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Research and Development Needs for Maintaining the Safety and Mobility of Older Drivers

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The chairman and secretary of the Task Force owe an especial debt of acknowledgement to Dr. Karlene Ball and Dr. Cynthia Owsley whose original research endeavors and willingness to lead the way did so much to get this circular started. We are equally indebted to Dr. Frank Schieber who underwent the enormous task of consolidating volumes of information and distilling their essence so that this circular could take the form that it has. Ray Peck also contributed his rich experience selflessly to focusing the issues and clarifying their significance. Their work is a shining example to us all.

Introduction

During the past two decades interest in older driver issues has grown at a steady pace. Since 1975, numerous conferences and focused workshops have been conducted in order to examine the emerging problems of older drivers. In the Spring of 1991, with funding from NHTSA, the *Transportation Research Board's Task Force on the Mobility and Safety of Older Drivers* initiated a study to identify, synthesize and prioritize the critical research and development needs in this area. This circular describes the nature of this study and introduces the Task Force's *Research and Development Needs Statement* for the decade of the 1990's.

The process employed to establish the *R&D Needs Statement* consisted of the following steps: First, the principal investigator[1] reviewed the proceedings and publications generated by older driver conferences held throughout North America during the past two decades and identified the high priority research needs reported therein. Approximately 130 unique research and development needs were identified in this manner (see Appendix A for a complete list of these topics). Next, 12 key members of the TRB Task Force (including the 8 subcommittee chairs) rated these items in terms of their relative importance. On the basis of this preliminary screen through the candidate R&D issues, 38 items emerged as clear consensus, high priority research and development needs. These 38 items were subsequently used to construct a survey instrument which was then circulated to the entire membership of the TRB Task Force (both regular and affiliate members were surveyed). The last step in this process involved collating the completed questionnaires and using the feedback from the membership to establish a "consensus" high priority research and development needs statement pertaining to the maintenance and improvement of safety and mobility among the older driver population.

Formulating a concise list of the "highest priority" items to incorporate into the Task Force's *R&D Needs Statement* was a difficult process. The major problem stemmed from the large number of significant research needs which exist in this area of inquiry. For example, every one of the 130 issues listed in Appendix A were originally identified as major researchable issues by various national conferences or workshops dealing with older driver concerns. Reducing this large compendium of important issues to a short list of the very highest priority R&D needs, by necessity, resulted in the exclusion of many highly significant topics of concern. Despite such caveats, the study team was able to construct a *Research and Development Needs Statement* which identified 16 major areas where resources should be concentrated during the upcoming decade. The major criterion for inclusion into the final group of 16 issues was a "consensus" high priority rating from the Task Force membership. These items are summarized in Table 1 and are discussed in the text of the circular which follows.

Research and Development Needs Statements

The R&D needs identified by the Task Force as "most critical" can be divided into two major categories: (A) Problem Identification and (B) Program Development (See Table 1). The issues and problems addressed under the heading of *Program Development* tend to depend upon the data generated by the projects outlined in the *Problem Identification* area. Hence, in general, most of the Problem Identification work will need to be conducted either prior to, or concurrently with, the initiation of the proposed Program Development projects.

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[1] This work was conducted by Frank Schieber (Psychology Department., Oakland University, Rochester, MI 48309) in partial fulfillment of NHTSA Contract DTNH22-91-P-07323.

Table 1.

Older Driver Priority Research and Development Needs
as Identified by the TRB Task Force

A. Problem Identification

1. Analyze Driving Tasks - Identify how older drivers, particularly the older-old, perform critical driving tasks.

2. Functional Ability - Study the relationship between age-related disease, comorbidity and functional disability on driving performance and accidents.

3. Driver Risks - Identify the pre-crash factors which increase accident risks among older drivers.

4. Performance Measures - Develop performance-based measures of driving ability and safety.

5. Driving Compensatory Strategies - Identify compensatory strategies of reduced-ability drivers and the role of "self awareness" of disabilities on driving behavior.

6. Drugs and Driving - Study the effects of commonly used drugs on driving among the elderly.

7. Cognition and Driving - Study relationship between age-related cognitive/attentional changes and driving performance.

8. Model Older Driver Maneuvers - Develop an engineering model of how older drivers perform key maneuvers for use in conducting traffic analyses and guiding system changes.

B. Program Development

1. Crashworthiness - Reduce the crash injury vulnerability of older motor vehicle occupants.

2. Driver Licensing - Develop and evaluate a model "graded licensing system" aimed at monitoring and maintaining the mobility of reduced-ability drivers.

3. Medical Guidelines - Establish comprehensive medical guidelines for counseling and licensing functionally impaired drivers.

4. Driver Training - Develop theoretically sound and empirically supported driver training programs.

5. Traffic Control - Develop specifications for universal traffic control devices and highway design which satisfy the performance limitations of older drivers and pedestrians.

6. Night Driving - Identify the environmental and vehicle design factors that impair night driving and develop techniques to overcome them.

7. Anthropometric Database - Compile/Develop anthropometric design data representative of older drivers.

8. IVHS - Explore potential of emerging vehicle/highway technologies to offset age-limitations.

A. PROBLEM IDENTIFICATION

A.1 **TITLE:** Identify how older drivers, particularly older-old (those over 75-80 and/or those with specified functional limitations) perform varying driving tasks.

PROBLEM
Inadequate information exists on how older people drive, particularly those with functional limitations. It is well known that older drivers tend to have poor visual accommodation, poor ability to see in darkness or under dim illumination, decreased accuracy of distance and closing speed estimation, decreased ability for selective attention and attention sharing, poor short term memory, etc. What is unknown is how these limitations affect their driving performance in terms of both decision-making and vehicle control. Some data exists from the Yale and Iowa EPESE studies on where and when old people drive. But, more importantly, we don't have enough detailed information on how they drive and its relationship to miles driven, time behind the wheel and quality of the driving. Before specifying improvements to driver, vehicle or highway programs we must have much more detail on how those with functional limitations actually perform the driving task and how that performance compromises their safety or mobility.

OBJECTIVE
Compile available research data and collect new data as needed on the performance capabilities and limitations of selected populations of older drivers. Special emphasis should be placed on: (1) having these groups drive under representative conditions (e.g., familiar environments); and, (2) establishing representative samples of older drivers (i.e., avoid the volunteer bias which is so prevalent in studies of older drivers).

Classify limitations in performance of the driving tasks which are best addressed by vehicle design, highway design and operation, and/or driver intervention programs.

KEY WORDS: functional assessment; performance; driving task-analysis; disabled drivers; driving skill

RELATED WORK-IN-PROGRESS: Carr's "Activities of Daily Living" (ADL/IADL) study; NIA's Iowa and Yale work with the "Established Populations for Epidemiological Studies of the Elderly" (EPESE); N. Lerner's (COMSIS Corp.) Freeway Study; L. Staplin's (Ketron) traffic maneuvers study for FHWA; J. McKnight's (NPSRI) Arizona psychophysical driver assessment battery; R. Bishu (University of Nebraska) "Driving habits of the elderly" survey; L. Laux and D. Mayer's (Rice U.) "Locating vehicle controls and displays" study.

URGENCY/PRIORITY: High

ESTIMATED COST: 1-2 Million (Higher if simulation technology is employed)

USER COMMUNITY: NHTSA, FHWA, NIA, NEI, CDC, AARP, AAA, NSC, State highway offices; DMVs; Insurance companies; vehicle manufacturers.

IMPLEMENTATION: Basis for subsequent problem identification research on drivers, vehicles and highways.

A.2 **TITLE:** Age-related disease, comorbidity and functional disability affects on driving performance.

PROBLEM
Research to date has tended to focus on disease categories rather than on the functional disabilities associated with aging and age related diseases. For the most part healthy older adults exhibit little systematic decline in their driving safety and mobility patterns. However, some of those suffering from age-related diseases appear to experience significant declines in functional ability which impacts directly upon their ability to safely and efficiently operate an automobile. Yet, little is known about the relationship between functional limitations associated with common age-related disease and driving performance.

OBJECTIVE
Develop a better understanding of the relationship between functional limitations associated with age-related diseases and driving performance, safety and mobility. The objective should consider a severity-of-illness model tied to functional ability and focus upon a limited number of disorders thought to impact highly upon driving behavior (e.g., dementia, stroke/closed head injury, insulin dependent diabetes, macular degeneration, and arthritis).

Develop a better understanding of the primary mechanisms responsible for reduced mobility among older populations of drivers with specified functional limitations.

Define target populations needing special attention which would serve as a basis for the development of performance based assessment techniques, guidelines for medical advisory boards and motor vehicle administrators, driver limitations that vehicle designers, highway designers and traffic engineers should consider in their systems.

KEY WORDS: Functional assessment; severity-of-illness models; diabetes; low-vision; visual impairment; dementia; stroke; arthritis; disability.

RELATED WORK-IN-PROGRESS: NHTSA/NIA sponsored EPESE studies at Iowa and Yale on driving patterns and functional ability. [See also papers by Foley, Wallace, Eberhard and Ostfield "Driving skills in the eighth and ninth decade of life", and Shinar's "Vision testing and elderly drivers", Kaszniak (University of Arizona) et al's "Dementia and the older driver", Reuben's "Dementia and the older driver--a risk form motor vehicle crashes?" Drachman's survey work on dementia; D. Yee, J. Melichar and D. Puccetti (San Fancisco State) AARP Andrus Foundation "elderly driver assessment profile" study.

URGENCY/PRIORITY: High

ESTIMATED COST: 2-3 Million

USER COMMUNITY: Policy makers, medical community, DMV administrators and medical advisory boards, older driver training and information specialists, vehicle manufacturers.

IMPLEMENTATION: Licensing and rehabilitation programs; policy makers re highway/vehicle changes to better accommodate older drivers.

A.3 **TITLE:** Identify the pre-crash factors which increase accident risks among older drivers.

PROBLEM
Existing data has not adequately defined the specific accident risk factors which characterize different subgroups of normal and age-related disease groups. This is particularly true at the upper age ranges (75+) where most disabling diseases and frailty are likely to occur.

OBJECTIVE
Identify the pre-crash behaviors that older drivers engage in that increase their risk of having an accident while performing their driving tasks. Particular attention should be given to the roadway conditions that are particularly difficult for them and how certain groups of older drivers have more difficulty because of their functional limitations.

KEY WORDS: Crash risks; crash causes

RELATED WORK-IN-PROGRESS: K. Ball (University of Western Kentucky) and C. Owsley (University of Alabama) work on visual attention, cognitive status and variable crash risk among older drivers; J. Guerrier and S. Czaja (Stein Gerontological Institute) have begun preliminary work in these areas.

URGENCY/PRIORITY: High

ESTIMATED COST: 1.5 Million

USER COMMUNITY: Government policy makers; AARP; CDC; NIA; NSC; Insurance companies; State highway and driver licensing agencies; Law enforcement and accident investigation groups.

IMPLEMENTATION: Basis for driver, vehicle and highway programs.

A.4 **TITLE:** Develop performance-based measures of driving ability and safety.

PROBLEM
The accident has served as the *de facto* criterion for the great majority of driving research conducted in North America. Accidents have high face validity in terms of safety related issues and have enabled researchers to avoid the difficult and costly issues of construct validity. However, the driving accident, as a research variable, provides great limits upon research design, power and interpretability. These events tend to be relatively unique and totally uncontrolled. These limitations become especially problematic where one is concerned about assessing the *causal* influences of age-related changes in performance. The development of performance-based measures for assessing specific categories of driving capacity and limitation would foster important improvements in our ability to identify and understand the mechanisms underlying driving dysfunction as well as provide a basis for reliable field or clinical evaluation of "problem" older drivers.

OBJECTIVE
Develop working models of driving based upon functional limitations and real-time vehicle control decisions in situations with known or quantifiable demands on operator performance.

Develop a predictive battery of driving performance measures based upon the working models and develop a valid instrument that can be used to evaluate either all older drivers or those with specified functional limitations. Such an instrument could, for example, include the use of a low-cost, computer-based, driving simulator or some other form of valid and practical off-road test designed especially for evaluating older drivers.

KEY WORDS: driving assessment; road tests; neuropsychological assessment

RELATED WORK-IN-PROGRESS: FHWA traffic maneuvers study, R. Wallace (University of Iowa) Iowa EPESE follow-up study; Odenheimer's (Veterans' Administration) simulator and road test; J. Szlyk's (University of Illinois) driver video simulator studies; Malfetti and Winter's (Columbia University) "Safe and unsafe performance of older drivers: A descriptive study"; J. McKnight's

(NPSRI) driver assessment battery work; R. Peck's (California DMV) development and assessment of alternative driver assessment battery; W. Schiff (New York Univ.) AAA Foundation grant to study "Real-time microcomputer/video-based performance measures of driving safety"; Ketron's (L. Staplin) FHWA traffic maneuvers study; R. Gianutsos and A. Beattie's (Cognitive Rehabilitation Services Corp) driving simulator assessment system.

URGENCY/PRIORITY: High

ESTIMATED COST: 2-3 Million

USER COMMUNITY - Basic Researchers, Driver License and Training developers, Vehicle/Highway systems developers and evaluators; DMV's; AAMVA.

A.5 **TITLE:** Identify and evaluate the coping/compensatory strategies used by reduced-ability drivers and assess the nature, extent and role of "self awareness" of disability and its influence upon their driving behavior.

PROBLEM

Adult aging is associated with an accelerated increase in the incidence of functional disabilities which may impair driving safety and mobility. The emergence of an anticipated "safety problem" with the graying of the population will depend upon the extent to which impaired elderly drivers can accurately detect and assess their own level of disability; and, then, compensate accordingly. Many reduced-ability older individuals continue to drive without demonstrating increased risk of becoming involved in an accident. Survey-based research indicates that some impaired older drivers tend to change their driving behavior and compensate for a wide range of functional disabilities. However, little has been done to catalog the nature and extent of such compensatory behaviors nor to evaluate their role in maintaining mobility among older driving populations.

OBJECTIVE

Identify and understand the compensatory strategies used by reduced-ability drivers to maintain both their mobility and safety. A taxonomy of compensatory behaviors could emerge from a programmatic study of drivers using questionnaires, interviews and road tests. Laboratory and/or simulation follow-up studies will be required to isolate and understand the mechanisms and limits of the identified compensatory strategies. This work will also enable researchers to evaluate the extent to which compensatory strategies are effective in the absence of intervention. Relatedly, the cataloging of such compensatory mechanisms and strategies should prove most useful in the development of rehabilitation and training programs for reduced-ability drivers of all ages.

KEY WORDS: rehabilitation; coping; perceptual learning; cognitive intervention; adaptation

RELATED WORK-IN-PROGRESS: NHTSA/NIA EPESE studies (particularly Phase II Iowa study); K. Ball's (U. Western Kentucky) "driving questionnaire" study; Kline, et al. (1991) "vision and driving survey".

URGENCY/PRIORITY: High

ESTIMATED COST: 500-900K

USER COMMUNITY: DMV Policy makers, those interested in "graduated" licenses; mature driver training programs.

A.6 **TITLE:** Study the effects of commonly prescribed and over-the-counter drugs upon driving in the elderly

PROBLEM
Many commonly prescribed medications have effects upon the central nervous system which may have potentially impairing effects on driving ability and safety. Since the prevalence of prescription drug use, especially polypharmacy, increases significantly with advancing adult age, it follows that medication-related driving problems should also increase among older populations. Although data exists regarding the effects of drugs upon driving performance, most of this research has been exclusively limited to younger adults. However, it is very difficult to generalize the findings from such research to older driving populations because of age-related changes in both pharmacokinetics and pharmacodynamics. Yet, little is known about the nature and magnitude of such potential problems.

OBJECTIVE
Determine the effects of commonly prescribed medications upon both the mobility and safety of older drivers. Analyses of drug related safety risks (i.e., accident analyses) require very large samples of medication users in each age by drug category. Recent work suggests that cross-tabulations of the prescription records of large Health Maintenance Organizations (HMO's) with state motor vehicle records holds great potential for generating the large sample sizes which are required for such research. Survey questionnaires building upon such a database could also be employed to assess mobility-related issues. There is a clear need to include samples of older persons, including those with functional impairment known to influence driving performance, in the evaluation of behavioral side effects of commonly prescribed as well as recently introduced medications. It is also important to document the potential contribution of medications for reducing the symptoms of age-related disease which inhibit driving-related performance and activities. Findings from these studies would be used to catalog driving-related "risk factors" stemming from drug use and be applied in the decision-making process regarding the selection of prescription drugs as well as the implementation of "graded" driver licensing programs.

KEY WORDS: medication; side-effects; pharmacokinetics; pharmacodynamics

RELATED WORK-IN-PROGRESS: Ray and O'Hanlon's reviews (Human Factors, Feb 1992); W. Ray (Vanderbilt University) "A cohort study of psychoactive medication and crash risk in an elderly Medicaid population"; M. Wolf (University of Washington) "Case-control study of medication, medical conditions and automobile crashes".

URGENCY/PRIORITY: High (and on-going with new medications)

ESTIMATED COST: 1-2 Million (when done in conjunction with regular drug evaluation trials)

USER COMMUNITY: Medical Advisory Boards, Medical community prescribing drugs, Older driver training and information programs.

IMPLEMENTATION: Training programs, Physicians Desk Reference, Pharmacists; DMV licensing.

A.7 **TITLE:** Study relationship between age-related cognitive/attentional changes and driving performance.

PROBLEM
Advanced adult age is associated with declines in various attentional capacities and cognitive skills. Among normal, healthy adults these declines are relatively mild; yet, among those suffering from common age-related pathologies, such as dementia of the Alzheimer's type, these changes may be severe. Little is known about the relationship between the expected levels of age-related attentional and cognitive decline and its impact upon driving performance.

Recent research has revealed that the assessment of attentional capacity and cognitive status may be more efficacious in identifying functional driving impairment among older drivers than traditional screening procedures such as vision, road or knowledge tests. Tests of "attention switching" have been found to be especially useful in characterizing and predicting driving performance among dementia patients - the elderly population most likely to contribute to the emergence of an age-related safety problem. Relatedly, a new attentional assessment technique which detects the presence of age-related "perceptual tunnel vision" (or, the Useful Field of View) appears to be highly correlated with accident involvement among older drivers.

OBJECTIVE
Identify the mechanisms mediating the relationships between attentional and cognitive factors and driving performance, then, develop reliable and sensitive standardized attentional and cognitive assessment procedures. In particular, there is a need to develop a test which is likely to identify those who are at a stage in dementia where they should no longer drive. Consideration should be given to whether current conventional tests in a DMV setting are able to detect the demented driver or other driver groups whose attentional or cognitive capacities have become limited.

KEY WORDS: neuropsychological assessment; attention; driver screening tests; dementia; cognitive impairment

RELATED WORK-IN-PROGRESS: K. Ball and C. Owsley's UFOV and related data; L. Cushman's (University of Rochester) NIA grant to study the relationship between neuropsychological measures of memory, cognition and attention and their relationship to driving performance in the elderly; Odenheimer's (Veterans' Administration), P. Keyl's (Johns Hopkins) and L. Hunt's (St. Louis University) dementia and driving performance research; J. Szlyk's (University of Illinois) peripheral vision and driving research; R. Parasurman (Catholic University) and A. Kaszniak's (University of Arizona) reviews on dementia and driving in Human Factors (Oct 1991 special issue)

URGENCY/PRIORITY: High

ESTIMATED COST: 1.75 Million

USER COMMUNITY: DMV's, Medical community

IMPLEMENTATION: Rehabilitation centers, DMVs, Medical Community

A.8 **TITLE:** Develop an "engineering design model" of the older driver.

PROBLEM
Designers of vehicle and highway systems, particularly traffic engineers, do not have adequate techniques to determine how older drivers perform under given traffic control situations.

OBJECTIVE
Catalog and organize existing performance data regarding older drivers and transform it into tables, curves and functions that facilitate their use in the engineering and design process. Study how drivers of different ages interact with their vehicle environments (mirrors, controls, dispalys, lighting, etc) and develop models and/or guidelines for optimizing the older driver/vehicle interface.

Develop a model of driving maneuvers as performed by older drivers, particularly those with disabilities likely to be impacted by changes to the system, that can be used by to conduct traffic analyses and guide related decision-making.

KEY WORDS: performance; human factors guidelines; ergonomics; design driver

RELATED WORK-IN-PROGRESS: L. Staplin's (Ketron) traffic maneuver study for FHWA; Ranney's (TRB Committee on Vehicle User Characteristics) work to revise NHTSA's "Driver Performance Databook"; Society of Automotive Engineers (SAE) Mature Driver Standards Committee's (T. Yanik, Chair) work to revise the "SAE Handbook" to reflect age-related changes in user characteristics.

URGENCY/PRIORITY: Medium

ESTIMATED COST: 500-750K

USER COMMUNITY: Traffic Engineers, highway designers, vehicle designers, training development specialists.

IMPLEMENTATION: AASHTO, SAE, FHWA, NHTSA

B. PROGRAM DEVELOPMENT

B.1 **TITLE:** Reduce the crash injury vulnerability of elderly motor vehicle occupants.

PROBLEM

The number of driving-related fatalities declined for the years 1980 through 1989 for all subgroups below the age of 65. However, during this same period of time, the number of fatalities for the 65+ age group increased significantly. Part of this increase was due to the fact that both the number of older drivers as well as their estimated annual mileage rose during this same time period. However, these factors account for only a portion of the diverging fatality statistics across the young vs. older age groups. It appears that when older drivers are involved in accidents of similar type and magnitude that they are more likely to die than their younger counterparts. If they are fortunate enough to survive a crash, older adults are also more likely to suffer serious injuries and long-term disability. This increased crash vulnerability appears to be exacerbated for drivers over the age of 75 - the fastest growing demographic group.

OBJECTIVE

Identify the physiological, biomechanical and behavioral factors which contribute to the increased crash vulnerability of older automobile occupants. Once identified, these factors need to be translated into automobile design guidelines and/or standards which will contribute to improving vehicle crashworthiness relative to the needs of the older "design driver".

Identify the special "emergency medical services" needs of older accident victims which could contribute to their increased probability of surviving a crash and/or recovering full function following recuperation and therapy.

KEY WORDS: Injury vulnerability; frailty; emergency medical services (EMS); vehicle crashworthiness; survivability

RELATED WORK-IN-PROGRESS: NHTSA grant with Jackson Memorial Hospital to develop an Automobile Trauma Care and Research Facility. It should provide detailed data on automobile injuries, treatments, outcomes, and costs on automobile injury victims. Insights into the prevention of restrained/unrestrained occupant injuries of air bag and automatic and manual belts. NHTSA is supporting the Transportation Systems Center to use math simulation and experimental work to identify probable incompatibilities between current belt/bag systems and vehicle occupants. Particular attention will be paid to identifying possible approaches to improve alternate restraint

designs or requirements that focus on the needs of older vehicle occupants. Also see work by L. Evans (General Motors).

URGENCY/PRIORITY: Highest

ESTIMATED COST: 5-10 Million

USER COMMUNITY: Automobile Manufacturers, EMS, public information specialists

B.2 **TITLE:** Develop and evaluate a model "graded" licensing program aimed at monitoring and maintaining the mobility of reduced-ability drivers.

PROBLEM
Driving or riding in a car is the only transportaion alternative for most older people. Based on all recent surveys, older drivers intend to drive well into very old age, frequently despite extensive functional disabilities. In the presence of functional loss, most older drivers appear to appropriately modify or restrict their driving behavior. However, some do not - either because they are unaware of their limitations or disregard them. There is a need for programmatic research aimed at the development of a "graded" system of licensure that would limit driving access along a continuum on the basis of specific functional loss relative to a specific individual's transportation needs and compensatory capacity. This "case approach" would extend the restrictive license used by some states relating driving privilege to demonstrated capabilities.

OBJECTIVE
Investigate the changing role of current licensing system in the assessment of reduced ability drivers. Look at existing "graded license" practices of states such as Iowa, Wisconsin, Oregon and Washington.

Develop and evaluate a battery of clinical and DMV administered tests to identify problem drivers. Attention should be given to recent promising developments, such as the Useful Field of View (UFOV) test for identifying attentionally impaired drivers. Catalogue and assess the wide range of functional disabilities together with their impact upon driving-related performance. Develop a "graded license system based upon the functional abilities and the inability of certain aged driver groups to self assess and take proper precautions in their driving. Assessments using a mix of clinical test batteries, road tests and part-task driving simulation protocols would probably to be required. Rehabilitation centers/hospitals would appear to provide an optimal test-bed for developing the tests.

KEY WORDS: functional assessment; disabled driver; disability; cognitive impairment; license revocation; license restriction

RELATED WORK-IN-PROGRESS: AAMVA's "Model driver screening and evaluation program"; B. Jones' (Oregon Department of Motor Vehicles) "Older Driver Counseling Program", R. Wallace (University of Iowa) Iowa EPESE study, L. Temple's (University of Nevada, Las Vegas) review of state practices for AARP; Malfetti and Winters' (Columbia University) series of reports on graded licensing

URGENCY/PRIORITY: High

ESTIMATED COST: 2-3 Million

USER COMMUNITY: DMV's, Medical Advisory Boards, Rehab Centers, Medical Community

IMPLEMENTATION: DMV's, Rehabilitation and Geriatric centers

B.3 **TITLE:** Establish comprehensive medical guidelines for counseling and licensing functionally impaired drivers.

PROBLEM
Motor vehicle departments, physicians, and others have long sought functional criteria as to when an individual should or should not drive. Research in the area has been hampered by inadequate definition of medical conditions, failure to take into account the comorbidity of conditions and, for the most part, inadequate sample sizes. All of the recent conferences attempting to identify the older driver problems have pointed out the need to establish functional performance criteria as related to driving restrictions.

OBJECTIVES
Based on the research conducted in the problem identification section develop *comprehensive medical guidelines* which would map specific functional impairments to specific domains of driving disability; and, thus, provide a research-based rationale for administering license restrictions and counseling older people as to when they should or should not drive.

KEY WORDS: functional assessment; disability

RELATED WORK-IN-PROGRESS: L. Temple's (UNLV) review of state practices for AARP; British and Canadian Medical Guidelines; E. Petrucilli's (AAAM) medical advisory board guideline review for NHTSA/FHWA.

URGENCY/PRIORITY: High - research based functional criteria need to be developed in an orderly, less time constrained manner.

ESTIMATED COST: 500K

USER COMMUNITY: DMV's, Medical Advisory Boards, Rehabilitation Centers

IMPLEMENTATION: DMV's, Medical Advisory Boards, Rehabilitation Centers, Primary care physicians

B.4 **TITLE:** Develop an effective older driver training and informational program.

PROBLEM
In response to common age-related changes in psychomotor and cognitive capacity, there are a number of "mature driver" (re)training programs. For example, those offered by the American Association of Retired Persons and the National Safety Council. However, little is known about the appropriateness of the curriculum nor the effectiveness of such retraining programs.

These programs should improve driver awareness regarding personal limitations which may contribute to unsafe driving and/or limited mobility as well as provide information regarding appropriate compensations for age-related limitations. Comprehensive evaluation studies are needed of existing programs and more research-based diagnostic assessment and individualized training are needed to optimize new performance based training programs.

OBJECTIVE
Study the effectiveness of mature driver training programs addressing the following issues: 1) the appropriateness and comprehensiveness of the course curriculum; 2) the effectiveness of the training materials in terms of the mature student's ability to comprehend and retain the information which is presented; and, 3) the real-world impact of participation upon driving habits, mobility patterns, comfort and safety.

Develop a theoretically sound, performance data based curriculum and informational packages that focus on specific difficulties that older drivers have either with safe performance or unnecessarily limiting their driving. Wherever possible, these informational packages should be based on data that demonstrates how their psychophysical deficit causes specific driving errors and ways to overcome or cope with the difficulties.

Develop behind the wheel instructional programs for those older persons learning to drive and for those current drivers with functional disabilities that require markedly different skills.

KEY WORDS: Functional limitation; rehabilitation; driver assessment; remedial education

RELATED WORK-IN-PROGRESS: California DMV accident study (Janke et al.); K. Ball's (University of Western Kentucky) research on training Useful Field of View; AARP's review of 55 Alive.

URGENCY/PRIORITY: High - Effectiveness studies of existing programs should be undertaken as soon as possible. Most of the performance based development must await the research recommended in the problem identification section.

ESTIMATED COST: 300K for effectiveness evaluation; 600K for performance-based program development.

USER COMMUNITY: AARP, AAA, NSC, DMV's, NIA, NHTSA, Highway safety offices, AOTA, ADED, Rehabilitation/Low Vision Centers, Insurance companies.

IMPLEMENTATION: Existing national programs - AARP, AAA, NSC, plus rehabilitation centers and, possibly, a new market for commercial driving schools.

B.5 **TITLE:** Develop specifications for universal traffic control devices and highway design which satisfy the performance limitations of older drivers and pedestrians.

PROBLEM
Existing guidelines and specifications for the design of traffic control devices and highway geometry have been developed on the basis of human performance parameters derived from young adult observers. Since average visual sensory and perceptual capacity is known to decline significantly with advancing age, many of the published design specifications may fail to provide sufficient "perceptual/cognitive response time" for older driver populations.

OBJECTIVE
Specifications and guidelines in the Manual of Uniform Traffic Control Devices (MUTCD) which are dependent upon assumptions regarding visual and perceptual response times need to be reevaluated on the basis of response distributions obtained from older adult populations. New specifications should be generated for design areas where the minimum psychomotor and perceptual tolerances required by older drivers are not met. This work should carefully consider the life-cycle costs of implementing such "improved" guidelines and explore alternative techniques for conveying information and controlling traffic flow which may contribute to the special needs of older drivers as

a group. Based upon the success of such initiatives, related analyses of highway geometric design rules and guidelines (e.g., the AASHTO handbooks) should also be initiated.

KEY WORDS: safety; ergonomics; human factors; highway signs; highway design; traffic signals

RELATED WORK-IN-PROGRESS: FHWA has initiated work in this area (see Mast, 1991 for description; NCHRP is also funding research in the area; UMTRI's (Paul Olson) highway sign illumination studies; Florida Department of Transportation's "Highway Corridor Safety Program".

URGENCY/PRIORITY: High

ESTIMATED COST: 800K

USER COMMUNITY: AASHTO, FHWA

IMPLEMENTATION: States, FHWA, AASHTO, Manual of Uniform Traffic Controls and Devices

B.6 **TITLE:** Identify the factors which impair nighttime driving and develop techniques to overcome them.

PROBLEM
Although older drivers clearly demonstrate problems associated with nighttime driving, much remains to be learned about the mechanisms which mediate such age-related difficulties. Age-related changes in the eye which (1) reduce retinal illumination and (2) increase intraocular light scatter contribute greatly to the general problems of visibility and susceptibility to glare often experienced by older drivers. However, little or no work has been done which examines these nighttime driving difficulties in terms of the modified information-processing demands of the nighttime driving environment - namely, the reduced "lead time" available for detecting, identifying and processing visual stimuli. Moreover, little is known about the night-time driving requirements of older drivers and whether there is a cost/benefits based need to change the driving environment to facilitate their nighttime mobility.

OBJECTIVE
Investigate how age-related changes in visual function and cognitive information-processing capacity influence, both separately and interactively, difficulties associated with nighttime driving. Laboratory, simulation and road-tests would be used to examine how factors such as lens opacification, decreased pupillary size and glare recovery time relate to subjective and objective measures of nighttime driving performance. Any such studies should also evaluate the effects of cataract surgery upon performance. Relatedly, laboratory and simulation studies which examined the effects of decreased environmental information and perceptual "lead time" required for decision-making would be needed to assist in separating age-related nighttime driving problems into their sensory/perceptual vs. cognitive information-processing components.

Determine the need for and ways (e.g., roadway lighting specifications; modified vehicle headlamps, etc) to accommodate drivers with limited night time driving capability.

KEY WORDS: Glare; cataract; information-processing; low luminance; low illumination; mesopic.

RELATED WORK-IN-PROGRESS: J. Szlyk's (University of Illinois) work with driving simulation in visual pathology patients; D. Shinar (NHTSA) & F. Schieber's review in Human Factors (Oct 1991); P. Olson (UMTRI) work with glare/nighttime visibility; Kline, et al's "visual problems of older drivers" survey.

URGENCY/PRIORITY: Medium

ESTIMATED COST: 600-800K

USER COMMUNITY: Rehabilitation centers, DMVs, Medical Community, Vehicle and Highway designers

IMPLEMENTATION: Auto manufacturers, traffic engineers, vision specialists

B.7 **TITLE:** Develop an anthropometric database which represents the distribution of bodily dimensions and performance parameters of the older adult population.

PROBLEM
Automotive engineering groups are attempting to optimize vehicle design features to meet the emerging needs of older drivers. However, much of this effort has been slowed due to a dearth of comprehensive anthropometric data regarding the static and dynamic parameters used to describe bodily dimensions, range of motion and work capacity.

OBJECTIVE
Gather comprehensive anthropometric data from representative older driver populations. Special care must be taken to identify which physiological measures need to be collected in the service of optimizing vehicles design in terms of entry/egress, seating comfort and safety, passive and active restraint systems, access to control and instrument panel systems, etc.

KEY WORDS: Design driver, human engineering guidelines, control/display optimization; ergonomics.

RELATED WORK-IN-PROGRESS: Human engineering guidelines for IVHS (Paul Green -- UMTRI); TRB's update of the design driver data book (Perel/Ranney).

URGENCY/PRIORITY: Medium

ESTIMATED COST: 400K (800K if the acquisition of new data is required)

USER COMMUNITY: Vehicle/highway designers, training specialists

B.8 **TITLE:** Conduct engineering research to apply emerging technologies to the design of vehicles which offset age-related declines in motor, sensory and cognitive capacity.

PROBLEM
Currently there is a major emphasis on the development of an intelligent vehicle/highway system (IVHS). The goal of this work is to vastly improve the safety, capacity and efficiency of highway transportation. How these systems will accommodate the declining capabilities of older driver populations is unknown. Technology may have much to contribute to the continued mobility of older drivers and pedestrians alike. However, there is an important caution. Namely, advanced technology also holds the potential for making driving more difficult for the elderly by overloading their sensory/perceptual capacities.

OBJECTIVE
Determine the role new technology may play in keeping older drivers, passengers and pedestrians safely on the road for as long as they desire. Determine if new vehicle/highway technology can be developed to offset the emerging difficulties experienced by many older drivers. Candidate systems for the application of such "earmarked" funds include, but are not limited to: improved design and

location of low-beam headlights (e.g., using HID technology), the development of night vision systems and/or obstacle detection and avoidance systems, adaptable mirror technology, dynamic occupant protection systems, head-up windshield displays, and an expanded role of the emerging Intelligent Vehicle Highway System (IVHS) as a means to compensate for age-related perceptual and cognitive deficits toward the end of monitoring, maintaining and/or improving mobility among the older driver population.

KEY WORDS: biomedical engineering; crash avoidance; IVHS; electronic surveillance; applied technology

RELATED WORK-IN-PROGRESS: P. Green's (UMTRI) IVHS contract research for FHWA; T. Yanik's (General Motors) review of automotive industry initiatives in this area (SAE Congress, 1991); work in the UK aimed at exploring ways of applying intelligent vehicle/highway technology toward maintaining mobility among older drivers.

URGENCY/PRIORITY: High

ESTIMATED COST: 500K-900K (exploratory studies only)

USER COMMUNITY: Vehicle/highway designers and manufacturers; MVMA, NHTSA.

IMPLEMENTATION: Vehicle/highway designers

Glossary

AAA	American Automobile Association
AAAM	American Association of Automotive Medicine
AAMVA	American Association of Motor Vehicle Administrators
AARP	American Association of Retired Persons
AASHTO	American Association of State Highway and Transportation Officials
ADED	Association of Driver Educators for the Disabled
ADL	Activities of Daily Living
AOTA	American Occupational Therapy Association
CDC	Centers for Disease Control
DMV	Department of Motor Vehicles
EMS	Emergency Medical Services
EPESE	Established Population for Epidemiological Studies of the Elderly
FHWA	Federal Highway Administration
IVHS	Intelligent Vehicle-Highway System(s)
MVMA	Motor Vehicle Manufacturers Association
MUTCD	Manual of Uniform Traffic Controls and Devices
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NEI	National Eye Institute
NIA	National institute on Aging
NPSRI	National Public Service Research, Inc.
NSC	National Safety Council
SAE	Society of Automotive Engineers
TRB	Transportation Research Board
UFOV	Useful Field of View
UMTRI	University of Michigan Transportation Research Institute

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Recommended Reading

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Appendix A

R&D Needs Identified During Initial Literature Review

Highway Design Issues

1. A series of integrated studies should be conducted to provide quantitative information about age-related changes in perception-brake-RT, perception-RT for intersection sight distance, and for the perception time required to detect, identify and react to objects in the road. These studies should also take into account the variability in performance among older persons and use large, representative samples.

2. Re-evaluate the perceptual-and-performance models used to establish highway design standards to ascertain the extent to which they misrepresent the information processing and response time needs of the older population.

3. Identify and evaluate intersection traffic and control devices which accommodate the changing perceptual, cognitive and motor capacities of older drivers and pedestrians.

4. Develop specifications for the family of traffic control devices that will satisfy the known performance limitations of older drivers and pedestrians (including signs, signals and delineation systems).

5. The Manual of Uniform Traffic Control Devices (MUTCD) should develop and adopt a performance standard for highway and street signs based on the degree to which a sign ensures the minimum required visibility distance of the older population.

6. Study the utility of employing redundant Advance Notice Signs for off-loading the diminished information processing and response time needs of older drivers.

7. The FHWA should support research on the development and use of Symbol Signs as a means for improving response lead-time among older drivers.

8. The FHWA and the states should cooperate through the National Cooperative Highway Research Program (NCHRP) on a project to determine the level of retroreflective sheeting intensity needed to provide adequate conspicuity for older drivers and to identify the types of signs that would be good candidates for enhancement with high-performance retroreflective sheeting.

9. The states should work through NCHRP to develop procedures for sign budgeting, inspection and maintenance to ensure that sign condition, mounting, placement, contrast and reflectivity are maintained.

10. Traffic engineering models which depend upon estimates of the walking speed of pedestrians (e.g., 4 ft/sec) should be reevaluated regarding the needs of older persons. Because of the implications for traffic flow, guidelines for tailoring walking speed assumptions to site-specific requirements should be developed.

11. Determine if there is a need to modify existing sight-distance standards for roadway geometric design in order to accommodate the changing functional capacity of older drivers.

12. Study how the parameters of intersection geometric design can be optimized to meet the changing needs and capacities of older drivers and pedestrians.

13. Research is needed to determine if current AASHTO specifications of sight-distance triangles for the design of intersections adequately address the sensory, attentional and cognitive characteristics of older drivers.

14. Studies are needed to provide guidance and recommendations for the design of left-turn traffic control procedures. This research should be driven by the special limitations and increased risk of left-turn accidents demonstrated by many older drivers.

15. The FHWA should fund research on the safety performance of alternative street layouts and networks with a focus on the frequency of intersections and their design.

16. Develop design guidelines and operational procedures that will assure adequate conspicuity and legibility of Changeable Message Signs (CMS) for older drivers. The frequency of CMS applications is expected to increase dramatically with the advent of Intelligent Vehicle-Highway Systems (IVHS) technology.

17. Conduct studies to assure that Hazard Warnings and Markers meet the comprehension and visibility needs of older drivers.

18. Identify and develop guidelines for pavement marking and delineation systems which will accommodate the reduced nighttime vision capacity of older adults.

19. Develop material and techniques for improving the nighttime legibility of highway informational and warning signs.

20. Identify the mechanisms underlying driving speed variations among the older driver population. Possible mechanisms include: limited information processing capacity, greater adherence to posted speed limits, lifestyle changes (i.e., retirement) which reduce time stress pressures, etc.

21. Develop techniques to reduce traffic speed variability based upon age-related sensory, attentional and cognitive changes.

Vehicle Design Issues

22. Basic research is needed to develop an anthropometric database which describes the full range and distribution of physical/bodily parameters for the older adult population.

23. Research is needed to improve the accessibility and performance of safety belts for older populations.

24. NHTSA should develop a consumer oriented program that will raise the awareness of older consumers to the vehicle features that are of special benefit to them as they age. NHTSA should also work with other organizations in the public and private sectors to develop and disseminate such information.

25. NHTSA should develop and fund a crashworthiness research program that would (1) conduct biomechanical studies to delineate differences in the vulnerability to injury across age groups, (2) develop anthropometric dummies to be used in crash tests that are more representative of the impact response of the various segments of the motoring public, (3) examine crash protection for older persons in lower speed crashes, and (4) collect control data on driving exposure and crash exposure representative of the age distribution of the driving population.

26. NHTSA should reevaluate the adequacy of the Federal Motor Vehicle Safety Standard 200 Series for protecting a growing population of older persons more vulnerable to injury.

27. Determine the relative "eyes-off-the-road" time that older drivers can tolerate when they switch attention from the roadway to instrument panel controls and displays. This data is needed to guide the design of automobile instrument panels which would be optimized for the needs of

older drivers.

28. Determine the low-beam headlight parameters which maximize nighttime visibility for older drivers and explore headlight technologies which could implement these lighting needs while minimizing the deleterious effects of glare.

29. Investigate the effects of windshield tinting and other forms of glazing upon nighttime visibility in older drivers versus the protection afforded against daytime glare.

30. Study the effects of age-related changes in accommodation and convergence in relation to the use of instrument panel displays and controls.

31. Explore the extent to which current and emerging vehicle design technologies can offset age-related declines in motor, sensory and attentional capacity.

32. Determine the effectiveness of vehicle route guidance systems for older driver populations, including those with diminished cognitive capacity.

33. Determine the priority that older drivers give to secondary control systems such as the radio and climate control units during the driving task and evaluate the divided attention capability of different age groups.

34. Investigate the implications of age-related sensory, attentional and cognitive changes for the design of interactive interfaces to the Intelligent Vehicle Highway System (IVHS) proposed by the FHWA.

35. Study the injury tolerance levels of persons in different older age groups (e.g., 55-64, 65-74, 75-84, and 85+) and apply the results to an assessment of efficacy of current crashworthiness standards for older adults.

36. Study the relative effectiveness of competing restraint system technologies for older occupants.

37. Study parameters of seat design which could contribute to improved visibility, safety and comfort of older drivers.

38. Investigate techniques for improving mirror design to optimize indirect visibility while minimizing the effects of glare and the need to switch attention from the straight ahead.

39. Develop and evaluate vehicular mobility aids for mitigating the effects of high prevalence age-related disabilities.

40. Develop an Older Design Driver that will help scientists, engineers and policy-makers conduct trade-off analyses based upon economics, traffic capacity/flow and safety.

Licensing, Training & Rehabilitation Issues

41. NHTSA should support the development and evaluation of Model Licensing Programs aimed at maintaining the mobility of older drivers experiencing driving difficulties through the use of more extensive and frequent assessment, counseling and education, retraining, and a limited-privilege licensing system.

42. State Medical Advisory Boards hold great potential for shaping policies for identifying and evaluating individuals suffering from age-related driving disabilities. Yet, the activity of such groups has diminished markedly in recent years. As such, NHTSA should assess the causes for the decline of activity among state Medical Advisory Boards, recommend steps to reinstitute and reinvigorate them, and evaluate their full potential for assisting in the design and implementation of licensing procedures for impaired older drivers.

43. A research project should be funded to establish a photopic illumination standard for acuity

screening devices which is free from age bias.

44. A research project should be funded by NHTSA or NIA to evaluate the appropriateness of using a low luminance acuity test as a driver's license screening procedure.

45. Research is needed to evaluate the potential role of dynamic tests of visual function (e.g., visual search, Useful Field of View, etc) for identifying drivers with reduced attentional and/or cognitive capacities.

46. Research is needed to evaluate the appropriateness and specificity of contrast sensitivity and glare sensitivity tests for mass screening applications.

47. NHTSA should evaluate the feasibility and cost-effectiveness of computer automated evaluation systems for driver licensing applications.

48. Research is needed to evaluate the role of common age-related changes upon the certification requirements of Commercial Driver's Licensing programs (including School Bus drivers and any other individual who drives as a source of employment).

49. Research is needed to identify the characteristics of at-risk drivers in need of more comprehensive assessment (i.e., "trigger" criteria for referral to Tier 2 testing). Various methods such as age, referrals, traffic convictions and accident events should be explored

50. What role should road-tests play in the assessment of older drivers?

51. Should physicians or other health care providers be required to report impairment of older drivers to the department of motor vehicles?

52. Comprehensive medical guidelines should be established for licensing impaired or disabled drivers. Research should identify specific medical conditions that indicate a potential driving risk.

53. Medical review board decisions should be longitudinally evaluated to assess the efficacy of such programs in terms of both safety and mobility outcomes.

54. Research is needed to develop a comprehensive assessment battery for the evaluation of "at risk" drivers. Such a battery must include dynamic performance tests which tax cognitive and attentional abilities as well as motor control. Scoring should be along a quantitative continuum (as opposed to a simple "pass/fail") so that progress trends or rates of deterioration can be detected and accurately monitored.

55. Research is needed to identify the characteristics of older drivers who contribute most to traffic and safety problems so that a profile of "at risk" drivers can be developed and used to detect reduced ability drivers.

56. Research is needed to develop and evaluate guidelines and procedures for establishing a "graded licensing" system.

57. Investigate the role of age-related hearing loss upon performance and safety among reduced ability drivers. Although hearing loss does not appear critical for otherwise healthy drivers, loss of auditory acuity may exert more profound limitations upon impaired individuals.

58. What role should age exert in the qualification of drivers for renewal-by-mail programs?

59. Evaluate the feasibility of funding improved assessment and follow-up services aimed at maintaining the safety and mobility of reduced ability drivers from increases in individual licensing fees vs. fee-for-service approaches.

Medical: General Issues

60. Study how age and medical condition interact in terms of overall crash risk and crash type. Such epidemiological studies should employ a "severity of illness" approach rather than a simple nominal classification to a diagnostic category.

61. Determine the extent and nature of coexisting medical conditions and estimate their interactive effects upon overall crash risk and crash type (i.e., the comorbidity issue).

62. Evaluate the effects of recent changes in the medical treatment of insulin dependent diabetics upon driving performance and accident patterns (i.e., the tighter control of blood glucose levels as now practiced appears to be accompanied by an increased risk of hypoglycemic episodes).

Medical: Senile Dementia

63. Determine the relationship between the presence and severity of dementia and crash histories.

64. Study the natural history of driving behavior among demented patients and their support network.

65. Examine the possibility of predicting driving performance on the basis of measures which could be administered in the clinician's office.

66. Establish tools for measuring driving skills and their relationships to cognitive abilities. Validate these tools against actual on-road performance using instrumented vehicles and a comprehensive analysis protocol.

67. Study the relationship between measures of visual attention and deteriorating driving performance in dementia patients (Preliminary work suggests that attentional capacity may be a good predictor of driving ability among dementia patients).

68. Study dementia-related changes in the ability to engage and disengage visual attention and determine the extent to which these abilities are related to meaningful measures of driving performance.

69. Establish criteria to determine how often a demented driver's performance should be reevaluated.

70. Establish recommendations and procedures to be followed after the diagnosis of dementia (e.g., Alzheimer's disease) detailing what actions should be taken by the DMV and/or other licensing authorities? Criteria for limiting and/or revoking licensure MUST be established because: 1) eventually ALL dementia patients lose the capacity to drive safely, and 2) the number of dementia cases will grow significantly in the foreseeable future.

71. Identify which aspects of functional loss due to dementia significantly impair driving mobility and safety.

Medical: Drugs and Alcohol

72. Study the effects of commonly prescribed drugs upon driving performance in the elderly.

73. Conduct epidemiological studies relating computerized prescription medication records to highway traffic safety records. Identify those medications, alone or in combination, which appear most likely to impact driving safety as a function of age.

74. Study age-differences in the effects of blood alcohol level upon attentional, cognitive and motor components of the driving task.

75. Identify medications that may significantly impair driving safety and/or mobility.

76. Identify medications which may contribute significantly to improved driving performance.

Attention and Cognition

77. Identify the age-related cognitive/attentional changes which limit driving capacity.

78. Evaluate the efficacy of cognitive skills training upon driving performance among impaired older drivers.

79. Study age-related changes in driving performance under cognitively "stressful" operating conditions.

80. Model the role of attentional processes in the driving task and determine how older drivers differ from younger drivers in terms of attention allocation strategies and multitask prioritization and coordination.

81. Study the classes of possible natural compensatory behaviors and determine which of these behaviors are most effective for remediating performance and safety deficits among cognitively impaired drivers. Use the results of this study to develop effective intervention training strategies.

82. Conduct retrospective studies to determine if age differences in performance upon cognitive/attentional tasks (e.g., visual search, Useful Field of View, etc.) are related to number and types of accidents.

83. Study the extent to which sensory deficits interact with cognitive deficits to limit driving performance and safety.

84. Study the cognitive/attentional workload demands of various driving tasks and situations for young, old and disabled-old populations.

85. Conduct task-analyses of driving which distinguish automatized (overlearned skills) from controlled (cognitively effortful) information-processing components. Evaluate the extent to which "controlled" tasks may be more sensitive for the detection and identification of impaired functional driving ability.

Vision and Visual Perception

86. Study the effects of central versus peripheral disability upon driving performance, mobility and safety.

87. Evaluate the effects of variations in the visual environment upon driving performance, mobility and safety.

88. Establish criteria/procedures for "restricting" driving behavior on the basis of limitations in functional visual capacity.

89. Develop a two-tiered system of visual assessment involving preliminary screening at the DMV with a specific system of referral and followup evaluation for those drivers displaying diminished visual function. Research should be sensitive to the operational demands and limitations of the DMV setting.

90. Identify specific visual problems of nighttime driving in the elderly.

91. Develop methods for improving nighttime visibility and mobility among the elderly.

92. Determine how the optimal test-retest interval for the assessment of visual function varies as a function of age. Use this empirical data to establish age-specific retest specifications.

93. Determine whether older commercial drivers require additional levels of visual assessment prior to biennial recertification?

94. Evaluate the effects of cataract surgery upon safety and mobility patterns; and determine the potential impact of improved vision screening tests which have improved sensitivity for the detection of lenticular disease.

95. The prevalence of individuals with corrected visual acuity which is worse than 20/40 (the cutoff in most states) increases markedly beyond age 75. What types of driving capacity can be expected from these individuals? Can they benefit from training? Can the licensing system be modified to accommodate the minimal mobility needs of this rapidly growing disability group without unduly compromising safety.

96. Investigate how the role of vision care professionals can be expanded in the identification and remediation of drivers having significant loss of visual function.

97. Develop protocols and criteria for evaluating the "road worthiness" of visually impaired drivers.

98. Identify the perceptual/information-processing mechanisms which mediate age-related losses in the Useful Field of View (UFOV) test (Recent evidence suggests that the UFOV test may be sensitive to age-related changes in visual attentional capacity which contribute to increased crash risk).

99. Evaluate the role of emerging non-refractive visual tests (i.e., low contrast acuity, glare stress tests) for identifying correctable age-related problems of vision which are not detected by conventional acuity assessments.

Motor Control

100. Conduct prospective population-based studies of age-related changes in motor control capacity, strength and frailty. Determine the rate of progression of impairment and the age level(s) at which functional disabilities are likely to emerge.

101. Identify the discrete motor subtasks of driving and determine which driving skills are affected by loss of motor control.

102. Identify motor control, strength and flexibility criteria for clinical certification of driver readiness.

103. Determine which of the driving skills that are affected by loss of motor control can be maintained through compensating behaviors.

104. Determine the extent to which motor control losses due to arthritis and osteoporosis are due to extrinsic factors (such as exercise) and the extent to which such loss is reversible through available intervention techniques.

105. Study the effects of exercise upon the maintenance of driving-related motor skills in the elderly.

General Issues

106. Research is needed to quantify the magnitude of the older driver safety problem. Intelligent allocation of research resources requires such as estimate.

107. Research is needed to develop and validate performance-based measures of driving ability. Prospective research cannot efficiently utilize crash data. The statistical power of crash data is far

too low and experimental control is nonexistent.. Only prospective studies will enable us to identify the mechanisms underlying age-related changes in driving performance and safety.

108. Identify the coping/compensatory strategies employed by drivers with diminished functional capacity. Apply this analysis to the design of interventions.

109. Research is needed to see if road-tests can be made more challenging without exceeding minimal safety requirements (e.g., parallel parking is a road-test maneuver which taxes complex motor coordination skills without increasing the risk of injury). Without challenging the driver, the predictive validity of road-tests will be compromised.

110. Compare self-reports of functional status with clinical assessments in order to evaluate the strengths and weaknesses of the "self monitoring with compensation" mechanism of age-related change in driving behavior patterns.

111. Evaluate the driving performance of older persons with known disabilities (e.g., stroke, arthritis, dementia, etc) in order to identify candidate behaviors for inclusion in a comprehensive functional assessment battery.

112. Evaluate the strengths and weaknesses of current procedures for identifying older drivers with potentially debilitating medical conditions.

113. Evaluate the effects of generalized physical frailty upon driving mobility and safety and develop criteria for quantifying the nature and magnitude of the disability.

114. Evaluate the characteristics of older drivers who currently fail the DMV driving test or who otherwise drop out of the driving population. Determine if the appropriate individuals are being screened out of the driving population.

115. Determine the extent to which providing feedback from diagnostic testing, physicians, driver training, and counseling results in appropriate compensation and self-restriction by reduced ability drivers.

116. Develop and assess the effectiveness of age-tailored self-assessment kits for improving older driver performance and/or behavior patterns.

117. Develop and evaluate a part-task, cost-effective, driving simulator for assessing functional performance decrements (or improvements) and as a tool for providing remedial training.

118. Evaluate the use of rudimentary driving simulation technology for evaluating dementia patients.

119. Conduct a well-controlled, prospective experimental evaluation of the effectiveness of current mature driver training programs.

120. Develop a driver test that is functionally related to driving performance and tailored to common age-related skill deficits.

121. Study the current and anticipated need for nighttime driving among the older population.

122. Large-scale longitudinal research designs are needed to identify and assess secular trends which will influence the generalizability of current research findings for future cohorts of elderly drivers.

123. Determine the role of self-reports, collateral reports and driving logs as tools for improving our understanding of the dynamics of accidents, near-misses and related problems of mobility and safety among older drivers.

124. Investigate age-related changes in the effects of fatigue upon driving performance and safety.

125. Conduct improved analysis of accident patterns to ascertain patterns of crash "overinvolvement" by older drivers. Past analyses which scored accident-type on the basis of %-total-accidents are difficult to interpret and apply in a decision-making context.

126. Identify and estimate the relative strength of the factors which lead to reduced mileage with increasing age (e.g., retirement, health status, situational anxiety, self-rated driving capacity, etc). Use this information to assess the gap between mobility needs vs. mobility capacity.

127. Study how the travel/mobility needs of older persons will change over the next 40 years?

128. Develop a Taxonomy of Age-related Driving Problems. Determine driving risks as a function of specific driving situations/contexts (e.g., heavy volume traffic, freeway driving, unfamiliar neighborhoods, nighttime, bad weather, etc) using a wide variety of data sources - including interview, questionnaire and driving log data.

129. Assess the validity and extent of the "Self-monitoring with Compensation" assumption for older drivers who develop sensory, perceptual, and/or cognitive impairments. Identify the domains of behavior where self-awareness is highly accurate as well as where it tends to be highly inaccurate.

130. Conduct a comprehensive human factors analysis of the driving task using a large and representative sample of older drivers.