated with supporting safe driving practices for mature drivers. Conduct evaluations of the effects of any changes to PennDOT's policies and practices.

PennDOT should continue its efforts to promote safety for the growing number of mature drivers traveling the Commonwealth's roadways. A variety of educational practices are being used in many contexts across the nation. These practices are designed to better prepare mature drivers for the task of safe driving, to more closely involve family and caretakers of mature drivers in their driving choices, and to better integrate existing programs and services into mature drivers' routines.

4a. In conjunction with sponsoring organizations including PennDOT partners, evaluate the effectiveness of currently offered safe driving educational activities in Pennsylvania. With these sponsors, jointly determine (if appropriate) how to best enhance the offerings to promote increased safety for mature drivers. Consider opportunities that address:

    i. Mature driver skills and fitness to drive
    ii. Family and close others' roles
    iii. Enforcement role and responsibilities
    iv. Medical community role and responsibilities

4b. Based on the evaluation above, identify venues that could have an expanded safe driver course curriculum. Consider incorporating or greater emphasis on topics such as:

i. Assessment or self-assessment of driving skills and functional abilities such as: the Mars Letter Constrast Sensitivity Test, a short cognitive assessment test, and/or the AAA's Roadwise Review (a free 30-minute online assessment of physical and mental fitness to drive).

ii. PennDOT Publication 381, *Driving Safely as You Get Older* – consider for use after updating course content.

iii. Mobility alternatives (Free Transit, Shared Rides, local transportation volunteer services, taxicab discounts, car turn-in programs).

iv. Driving cessation issues such as planning for future mobility as a non-driver.

v. Family and close others' roles and involvement in mobility including cost tradeoffs for vehicle ownership and operation vs. alternative transportation options.

vi. Enforcement community's interaction with mature drivers, identification of mature driver aspects in crash reporting and driving behavior

vii. Medical reporting responsibilities and requirements

4c. Where there are no existing venues, work with partners to develop educational opportunities that fill gaps.

4d. Further develop growing partnerships among PennDOT districts and the CarFit program (AARP, AAA, and American Occupational Therapy Association sponsors).

4e. Investigate the potential for increased discounts on automobile insurance for mature drivers who successfully complete a driving skills course – use the added incentive to launch information campaigns to draw more course participants.

4f. Provide educational material or opportunities targeted at drivers aged 45 to 64 to plan for future mobility, including maintaining driving skills, family and close other roles, and transportation alternatives.

i. Work with partners to develop planning tools and materials aimed at raising awareness of the mobility needs facing the mature driver or future non-driver.

ii. Develop PennDOT web pages that provide information about preparing for future mobility

iii. Develop a PennDOT brochure or handbook that discusses mobility topics and incorporates relevant information gathered in Recommendations 1 and 2 (Older Pennsylvanian Mobility Needs and Options) and make this document available in hard copy and on the PennDOT website

iv. Provide materials to District Safety Press Officers and other district personnel involved with mature driver activities

v. Consider creating a marketing campaign to raise awareness of the need for preparing for future mobility

4g. Encourage at-risk older drivers (particularly those with histories of crashes and/or violations) to utilize resources such as the AAA Roadwise Review and similar resources available from AARP, Seniors for Safe Driving, the National Safety Council, and others.

Update PennDOT Publication 381, *Driving Safely as You Get Older.* This pamphlet educates mature drivers about diminishing abilities, provides safe driving tips, and also includes several brief and informal self-assessments of vision, cognitive processing of visual information, arm and head/neck movement, and physical coordination. Interpretive guidelines help drivers make decisions to stop or reduce their driving. Additional information and tools for self-assessment may be provided in this pamphlet (such as mention of the AAA Roadwise Review program).

4h. Continue to adopt an "evidence-based management" perspective when evaluating mature driver initiatives. To the extent possible, PennDOT should evaluate mature driver programs, policies, or practices using relevant data. For example, Recommendation 3a outlines a suggested strategy for evaluating the outcomes of a change to medical reporting procedures.

Educating the mature driver population will increase safety on Pennsylvania's roadways. Additionally, PennDOT's strengthening of its partnerships with other organizations that also address mature driver safety will serve as a catalyst for promoting more activity and opportunity for effective education. Finally, data-based evaluations of mature driver policies and practices ensure that resources are devoted to areas where they can have the greatest impact.

Recommendation 5: *Increase marketing and outreach activities and materials to communicate with and inform mature drivers, their families, and close others about mature driver safety and related educational opportunities.*

Increased marketing and outreach activities to communicate and inform are essential to enhancing mature driver safety in Pennsylvania. The growing numbers of mature drivers need to be smart about skill levels, resources available, mobility options, and more, and PennDOT is a primary source of accurate and trustworthy information. Presenting the right information through effective venues and materials is the foundation for positive change. PennDOT's marketing and outreach activities enable the correct information to reach mature drivers, their families, close others, and those who serve them. Yet, more marketing and outreach needs to be done – and because of the significant and growing numbers of mature drivers, an even more concerted and persistent effort to communicate and inform will be necessary.

5a. PennDOT has numerous professionals positioned to add value to any marketing or outreach effort. The Central Office Press Office and the District Safety Press Officers form an existing network that effectively publicize and communicate with motorists as well as partner organizations such as the Pennsylvania State Police, AARP, AAA, medical societies, religious and community organizations, and others. Use of this existing network for outreach activities can be markedly enhanced through committing resources where none currently exist.

5b. Use of internet and electronic communications as well as more traditional means of reaching mature drivers should be investigated.

Marketing and outreach are cooperative functions with educational opportunities. Marketing is a means to attract the appropriate audiences to take advantage of the available knowledge. Outreach promotes engagement and participation of mature drivers, their families, close others, and those serving these populations. Knowledge, engagement, and participation promote safer mature drivers.

ENGINEERING SAFETY COUNTERMEASURES

The "black spot" method has been the most common method used by transportation agencies in the U.S. for identifying candidate locations for safety investments. This is the case in Pennsylvania. The objective of black spot analysis is to find locations that exhibit unusually high crash frequencies or crash rates. The crash data is then analyzed and problem locations are prioritized and ranked. Infrastructure-based countermeasures, such as improving intersection geometry, are then applied to address safety deficiencies at these specific locations. This can be applied to mature driver crashes, just as it is applied to pedestrian crashes, run-off-the-road crashes, and so on.

Recommendation 6: *Work with other PennDOT organizations to implement strategic engineering countermeasures using both "black spot" AND "systematic" methods simultaneously.*

To implement the "black spot" method, our recommendations are to:

6a. Identify crashes involving older drivers.

6b. Map these locations using C-DART GIS tools.

6c. Identify clusters and location trends for older driver crashes based on the results of the above steps.

6d. Identify areas where these locations are different from all-age crash clusters.

6e. At each crash cluster location, review detailed crash information to identify types of crashes (angle, rear end, etc.), complete field reviews, and identify contributing factors for crashes (poor gap judgment, speeding, etc.).

6f. Implement appropriate countermeasures at locations where older driver crash clusters have been identified.

Note that in Pennsylvania, about 9% of the total crashes in 2008 were crashes involving older drivers. Secondly, crash *rate* information is *not* available as PennDOT does not have exposure measures for locations. Therefore, PennDOT may be limited to just numbers of crashes. When crashes are plotted on a map, one result may be that the high crash clusters for *all* drivers will be the same high crash areas for older drivers. Also, it may be more difficult to identify older driver crash clusters as the numbers will be much

smaller, so fewer clusters will likely be evident (crashes may be widely distributed geographically making it difficult to efficiently identify specific problem locations). Further, data may be skewed towards locations with high traffic volumes in urban areas. As a result, common black spot locations may be intersections, particularly signalized intersections along multi-lane urban arterial roadways. Based on our analyses, black spot analysis may be effective for intersection crash analyses as older drivers clearly have a higher percentage of angle crashes at intersections than younger drivers. Although crash locations with lower volumes of traffic may be overlooked by black spot analysis, the overall goal of this approach is to identify locations where mitigation efforts will have the greatest impact.

Therefore, the "systematic" method of reducing crashes should be implemented *simultaneously* with black spot methods. A systematic implementation of lower-cost engineering countermeasures over many miles of roadway segments, intersections, corridors, or even over the entire roadway system could be an effective means of helping reduce older driver crashes everywhere, rather than a few specific locations. Missouri DOT and other state DOTs have implemented systematic countermeasures with noteworthy success, benefitting all road users.

6g. Deploy countermeasures systematically for these types of crashes:
  i. turning movements at intersections;
  ii. judgment of gaps at intersections;
  iii. traffic signal head placement and conspicuity;
  iv. stop sign placement and conspicuity;
  v. pedestrian and crossing location visibility;
  vi. wrong way entrance to divided highways, ramps, and one-way streets; and
  vii. work zones.

During the Mature Driver Symposium, specific countermeasures (many of which are described in the FHWA Design Handbook for Older Drivers and Pedestrians) were identified for each of these seven areas. Also, continue implementation of countermeasures that enhance safety for all drivers, such as centerline and edge line rumble strips.

Recommendation 7: Incorporate the appropriate countermeasures for the crash types noted above into PennDOT policies, design manuals, and publications, such as:

  7a. PennDOT Publication 13M (Design manual II)
  7b. PennDOT Publication 23 (Maintenance Manual)
  7c. PennDOT Publication 35 (Approved Construction Materials – Bulletin 15)
  7d. PennDOT Publication 46 (Traffic Engineering Manual)
  7e. PennDOT Publication 70M (Guidelines for the Design of Local Roads and Streets)
  7f. PennDOT Publication 72M (Roadway Construction Standards)
  7g. PennDOT Publication 111M (Traffic Control Pavement Markings & Signing Standards-TC 8600 & 8700)
  7h. PennDOT Publication 148 (Traffic Standards (TC-7800 Series) Signals)

7i. PennDOT Publication 149 (Traffic Signal Design Handbook)

7j. PennDOT Publication 212 (Section 212 of Title 67; Official Traffic Control Devices) Note: regulatory process will be necessary

7k. PennDOT Publication 213 (Temporary Traffic Control Guidelines)

7l. PennDOT Publication 236M (Handbook of Approved Signs)

7m.　PennDOT Publication 383 (PA Traffic Calming Handbook)

7n. PennDOT Publication 408 (Highway Specifications)

7o. PennDOT Publication 414 (Guide to Roundabouts)

7p. PennDOT Publication 447 (New Product Evaluation for Low Volume Local Roads)

7q. PennDOT Publication 638 (District Highway Safety Guidance Manual)

7r. These countermeasures should also be communicated to local municipalities for implementation on locally-owned roads in Pennsylvania through PennDOT's Local Technical Assistance Program.

7s. To fully implement the countermeasures, training should be offered to PennDOT traffic safety, design, maintenance, and construction inspection personnel and its business partners. The training should focus on the seven focus areas noted above and the corresponding countermeasures that have been woven into PennDOT's processes and publications.

By institutionalizing these practices via training and revised publications, these countermeasures could be implemented in the course of routine design and maintenance operations.

Recommendation 8: Review the new edition of the FHWA Highway Design Handbook for Older Drivers and Pedestrians when it becomes available. Implement applicable new strategies and improvements.

FHWA plans to publish a new version of the *Highway Design Handbook for Older Drivers and Pedestrians* in 2010. Each individual recommendation in the Handbook should be reviewed for applicability to Pennsylvania roadways. We anticipate that many of the recommended countermeasures in the new version are already being implemented in Pennsylvania. Those that are not should be reviewed for inclusion in black spot and systematic treatments. Focus should be placed on recommendations in areas identified by the data analysis, literature review, and Mature Driver Symposium. In the Symposium, specific countermeasures (many of which are in the *Highway Design Handbook for Older Drivers and Pedestrians*) were identified for implementation in each of these seven areas:

1) turning movements at intersections
2) judgment of gaps at intersections
3) traffic signal head placement and conspicuity
4) stop sign placement and conspicuity
5) pedestrian and crossing location visibility
6) wrong way entrance to divided highways, ramps, and one-way streets
7) work zones

8a. When FHWA offers training associated with the revised *Highway Design Handbook for Older Drivers and Pedestrians*, appropriate PennDOT and municipal personnel should be afforded an opportunity to attend.

Recommendation 9: Institutionalize a process to integrate the latest thinking from partners and external sources into PennDOT's safety approach to reducing mature driver crashes.

9a. On an annual basis, PennDOT should review implementation strategies in each district to ensure black spot methods are being implemented.

9b. New mature driver countermeasures should be evaluated on an annual basis and included in appropriate regulations and publications so that systematic methods can be most effective. This can be accomplished through the quarterly updating of Pennsylvania's Strategic Highway Safety Plan (SHSP) and strike-off letters for communication.

9c. Metrics should be developed to measure the extent of implementation and its effectiveness. These metrics could include:
   i. Number of countermeasures implemented to address identified crash clusters via the black spot method.
   ii. Number or length (extent) of countermeasures implemented via the systematic method.
   iii. Number of publications updated to include the identified countermeasures.
   iv. Number of persons trained on engineering countermeasures to address older driver safety.
   v. Number and severity of crashes involving older drivers.
   vi. Reduction in the areas of overrepresentation of older driver crashes through a comparison of older driver crashes versus all driver crashes.

DATA & METRICS

PennDOT stores data for millions of drivers, including decade's worth of driving records, crash records, reported medical conditions, and related information. With such vast amounts of data, proper database setup and design is crucial to ensure the validity of the data and to accommodate the requirements of authorized database users.

Recommendation 10: Update the MEDS (medical reporting) and DL&C (driver licensing) database systems to properly and thoroughly store reported medical conditions and re-exam histories.

To implement better data handling, our recommendations are:

MEDS:
10a.   Do not store a Re-Exam as if it is a medical condition. Re-Exam should be its own category.
10b.   Medical conditions that are a result of a Re-Exam (and vice versa) should be denoted as such.

DL&C:

10c.   Store Re-Exam outcomes: pass/fail/turned in license/no result.
10d.   Store a running total of Re-Exams ordered.
10e.   Store "Last Re-Exam" date.

CONCLUSIONS

As noted previously, PennDOT already devotes substantial attention and resources to older driver safety and mobility. Recognizing this fact, many of the recommendations offered in this report are intended to build on PennDOT's current practices. The recommendations for older Pennsylvanians' mobility needs and options directly address mobility issues and indirectly address safety – encouraging older drivers to use transportation alternatives enhances their personal safety and that of other road users. The medical condition reporting, driving skills assessment, and policies and practices recommendations directly address safety of older drivers – by improving their driving skills or rescinding their driving privileges if they can no longer drive safely – and indirectly enhance the safety of all road users when unsafe drivers are taken off the road. The engineering safety countermeasure recommendations directly address safety by mitigating factors that contribute to older driver crashes, thereby increasing the safety of older drivers *and* all road users. Taken together, these recommendations are intended to help make Pennsylvania's roadways safer for all who use them.

Appendix A

Visual Predictors of Crashes – Contrast Sensitivity and Useful Field of View

Vision is an important component of driving, and visual deficits can hinder an individual's ability to drive safely. There are specific conditions under which visual deficits are more likely to compromise driving safety, including low light, adverse weather, complex and changing visual environments, and significant glare.

What does "visual functioning" mean, and what determines whether someone, particularly an older driver, has healthy vision? Vision is a complex process that involves distinct components of physiology and neural/cognitive processing. There are many measures of vision and visual health.

The predominant visual assessment utilized (and the only requirement in Pennsylvania) is a measure of high-contrast static acuity – the extent to which an individual can make out small details on a still target where the target is dark (black) and the surrounding area is very light (typically white). This type of acuity is typically measured as 20/X, ranging from 20/10 (the maximum limit of human vision) to 20 over many hundred. The legal limit of static visual acuity for drivers is 20/60 in Pennsylvania for an unrestricted license.

Static visual acuity is a predictor of crashes – drivers with lower visual acuity tend to be involved in more crashes. However, there are other measures of vision which are independent of static visual acuity and are also predictors of crashes – in some cases these measures of visual functioning are BETTER predictors of crashes than static acuity. These independent predictors include contrast sensitivity and visual-cognitive processing measures such as the Useful Field of View. These are discussed below. It should be noted that while these measures are predictive of crashes, there is no generally accepted cutoff score on any of the tests that would allow a hard criterion for licensure to be set. Rather, these measures may be helpful to drivers in making decisions about driving cessation, and/or may be used by vision care providers in making clinical judgments (along with other measures of overall health and visual health) about an individual's suitability to drive.

The Mars Letter Contrast Sensitivity Test

The general findings of the research literature concerning the Mars Letter Contrast Sensitivity Test to date are that (1) the Mars test is an effective tool for measuring an individual's vision under conditions of low contrast (i.e., when objects have approximately the same visibility as their background), and (2) the Mars test may be more easily administered and predictive than the predominant test of contrast sensitivity, the Pelli-Robson charts.

Contrast sensitivity is one component of visual functioning that is uniquely predictive of crashes. However, like static visual acuity measured by the standard letter charts, it is **only one** visual

predictor of crashes, and the evidence suggests that it is not the strongest predictor. In other words, while the Mars test is a partial indicator of visual functioning and may indicate presence of underlying problems such as cataract, evidence does not yet suggest that performance on this assessment is a highly effective predictor of crashes among mature drivers. It should also be noted that while there are some very rough norms around the Mars test, no clearly established norms or cutoffs for this assessment have been established to guide a potential "cutoff" for safe driving or licensure, but future research by vision and driving researchers could potentially allow for the establishment of a cutoff at some point down the road.

The following citations are peer-reviewed research publications about the Mars test.

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- Thayaparan, K., Crossland, M. D. & Rubin, G. S. (2007). Clinical assessment of two new contrast sensitivity charts. *British Journal of Ophthalmolology*, *91,* 749-752, doi:10.1136/bjo.2006.109280.
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An example of the Mars test follows (used with permission). Note: the bottom rows have been made more visible (i.e., higher contrast) for exemplary purposes.

C H V O S N

D S Z N R K

N D R H V Z

C S O N K H

K N V D S R

Z R D K H O

H Z C V R K

S C Z D V O

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Visual Cognitive Processing Speed - Useful Field of View

A potentially promising component of visual functioning that appears to be predictive of real-world tasks, particularly driving, is a measure of visual cognitive processing speed. Driving involves processing a significant amount of information from the visual field and attending to important objects and dangers. Some people, particularly as they age, may experience declines in the extent to which they can process this visual information. It is not that they can't see detail (as measured by traditional static acuity) or can't see under low contrast conditions, but that they don't quickly process and attend to information in a rapidly changing driving environment. In other words, they can see everything, but they don't process all of the relevant information in time.

Research indicates that one measure of visual-cognitive processing speed, the Useful Field of View test, may be an independent and significant predictor of crashes in mature drivers. This test, which can be administered via computer, may be incorporated into self-assessments to provide individuals with another piece of information around which they could make decisions about driving cessation. Currently, there exists no defensible criteria for making actual licensing decisions, but this research may progress in the future and allow for measures of visual cognitive processing speed to be easily incorporated into visual tests used at driver licensing centers.