



U.S. Department
of Transportation
**Federal Highway
Administration**

Visual Disorders and Commercial Drivers

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16. Abstract The objectives of the project were to reassess the adequacy of the current Federal vision standards for CMV operators (49, CFR, 391.41(b)(10),1985). The technical approach included doing a critical review of existing literature; providing a preliminary draft of recommendations; preparing a risk assessment of visual criterion levels proposed; conducting a workshop to review draft recommendations with expert industry and vision panelists; and providing a summary of the project with final recommendations. A review and critical evaluation of the most significant scientific research, which investigated the vision performance of passenger and commercial drivers, revealed no conclusive evidence to support definitive changes to the current standard. However, it was deemed important to include visual acuity and visual fields, requirements for the standard. Based on the critical review of the literature, opinion surveys, and workshop results collected from panelists representing the vision industry field, the following recommendations were made: distant visual acuity of at least 20/40 in each eye without corrective lenses or Visual acuity separately corrected to 20/40 or better with corrective lenses, distant binocular acuity of at least 20/40 in both eyes with or without corrective lenses, field of vision of at least 120 degrees in each eye measured separately in the horizontal meridian, and the ability to respond safely and effectively to colors of traffic signals and devices showing standard red, green, and amber. No test for color vision is required. The instructions to perform and record the visual examination were extensively revised. Identification of the type of equipment, the stimuli needed to conduct the testing, and instructions on how to perform the tests were added. The full description of the definition and testing procedures Of the standard is provided in the body of the report. In addition, revisions were made to the list Of visual disorders and impairments to be noted on the exam form.			
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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
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LENGTH

in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km

AREA

in ²	square inches	645.2	millimetres squared	mm ²
ft ²	square feet	0.0929	metres squared	m ²
yd ²	square yards	0.836	metres squared	m ²
mi ²	square miles	2.59	kilometres squared	km ²
ac	acres	0.395	hectares	ha

MASS (weight)

oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

VOLUME

fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft ³	cubic feet	0.0328	metres cubed	m ³
yd ³	cubic yards	0.0765	metres cubed	m ³

NOTE: Volumes greater than 1000 L shall be shown in m³.

TEMPERATURE (exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C
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* SI is the symbol for the International System of Measurements

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
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LENGTH

mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi

AREA

mm ²	millimetres squared	0.0016	square inches	in ²
m ²	metres squared	10.764	square feet	ft ²
km ²	kilometres squared	0.39	square miles	mi ²
ha	hectares (10 000 m ²)	2.53	acres	ac

MASS (weight)

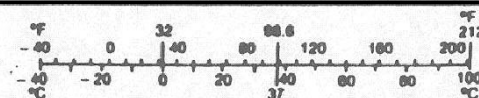
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T

VOLUME

mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m ³	metres cubed	35.315	cubic feet	ft ³
m ³	metres cubed	1.308	cubic yards	yd ³

TEMPERATURE (exact)

°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F
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These factors conform to the requirement of FHWA Order 5190.1A.

PREFACE

This project investigated the adequacy of the current Federal vision standard for operators of commercial motor vehicles.

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EXECUTIVE SUMMARY

There is widespread agreement that vision plays an essential role in the driving task. However, specifying a precise level of visual capability necessary for safe driving continues to be problematic because of the lack of definitive empirical evidence on which to base a clearly defensible visual performance standard. The purpose of establishing vision standards for drivers of heavy commercial motor vehicles* (CMVs) is to identify individuals who will represent an unreasonable and avoidable safety risk if allowed to drive CMVs. The objective of the research in support of a vision standard has been to identify the required level of seeing (based on empirical evidence in place of a consensus) in order that CMV drivers will not be a safety risk to themselves or to the motoring public. The purpose of this contract was to assess the adequacy of the current Federal vision standard for drivers of heavy CMVs. An exhaustive review was conducted of all new and previously existing research literature and data. In addition, further analyses, risk assessment of minimum visual criterion levels, and consensus from experts in the vision and industry fields were used as a basis for recommending changes to the current standard and to the procedures underlying its administration.

PROBLEMS WITH THE STANDARD

The Federal government began regulating vision standards for interstate commerce motor carriers in the late 1930s. At that time, the standard was based on a consensus of experts in the fields of vision and driver safety, but the goal of providing a firm empirical base for the standard has proved elusive. The vision standard has been changed steadily in the direction of requiring more stringent visual capability. The standard currently states, "...distant visual acuity of at least 20/40 (Snellen) in each eye without corrective lenses or visual acuity separately corrected to 20/40 (Snellen) or better with corrective lenses, distant binocular acuity of at least 20/40 (Snellen) in both eyes with or without corrective lenses, field of vision of at least 70 degrees in the horizontal meridian in each eye, and the ability to recognize the colors of traffic signals and devices showing standard red, green, and amber" (49, CFR, 391.41(b)(10), 1985). Along with the problem of providing an empirical base for the standard, other problems were identified, e.g., the statement of the visual field requirement and need for a specific color vision requirement in the current standard. The visual field requirement left doubt as to what the actual specification of horizontal field extent should be for each eye (70 degrees or 140 degrees), and the color vision requirement was found to be probably unenforceable on a practical basis.

*Defined as any vehicle with a gross vehicle weight rating of 10,001 pounds or more; any vehicle that transports hazardous materials requiring placards; and a bus designed to transport more than 15 passengers including the driver.

REVIEW OF EMPIRICAL STUDIES

A review and critical evaluation were conducted on the most significant scientific research directed at investigating the relationship between visual performance and driving for passenger, commercial, and aged/visually impaired motor vehicle operators. Many studies relating visual test performance to correlates of driver safety, such as accident and violation rates, have been reported since the last major revision of the CMV vision standard in 1970. Reports on new testing methods were reviewed, including contrast sensitivity, glare sensitivity, low-light visual acuity, and dynamic visual acuity. In general agreement with studies reported prior to 1970, these newer studies were able to demonstrate only weak relationships between measures of vision and correlates of driver safety. No study involving purely visual measures reported an empirical ability to identify unsafe drivers at a level that was substantially greater than had previously been demonstrated for tests currently called for in the standard or for new tests. Thus, no new study or synthesis of studies provided a definitive basis for extensive changes to the current CMV visual standard.

FUNDAMENTAL LIMITATION DETERMINING MINIMUM VISUAL CRITERION LEVEL FOR VISION SCREENING

Review of the historical research performed to provide a more adequate empirical specification of the vision standard for drivers of both passenger cars and CMVs suggests a fundamental limitation in terms of providing valid cutoff points for screening purposes. Numerous studies have shown that visual deficits are rarely the primary cause of major accidents. Typically, many factors are found to contribute. Secondly, persons involved in accidents have already been screened for visual deficits thus reducing the number of visually poor drivers actually on the road. For these and other related reasons, tests of primary visual capability cannot reasonably be expected to correlate highly with measures of driver safety or to provide unambiguous cutoff points for screening out unsafe drivers. This is true even though good vision is unquestionably an essential component of safe driving.

NEW DEVELOPMENTS

A new development worth noting is the useful field of view test (UFOV). The task central to this test includes a cognitive component. The observer must discriminate the test object from similar test objects and report its position in terms of a limited number of locations in the field of view. This task is thought to depend on information processing skills as well as on primary visual sensory processing. Correlations of test results with measures of driving safety have been reported as high as $r = 0.55$, which is considerably higher than the figure reported for tasks dependent only on primary visual processing. However, even a correlation of the magnitude reported for the UFOV task would not be sufficient to overcome the problem of a high false-positive rate. In addition, the nature of this task is substantially different from the one currently included in the CMV vision

standard, and the empirical data is insufficient to justify inclusion of the UFOV task in the standard. However, this area of research is perhaps the most promising of those reviewed and includes contrast sensitivity, glare sensitivity, low contrast acuity, and automated full-field perimetry.

STATE STANDARDS

State CMV vision standards applying only to intrastate driving were reviewed. The requirements for each state are generally less stringent than the current Federal CMV standard. The binocular visual acuity requirement in almost 80 percent of the states is 20/40, but less than 10 percent of the states deny a license for monocular vision. Less than 40 percent of the states have visual field standards comparable to the Federal standard and only 24 percent have a color standard.

INTERNATIONAL STANDARDS

Review of vision standards for CMVs in other industrialized countries revealed wide variances. Most countries require a visual acuity level for each eye separately that is higher than the current United States standard of 20/40 in each eye. Only a few countries have a binocular acuity requirement and when specified, it is more stringent than the United States requirement. For visual fields, most other countries state that the driver must have "normal" or "full" fields. Most other countries do not have a requirement for color vision. In addition, the driving privilege in many countries may be denied because of stereopsis, aphakia, diplopia, high myopia, night blindness, and nystagmus. Many countries also require periodic checks for vision.

MEDICAL PROFESSION RECOMMENDATIONS

The medical profession and the American Medical Association (AMA), in particular, have historically provided significant input to the process of setting vision test standards. The AMA guidelines for minimum visual performance for operating commercial motor vehicles are stricter than the Federal CMV vision standard for visual acuity (20/25 compared to 20/40) in each eye, but the recommendations for visual fields and color vision are the same. The AMA also lists visual disorders that are of concern but avoids recommending denial of the driving privilege based on them.

EXPERT OPINION SURVEY/RISK ASSESSMENT

Using a Delphi-type approach, a panel of experts conducted an assessment to judge the importance of, and safety risks associated with, various visual impairments of CMV drivers. This involved panelists identifying the visual tasks most significant to selected driving tasks and then ranking these in order of importance to safety. Results of this exercise were useful in development of the final recommendations. In addition, a risk

assessment was conducted to estimate the probable impact of changing the visual acuity criterion by a specified amount (i.e., from 20/20 to 20/400). Results of this analysis identified a theoretical level of risk associated with different binocular visual acuity levels for a CMV operator performing a specific truck maneuver.

WORKSHOP CONSENSUS

A workshop was conducted to review and provide a consensus on the preliminary draft recommendations. The panel represented industry and visual sciences communities, and consisted of licensed doctors of medicine, ophthalmologists, optometrists, professors in academic ophthalmology departments, and traffic and safety professionals in private industry. These panelists represented many of the professional medical and industrial associations. The 1-day workshop opened with a project overview presented by the principal investigator and subsequent discussion was structured around the presentation of viewpoints by the expert panelists. The workshop was addressed by the Director of the Office of Motor Carriers, who stressed the significance of the workshop and panelists' expert recommendations. Focused discussion was held on the most vital points at issue, including the need to exclude monocular drivers or those with substantial visual loss in one eye only, the statement of the visual field requirement, the need for more complete and accurate testing of visual field (more in accord with the medical diagnostic procedure), the benefit of including newer tests of vision, the intent and effectiveness of the current color vision standard, and the basis of a risk analysis model that could be used to evaluate changes to the standard. The workshop panelists concluded that there were no compelling reasons to change the current binocular visual acuity standard of 20/40, that there was a need to measure horizontal visual fields using a more rigorous method than currently employed in commercial vision screening equipment, and that the current color vision requirements are unenforceable and do not meet the intent of not excluding red-green color-defective individuals from the driving privilege. In addition, there was doubt on what risk, if any, there was for drivers who are color blind, since traffic signing has been standardized and drivers have many other cues to operate a vehicle in a safe and effective manner. Panelists generally felt that it was important to note visual disorders and ocular conditions and that individuals with specific conditions should be referred to ophthalmologists. Follow-up surveys were also sent to the panelists to identify the specific position they took on the visual acuity, visual fields, and color vision standards.

FINAL RECOMMENDATIONS

Based on the review of the literature, Delphi exercise, and the panelists' input, the recommended changes to the CMV standard were amended as follows. The statement of the visual acuity standard was found to be adequate. More specific wording to rule out below-standard performance in one eye was added to the Instructions for Performing and Recording Physical Examinations. Extensive revisions were made to this section to specify more completely the testing conditions and procedures to be used when measuring acuity, including light level, stimulus type, and specific test procedures. The Statement of the visual field standard was changed to require at least a

120-degree field of view in each eye measured separately in the horizontal meridian. Extensive revisions were also made to the Instructions section to specify minimum stimulus conditions and an acceptable procedure for testing in the horizontal meridian. The statement of color vision was changed to require only a “safe and effective response to colored traffic signals and devices, without requiring a specific test of color vision. Thus, red-green color-deficient individuals who can otherwise respond safely and effectively (virtually all) will be allowed the driving privilege under this statement. The recommended wording for the CMV vision standard is: “Has distant visual acuity of at least 20/40 in each eye without corrective lenses or visual acuity separately corrected to 20/40 or better with corrective lenses, distant binocular acuity of at least 20/40 in both eyes with or without corrective lenses, field of vision of at least 120 degrees in each eye measured separately in the horizontal meridian, and the ability to respond safely and effectively to the color of traffic signals and devices showing standard red, green, and amber. No test for color vision is required.

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INTRODUCITON

The assertion that vision plays an essential role in the driving task cannot be credibly opposed. However, the level of vision that is necessary for safe driving continues to be a contentious issue. The reason for this is the continuing unavailability of definitive empirical evidence upon which to base a clearly defensible visual performance standard. The purpose of setting vision standards for drivers of heavy commercial motor vehicles (CMVs) is to identify individuals who will represent an unreasonable and avoidable safety risk if allowed to drive CMVs. The first CMV vision standard to set specific performance requirements in 1939 was based on a consensus that defined the minimum vision necessary for safe driving. The research objective in support of a vision standard has been to identify the level of seeing, based on empirical evidence in place of a consensus, that has to be met in order that CMV drivers will not be a safety risk to themselves or to the motoring public. The objective is to review the current Federal vision standard(1) for drivers of heavy CMVs and new and existing data and analysis, as a basis for recommending possible changes to the current standards and procedures underlying its administration.

Driving safety is maintained through a constant stream of small decisions and less frequent larger decisions that require a high rate of accurate visual information about the driving environment. The level of vision required to support success in the decision-making process and driving safety depends on the level of complexity of the projected driving task (i.e., high speed, wide-open highway compared to congested urban or suburban roadway environments). It also depends on the consequence of encountering an error, or series of errors, in the decision stream that will lead to a catastrophic outcome to the driver and others in the driving environment. For drivers of CMVs, the consequence of error is likely to be much greater in terms of loss of life and property than the result of a similar error made by the driver of a private motor vehicle. This fact is supported by the statistics accumulated (1979 to 1986) on the disproportionately high rate of heavy vehicle involvement in fatal crashes. For all types of accidents (adjusted for exposure mileage), combination trucks (tractor and trailer combinations) have slightly less than 50 percent of the accident involvement rate of passenger cars, but have a fatality involvement rate that is nearly double that of passenger cars.⁽²⁾ In fact, in 1990, 4,061 people died in tractor-trailer crashes. However, only 12 percent were the truck occupants. The majority of the fatalities in these tractor-trailer crashes were passenger vehicle occupants.⁽³⁾

Driving errors that might not produce a crash in a smaller motor vehicle may well lead to a crash in a heavy vehicle because of its more limited maneuverability. The appreciation of these facts motivates the effort to define visual standards for driving that are most likely to lead to safer driving. In addition, the apparently greater difficulty of the CMV driver's vehicle control task and the obviously greater adverse consequences of heavy vehicle crashes

lead to the presumption that the visual requirements for the driver of a CMV should be more stringent than those thought to be appropriate for smaller vehicles. This view is reflected in the existing Federal vision standard for CMV operators.

The current need to reassess the bases for the Federal vision standard for CMV operators is motivated by many factors, such as more recent vision assessment technology and vision-driver performance evaluation methods.

PROJECT OBJECTIVES

Meeting the objectives of this project was accomplished in three ways: (1) by determining whether the current statement of vision test standards and testing procedures should be revised; (2) by defining the acceptable levels of vision necessary for operating a CMV, and (3) by examining the risk associated with certain “acceptable” levels of visual capabilities identified through vision tests and examination procedures. It is important to note that vision has traditionally been defined as an exclusively sensory task associated with transforming an object viewed in the environment into a light image on the retina and transmitting that image to the brain. Increasingly, however, vision-as it pertains to driving and other complex sensory-motor tasks-has become inextricably linked to more central processing or cognitive components of performance. The continuing evolution of performance standards may be expected to reflect this expanded analytical framework.

The technical objectives for specific project tasks were as follows:

- . Critical review and evaluation of scientific information and data sources pertaining to driver vision testing requirements for operating CMVs that weigh more than 10,000 pounds
- 4 Development of preliminary recommendations for revising vision test and testing requirements
- . Preparation of a risk assessment for the proposed acceptable level of vision provided in the recommendations
- . Conduct of a workshop to review draft recommendations with panelists representing industry and the visual science community
- . Summary of project findings including the draft recommendations for the vision test requirements and testing procedures; discussion of how the recommendations were determined; additional information and discussion of important issues raised at the workshop; suggestions for additional research to address unresolved problems; and other recommendations for licensing restrictions relating to specific visual impairments.

The final report consists of the Executive Summary and five main sections: Introduction, Project Objectives, Development of Recommendations, Proposed Revisions to the Standard, and Discussion. The five appendixes present a synthesis of the literature, a model developed for the risk analysis of a visual acuity criterion, the Federal Regulation for Physical Qualifications and Examinations for CMV Operators, the forms used for the Delphi approach, and the directory of panelists who attended the workshop.

DEVELOPMENT OF RECOMMENDATIONS

This section ~~describes~~ the research process used to arrive at the recommendations for revising of the current CMV vision standard. The ~~technical~~ approach included the following steps: (1) review and critical analysis of existing technical and scientific literature, and other information and data sources; (2) recruitment of a voluntary panel of experts in the fields of vision, driver safety, and the trucking industry for the purpose of ~~advising~~ the principal investigator and participating in a 1-day workshop; (3) preparation of a set of preliminary draft recommendations for changes to the standard; (4) use of a Delphi approach to estimate the relative significance of driver safety to visual tasks associated with visual capabilities tested in both the current and perhaps future standards; (5) assessment of the level of risk associated with a specified range of visual performance in a simulated truck driving scenario; and (6) conduct of an expert panel workshop for the purpose of eliciting advice and obtaining a consensus on the proposed changes to the standard.

REVIEW AND CRITICAL ANALYSIS OF LITERATURE AND INFORMATION

A review and evaluation were conducted of scientific literature, data, and other sources of information found to relate to the current Federal vision standards and the visual skills necessary to operate a CMV. This effort included a literature ~~search~~ a study of the history of the current Federal standard, and a comparative review of the standard with state and international driver licensing vision standards, along with AMA recommendations and other government guidelines. Also included is a critical evaluation of the empirical evidence relating driving safety and visual performance. The sections selected for Appendix A, Synthesis of the Literature are unabridged versions from the Task Report of the same title.

Literature Search

A comprehensive literature search was conducted using DIALOG's (Dialog Information Services, Inc., Palo Alto, CA) automated, online literature database system. Coverage of the following subjects was included: traffic safety, psychology, medicine, engineering, standards and specifications, **and** government research-related subjects. Keywords used in the online search included those relating to vision, vision screening and performance, vision standards and specifications, and truck ~~and~~ automobile operation. The majority of the relevant research literature was identified in the following databases: Medline (National Library of **Medicine**), NTIS (U.S. Department of Commerce), PsychInfo (American Psychological Association), and TRIS (United States Department of Transportation, Transportation Research Board). A manual search was also conducted through KETRON's transportation and traffic safety library and Scheie Eye Institute sources. ~~Finally~~, an automated and manual search was conducted by the Northwestern University Transportation Engineering library staff. Documents were obtained from academic and medical libraries and in-house sources.

Informal inquiries with visual science specialists, traffic safety engineers, state licensing agency personnel, and truck industry representatives were used to identify information and data that might have been missed or unpublished. Information on CMV vision standards was requested from more than 50 international standards organizations and international commerce, trade, and government organizations. Replies were received from approximately 35 percent of these organizations.

History of CMV Vision Standard

In the late 1930s, the Federal Government began regulating the vision standards of motor carriers in interstate commerce. The earliest vision standard for drivers of interstate trucks was specified in a general standard for medical fitness. The standard was very general and stated the following requirement: "Good eyesight in both eyes (either without glasses or by correction with glasses), including adequate perception of red and green colors." By 1939, the standard contained more specific minimum requirements for visual acuity, visual fields, and color vision. Table 1 provides a history of changes to the standard, which exhibits the standard moving in the direction of requiring more stringent visual capabilities. A complete description of the history of the standard is provided in Appendix A, Synthesis of the Literature.

The current vision standard is specified as part of the Federal medical standards (Code of Federal Regulations, Subpart E-Physical Qualifications and Examinations, Sections 391.41 to 391.49⁽⁴⁾) required to be met by operators of CMVs in interstate commerce. The commercial driver must be medically examined at least every 2 years and while on duty, a driver must have a certificate showing that he or she has passed the required examination. The examination covers the general health of the individual as well as setting specific standards for vision and audition. It also precludes individuals from driving if certain medical conditions exist, such as specific heart conditions and, important for vision, diabetes mellitus which must be controlled by insulin.

The visual requirements for CMV drivers are included in Section 391.41 and are stated as follows:

'Has distant visual acuity of at least 20/40 (Snellen) in each eye without corrective lenses or visual acuity separately corrected to 20/40 (Snellen) or better with corrective lenses distant binocular acuity of at least 20/40 (Snellen) in both eyes with or without corrective lenses, field of vision of at least 70 degrees in the horizontal meridian in each eye, and the ability to recognize the color of traffic signals and devices showing standard red, green, and amber.'

In addition, Section 391.43⁽⁴⁾ states that medical examination can be performed by a licensed doctor of medicine or osteopathy, and that a licensed optometrist can perform as much of the medical examination as pertains to visual acuity, field of vision, and the ability to recognize colors as specified in CFR 49. Section 391.41 paragraph (b)(1)

Table 1. History of the Visual Standard for CMV Operators

Date	Visual Acuity			Visual Fields		Red	Color Vision			Other Notes
	One Eye	Other Eye	Binocular	All Meridians	Horizontal Meridians		Green	Yellow	Amber	
1939 ⁽⁵⁾	20/40	20/100		45 degrees		Yes	Yes	Yes	-	-
1944 ⁽⁶⁾	20/40	20/100	-	45 degrees	-	Yes	Yes	Yes	-	-
1964 ⁽⁷⁾	20/40	20/40			140 degrees	Yes	Yes	Yes	-	Drivers requiring correction by glasses are required to wear them while driving .
1970 ⁽⁸⁾	20/40	20/40	20/40		70 degrees (uncorrected error)	Yes	Yes	Yes	Yes	
1985 ⁽⁹⁾	20/40	20/40	20/40		70 degrees (uncorrected error)	Yes	Yes	Yes	Yes	If Driver wears contacts, evidence to indicate good tolerance. ⁽¹⁰⁾

Few instructions for performing and recording the physical examination are **given**, but **instructions** regarding **specification** of **visual** acuity, prohibition **against monocular vision contact** lens tolerance, and **certain** common **eye conditions** are given as **follows**:

“when other **than** the **Snellen** chart is **used**, the **results** of such test **must** be **expressed in** values comparable to **the** standard **Snellen** test. If the applicant wears **corrective lenses**, **these** should be **worn** while applicant’s **visual** acuity is **being** tested. If appropriate, indicate **on** the Medical **Examiner’s Certificate** by **checking** the box, ‘Qualified **only** when **wearing corrective lenses**.’ **In recording** distance **vision**, use 20 feet as **normal**. **Report all** vision as a fraction with 20 as numerator **and the** smallest **type** read at 20 feet as denominator. Note **ptosis, discharge, visual fields, ocular muscle imbalance, color blindness, corneal scar, exophthalmos**, or operate commercial motor **vehicles under existing** Federal Motor **Carrier** Safety Regulations. If the driver **habitually wears contact lenses**, or intends to do so **while** driving, there **should** be **sufficient** evidence to indicate that he has good **tolerance** and is **well** adapted to **their** use. The use of **contact** lenses should be noted **on** the record.

A critical review of the **current standard** has found that a problem exists in **the** statement of the **visual field requirement**. The standard, as **published** in **the** Federal **Register**⁽⁸⁾ in 1970, states that a **70-degree** field of view is the minimum **requirement** for **each** eye. The Federal Highway **Administration** has taken **the** position that **the visual field standard** **should specify 140 degrees** of **visual** field as the **minimum requirement in** each eye.. The specification of 140 degrees for field of view in each **would be** close to **the** limit **expected** for a normal healthy adult eye. **In** addition, **problems were** found **with the** color vision **requirement, which on** a practical **basis** is probably **unenforceable**. The color **requirement** as **now** stated **would** not exclude red-green color-defective **drivers since** the standard does not provide adequate instruction **on** requirements for color vision **testing**. It is **also** doubtful that the standard intended to exclude typical red-green color-defective drivers **since these** drivers currently **are on** the road **and there is a lack** of evidence that **their** driver safety record is **worse than** the **one of those without** such color defects. Other specific issues **were identified relating to the** impact of **raising the** vision standard, **administration of** standards, **uniformity** of testing, and additional factors **that affect driver** safety.

Standard and International Visual Standards

Every State administers a **vision** test to **individuals** applying for a motor vehicle **license**. **Vision** standards **vary** slightly from state to state, but states that do **conduct visual screening** have a visual acuity **requirement** for intrastate **CMV licensing**. Other visual requirements **vary considerably in** different **states, with** many states **requiring visual** fields **testing, and** several **requiring** color **testing**. Some states have a **stereopsis** requirement. For **the** most part, State **vision** standards for intrastate commercial **driver licensing** are less **stringent than** the Federal standard for interstate commercial **driving licensing**. For example, **even though** a **binocular (best corrected)** visual acuity requirement of 20/40 is the standard **in** almost **80 percent of the** states, **less than** 10 percent of **the** states have reported denying a **license** for **monocularly**. **Figure 1** identifies the **binocular visual** acuity standards by percentage of states. **In** addition, approximately **38 and 36** percent of the **states** have a **visual** field **standard** for each eye and **in** both eyes. Nearly 24 percent of **the** states **have** a **color perception standard**, and for most states, the

standards are for recognition of **red, green, and amber**. In addition, **periodic** vision screening is **administered** in about **72** percent of the states.(“)

Review of the foreign **vision** standards for **CMVs** revealed wide variance among the **industrialized** countries where information **on** vision standards was identified **Visual** acuity for **each eye** is specified, with most countries requiring better than the **current 20/40** Federal requirement. Only a few countries have a **binocular** acuity requirement and it is more stringent than the Federal **20/40** requirement. For **visual** fields, most countries state that the drivers must have **"normal"** fields or **"full"** fields. Most of the countries did not have a requirement for color.

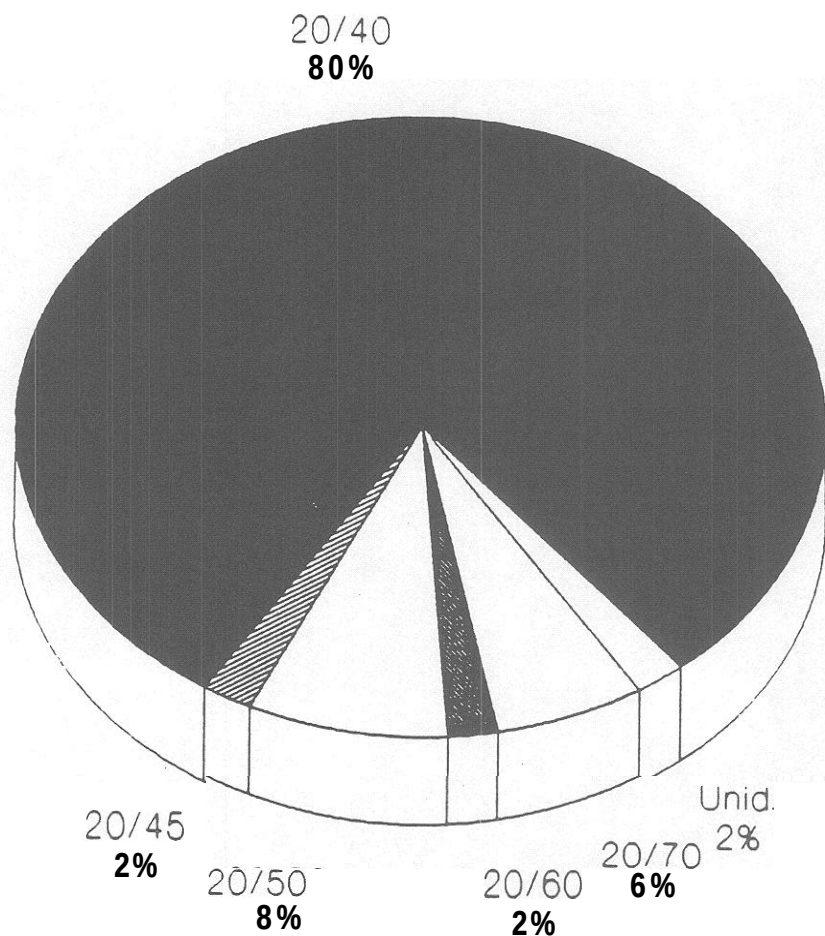


Figure 1. Binocular **Visual** Acuity Standard for **CMV** Operators

However, many had **other visual** requirements, **such** as **stereopsis**, and **will** deny **licensure** for **visual** disorders and impairments **such** as **aphakia, ametropia, diplopia**, myopia, night blindness, and **nystagmus**. In addition, many of **the** countries reported that **they** required periodic **checks** for vision.

Medical and Government Guidelines and Recommendations

The American Medical Association **has** participated **in** setting vision standards for CMV operators and has provided **guidelines**⁽¹²⁾ for vision testing to its members. The **guidelines published in 1986** differ from the Federal vision standard in **excluding** high-power **spectacle** lenses (10 **diopeters** or greater) **and in** requiring **visual** acuity in each eye of **20/25** or better compared to **20/40** for the **CMV** standard **In addition**, other **visual** disorders are **discussed including stereopsis**, nighttime **vision**, **diplopia** and **oscillopsia**, but **specific** recommendations for **excluding** drivers **with** these conditions are avoided

The U.S. Department of Transportation and National Highway **Traffic** Safety **Administration**, **in** cooperation **with** the American Association of Motor **Vehicle** Administrators, **published** a **1980 booklet** entitled "Guidelines for **Motor Vehicle** Administrators; **Functional** Aspects of Driver Improvement-A Guide for State Medical Advisory **Boards**."⁽¹³⁾ This **booklet** presented a **set** of recommendations for **all drivers** otherwise **medically** capable of **operating** commercial **vehicles**, **including** heavy trucks. The recommendation for **visual** acuity **differs** from the Federal vision standard but is the same as that **proposed** by the AMA (i.e., **20/25** or better is required in each eye, not **20/40** as **specified** in the Federal standard). **The** recommendation for **visual** **Gelds** is specified as 140 degrees for each eye **in** the horizontal **meridian**. The recommendation for color vision is the same as the Federal vision standard and AMA recommendations (i.e., **ability** to **distinguish** red, green, and **yellow/amber**). **The booklet provides** recommendations for **visual** acuity, **visual** fields, **ocular motility**, color **discrimination**, depth perception, dark adaptation, **refractive** states, and **strabismus** (crossed eyes).

Driving and Vision Performance: Empirical Evidence

A major effort was undertaken to identify **research which** reported measurements of the relationship between many aspects of **visual** performance **and accessible** indicators of driving safety. The studies identified were **primarily post** hoc **analyses** of data already **accumulated** through routine driver registration testing and record keeping. However, some studies introduced novel **controlled vision** testing methods into the driver testing routine designed to obtain data **on** a broad **scale which** could then be **correlated with the driving record over time**. **The** Literature search found numerous research projects that examined the **relationship** between **vision** test **results** for operators of motor **vehicles** and their driving performance record (i.e., accidents and violations), dating back to the mid-1950s. Most of these studies were **initiated** to determine what **visual skills** best **correlate** with **driving** performance. The **results** were used to recommend to state licensing agencies the most **practical** vision tests to **administer** to **license** applicants and renewals. Many of the studies focused on **vision** tests **that** were easily accessible through **commercial** vision screening devices. However, some of the studies **involved** developing customized vision testing apparatus, and some **used clinical** testing equipment known to be **impractical** for mass vision screening in a **licensing** bureau **environment**. In addition, most of the research **focused** on **the** passenger **vehicle** operator and **only** a few studies investigated the visual and driving **performance** of the CMV operator.

Passenger Vehicle Operators and Vision Performance—The most **significant** research efforts on vision **performance** of passenger vehicle operators versus **driving** performance records and on vision performance of CMV operators **versus** driving performance records are summarized in **this** section. The Synthesis of the **Literature** in Appendix A provides a more detailed description and critical review and **evaluation** of the **research** to date.

One of the earliest, most comprehensive studies on the relationship between **vision** and **the driving performance** record was conducted by **Burg**⁽¹⁴⁻¹⁷⁾ on over 17,500 drivers over a **3-year period** in the 1960s. **Driving** habits (**annual mileage** reported), **age**, and gender were reported **in** addition to information on their vision test **performance** for dynamic visual acuity, static **visual** acuity, lateral **visual** field, low-light recognition **thresholds**, glare recovery, **and** sighting dominance. Of **the** vision tests analyzed **in relation** to **traffic convictions** and accidents (reported), **statistically significant** correlations found between vision and **the driving performance** record were **very weak**. Like other researchers **from** the 1960s,^(18,19) Burg reported that **mileage** and age were **the** most **powerful** predictors of **traffic** accidents and convictions. **Further analysis** of the **Burg** data by Hi and Burg **in** 1977⁽²⁰⁾ revealed a **small** but **significant** correlation between static and dynamic visual tests, **and glare recovery** tests and accident rates for drivers over age 54.

In the early 1970s, the U.S. Department of Transportation was interested **in** the **results** of the **Burg** studies. **The** Department initiated a series of **investigations** designed to develop a battery of vision tests that were more **functionally** related to driver performance and safety, and that could **lead** to the development of a vision testing device for use in **screening** driver's license applicants or renewals. **In** this study, Henderson and **Burg**,⁽²¹⁾ after reviewing prior **literature** and analyzing earlier data, provided a systematic analysis of the **visual** requirements for driving. The initial phase of the study **identified** important **visual** functions: static visual acuity (**normal illumination**), central **angular** movement, **central** movement-in-depth, useful peripheral vision, static acuity (low-level **illumination**), **field** of view, eye movement and **fixation**, dynamic **visual** acuity, accommodation **faculty**, and **glare** sensitivity. These **visual** functions were incorporated into a **prototype** vision testing device (**the MARK I Vision Tester**). Over **600 license** renewal operators were screened **on** the device. Accident statistics were **collected** for the preceding 3 years for each operator. Results showed a moderate, consistent, age-related **decline** for **all the** visual functions. **Significant** age-related loss in **visual ability** was reported for static **acuity** under **normal** and low illumination, glare, and dynamic **acuity**. However, the correlational **analyses** conducted to **assess** the potential predictive **validity** of **the** MARK I showed many **significant** correlations **in** the direction of poor visual **performance** **statistically** related to a **good** driving record.

The U.S. Department of Transportation, encouraged by some of the results of the MARK I study, decided to **continue this** research **in** an effort to establish a generally **valid** vision screening device for motor vehicle department use. **Further testing** by Shinar⁽²²⁻²⁴⁾ on 890 licensed operators revealed very low correlations between accident rate measures and visual performance. **In** fact, no **significant correlation** existed between vision and **driving** records for the 25 to 54 age group. Additional testing indicated that poor dynamic and static visual acuity under

low levels of illumination was most consistently related to accidents; poor static acuity under low levels of illumination was related to nighttime accidents. There was also a relationship between central angular movement and accident involvement. In addition, none of the single vision tests was significantly associated with accident involvement for all age groups, but each test was significantly associated with accident involvement for one or more of the age groups. Results for the battery of vision tests and the driving statistics did not establish a clear-cut relationship between specific visual tests and the driving record.

Another important effort, conducted around the same period by Hofstetter,⁽²⁵⁾ correlated the visual acuity test scores of 13,700 drivers with self-reported accidents during the previous 12-month period. Data were collected nationally, over a period of 10 years, by means of a survey form given out in a variety of settings and populations, with support from the Auxiliary to the American Optometric Association, using commercial vision screeners. Accident rates for persons with acuity in the lower quartile of the measurements were compared to rates for persons with acuity above the median measurement. Drivers in the lower visual acuity group were found to be twice as likely to have had three accidents in the previous year as those with acuity above the median, and 50 percent were more likely to have had two accidents. No significant differences were found between the lower acuity and higher acuity drivers when only one accident was used as the criterion of comparison. This study provided some evidence of the connection between poor visual acuity and increased accident frequency. However, these results applied only to the very poor visual performers compared to the best in the driver cohort.

Studies on visual fields and glare were also conducted in the 1970s. Council and Allen⁽²⁶⁾ compared horizontal visual field measurements to accident rates for more than 52,000 drivers and found that only 1 percent of the drivers recorded a horizontal field of 120 degrees or less, and that the accident rate for these drivers was no higher than the rate for those whose fields were greater than 120 degrees. Studies on glare sensitivity incorporated into other vision testing using the MARK I and MARK II⁽²²⁾ devices were also unable to show any significant relationship. Wolbarsht⁽²⁷⁾ conducted a study of glare sensitivity using a modified commercial vision screener with a customized overlying glare source of controllable intensity. He tested 1,500 driver's license applicants and renewals for glare sensitivity at three veiling glare ratios (background:target) of 2:1 (high glare), 4:1 (medium glare), and 8:1 (low glare). The results showed no significant correlation between glare sources and driving performance, although the average glare sensitivity scores did increase with age.

Research on assessing visual and driving performance continued in the 1980s. Keltner and Johnson⁽²⁸⁾ used automated static perimetry to screen more than 500 drivers for any evidence of visual field loss in 1980. This technique found that approximately 5 percent of the motorists had significant visual field loss compared to only 1 percent found to have a noticeable deficit in the study by Council and Allen,⁽²⁶⁾ who tested only in the horizontal meridian. In addition, Keltner and Johnson reported that subjects over age 65 had four to five times the incidence of visual field deficits of younger persons. For the Keltner and Johnson study, field loss was defined as substantial depression of all or part of the peripheral visual field and/or an inability to detect two or more adjacent visual field

points (scotoma). This project was extended⁽²⁹⁾ to compare the visual field loss of 10,000 volunteer drivers with accident/conviction histories. For this larger study, it was found that drivers with visual field loss in both eyes had accident and conviction rates that were twice as high as those for drivers with normal visual fields. The results were statistically significant. It was suggested that decreased performance on a visual fields test probably results from age-related decreases in retinal illumination and other acquired vision impairments (such as glaucoma, degenerative myopia, diabetic retinopathy, and retinal detachment) which are more common in older age groups.

Another study, conducted by Davison⁽³⁰⁾ in 1985, examined 1,000 motorists who were randomly stopped in and around a town in England and asked to volunteer for a vision test and provide information on driving record, vision examination history, and other demographic information. Significant positive associations were found between accidents and right-eye or left-eye visual acuity and binocular acuity for all drivers and a relationship between accidents and heterophoria for drivers who were over 55. A recently completed study⁽³¹⁾ for the Pennsylvania Department of Transportation was undertaken to determine the value and feasibility of periodic vision screening during license renewal. The study examined the relationship of three vision measures (static visual acuity, horizontal visual fields, and contrast sensitivity) to accident and violation records for over 12,400 licensed operators who were unaware that they would be tested. It was found that drivers who failed the Pennsylvania Department of Transportation visual standard or scored below "normal" on the contrast sensitivity test were at a significantly higher risk for accidents in only the two oldest age groups (66 to 76 and 76+). However, the researchers found no significant relationship between poor vision performance on each of the vision tests analyzed separately with accident and violation records.

For the most part, significant statistical relationships between specific vision test scores and driver performance records (for passenger vehicles) have not been clearly established. Many researchers have stated that difficulties in trying to relate driving performance to visual capabilities can be attributed to the follow

- Vision is only one of many factors influencing driving performance.
- Some vision tests may not really relate to visual requirements of driving.
- Reliability of criteria used to measure driving performance may be low.
- Research methods may have used unrepresentative samples of the driving population
- Individuals with visual difficulties often place self-imposed limits on their driving, thus reducing their exposure to the risk of an accident.

CMV Operators and Vision Performance—In 1973, Henderson and Burg attempted to relate CMV driving skills to the visual tests included in the MARK I Vision Tester.⁽²¹⁾ Their goal was to establish a sound scientific basis for minimum visual standards for the Office of Motor Carriers. The relative importance of different aspects of the driving task was established by examining literature, interviewing truck drivers, observing truck drivers

in **action**, and conducting a systematic **examination** of the driving task. The **researchers established a** hierarchy of importance for the visual functions selected as most important. Weights were assigned to various driving **behaviors** and to **each visual** function according to its judged importance to driving behavior. Those **visual** functions judged to be **most important to** the truck driving task and necessary to **an analysis** comparing visual performance and accidents and violations were static **visual acuity**; dynamic visual acuity; perception of **angular movement**; perception of movement-in-depth, visual **field**, movement-in-depth and steady, **saccadic**, and pursuit **fixations**; **glare** sensitivity, and **angular** movement. **Significant** relationships between accidents and poor **visual** performance were found only with measures of perception of movement and dynamic **visual** acuity. No correlation was found between static **visual** acuity or field of view and accident frequency for commercial drivers.

In a more recent attempt to correlate **visual** performance **with** accident record, Rogers, **Ratz**, and **Janke** in 1987, ⁽³²⁾ compared the driving records of **visually** impaired heavy-vehicle operators with the records of a sample of visually **nonimpaired** heavy-vehicle drivers. **The** purpose of the project was to determine **whether** the Federal vision standard could **be** justified based on the traffic safety record of these drivers. The records of more **than** 16,000 heavy-vehicle operators registered by the California Department of Motor **Vehicles** were examined. Measures of driving performance consisted of **2-year** total accidents and **convictions** associated **with** incidents involving commercially registered vehicles. **Visually** impaired operators were categorized into **two** subgroups of substandard static **acuity**: (1) moderately visually impaired (corrected acuity between **20/40** and **20/200** in the worse eye, **20/40** or better in the other), and (2) severely **visually** impaired (corrected acuity worse than **20/200 Snellen** in the worse eye, **20/40** or better **in** the other). **Nonimpaired** drivers met current Federal acuity standards (corrected acuity of **20/40** or better in **both** eyes). Analysis results, adjusted for age, showed:

- **Visually** impaired drivers had a **significantly** higher incidence of total accidents and **convictions** and commercial-plate accidents and **convictions** than did **nonimpaired** drivers.
- Moderately impaired drivers had a significantly **higher** incidence of **commercial-plate** accidents than did **nonimpaired** drivers.
- The incidence of total accidents did not significantly differ between **the nonimpaired** and moderately impaired drivers.
- Severely impaired drivers had a **significantly higher** incidence of commercial-plate **convictions** **than** did **nonimpaired** drivers.
- **Nonimpaired** and moderately impaired drivers did not **significantly** differ on commercial-plate convictions.
- Drivers licensed to operate any combination of heavy vehicles had a higher incidence of total accidents and convictions and commercial-plate accidents and convictions than did those licensed to operate single **vehicles** having **three** or more axles.

These **findings** lead to qualified support for the current Federal **visual** acuity standard, particularly regarding exclusion from driving of the severely impaired (visual acuity below **20/200** in the worse eye, **20/40** or better **in** the other). Less support is offered regarding the restriction of the moderately **visually** impaired heavy-vehicle operator (visual acuity between **20/40** and **20/200** in the worse eye, **20/40** or better in the other).

Another recent study **identified in the literature assessing** the relationship between vision and truck operator performance was conducted by **McKnight et al.**⁽³³⁾ He examined visual and driving performance of monocular and **binocular** tractor-trailer drivers. On **the** visual measures, **the monocular** drivers were **significantly** deficient **in** contrast sensitivity, visual acuity under low **illumination** and glare, and **binocular** depth. However, **monocular** drivers were not significantly deficient in static or dynamic **visual** acuity, visual field of individual **eyes**, or glare recovery. **In** addition, driving measures of visual search, lane keeping, clearance judgment, gap judgment, hazard **detection**, and information recognition showed **no differences between** monocular and **binocular** drivers. The **one** exception was **sign-reading** distance, which **was defined** as the distance at which signs **could** be read **during** both day and **night** driving in a controlled road test. The **binocular** drivers were **first** able to read road **signs** at significantly greater distances than were the monocular drivers in both daytime and nighttime **driving**, and this decrement correlated **significantly** with the **binocular** depth perception measure. **McKnight** also reported a large variation **in** visual and driving **measures** among monocular drivers and several **significant** differences between them and **binocular** drivers., **suggesting** the need to assess the monocular drivers' **visual** functioning **capabilities** more closely and the need to continue research in identifying visual performance measures that **significantly** correlate **with** measures of safe driving skills.

only a few studies examined the relationship **between** driving performance record of CMV operators and their vision performance and they did not provide enough support to propose. **definitive** changes to the current Federal vision standards.

RECRUITMENT OF EXPERT PANEL

Potential members for the expert panel and workshop were identified through the **FHWA**, OMC, by contacting professional medical, vision, and **traffic** safety organizations, and by soliciting candidate **names** from leading experts in the vision and traffic safety field. The **following** professional organizations were represented in the selection **process** and ultimately on the **panel**:

- . American Ophthalmological Society
- . American Optometric **Association**
- . American College of Occupational Medicine
- . American Medical Association
- . American Trucking Associations

- Human Factors Society
- **Transportation** Research Board
- **American** Psychological Association

Representatives from the **Insurance Institute** for **Highway** Safety, Association for the Advancement of Automotive Medicine, **and** International Brotherhood of Teamsters were invited but were unable to attend the workshop due to prior commitments.

The list of potential panelists was reviewed and **refined with the FHWA, OMC**. Invitation letters were sent to **those** on the **final list**. **An** explanation of the project and **the** expected role of each panelist, **in** providing **advice** and participating **in** the workshop, was provided. The **following** panelists accepted the invitation to participate on the panel:

- Merrill I. **Allen**, O.D., Ph.D.; Indiana University, School of Optometry
- Clifford Anderson; Medical Resource. Services **Diagnostics**, Inc.
- **Karlene** Ball, Ph.D.; Western Kentucky University, Department of Psychology
- Bernard **Blais**, M.D.; General Electric **Corporation**, Medical **Director**
- Raymond P. **Briggs**, Ph.D.; Perceptual Safety **and** Systems **Research**
- **Neill Darmstadter**; American Trucking Associations, Senior Safety Engineer
- Chris **Johnson**, Ph.D.; University of California, Davis, Department of Ophthalmology, School of Medicine
- Arthur H. **Keeney**, M.D., Ph.D.; **University** of Louisville, **Lions** Eye Research Institute
- A. James **McKnight**, Ph.D.; National **Public Services Research** Institute
- Cynthia **Owsley**, Ph.D.; University of Alabama, **Birmingham**, Department of Ophthalmology, School of **Medicine**
- Sandra Z. **Salan**, M.D.; Social Security **Administration**, Office of Medical Evaluation Branch
- **Frank Schieber**, Ph.D.; Oakland University, Department of Psychology

Appendix E provides their addresses and telephone numbers.

RECOMMENDATIONS PRIOR TO WORKSHOP

Preliminary recommendations to the CMV vision standard were presented in a task report. A review of the current standard brought out **deficiencies in** three areas:

- **Errors in** the statement or intent of the standard;
- Practical limitations to testing procedures or **enforcement**; and
- Substantive changes **to** the standard that **could be** supported either by **new** empirical evidence **linking** the current tests to measures of driver safety or by new technical developments in **vision testing**.

For each **visual function specified in** the standard, problems were as **follows**:

- **Visual Acuity**—lack of **specificity in stating** conditions for **testing**,
- **Visual Acuity**—apparent error **in** the statement of **horizontal field** extent and **unspecified** methods for testing,
- **Color Vision**—**unclear intent** of standard, **unspecified** methods for **testing**, and problems with **enforceability**.

Other areas considered for change were the **visual disorder checklist**, **new** areas of testing, **and** enforcement procedures:

- **Visual Impairments and Disorders**—**appropriateness** of disorders **listed or** unspecified action if disorder **is** present
- ✗ **New Areas for Testing**—**contrast** sensitivity, low-contrast acuity, **glare sensitivity and** recovery, automated **visual** field testing, dynamic **visual** acuity, and **useful** field of view
- ✗ ✗ ✗ ✗ ✗ ✗ ✗ ✗ ✗ ✗ ✗ ✗ ✗ ✗ —**medical** testing vs. state agency **testing**, **restriction of** **specialty** for medical testing, medical card as an enforcement **procedure**, and periodic **renewal** or retesting

The remainder of this section presents a summary of the rationale for the preliminary recommendations set prior to the workshop.

Visual Acuity

Acuity of vision is **defined** as a measure **of the ability to resolve minimum visual angle of separation between** otherwise **continuous** parts of a letter or form. **The acuity** testing most often performed involves a wall-**mounted**, printed chart of letters or forms and relies on verbal response of the patient. Testing is inexpensive, requires low **technology**, is easy to **administer**, and takes only minutes to complete. **Measures** of acuity are **among** the oldest forms of systematic visual measurement and have in recent years received **intense** criticism as incomplete

and inadequate for characterizing overall **visual** status. On the other hand, it is doubtful that **any eyecare specialist** would consider a **visual exam** complete without taking such a measurement. In emergency **eyecare** situations, the **first** important piece of information comes from a **measure** of acuity. In all ophthalmologic exams **begin with** a measure of acuity. In spite of **intense** and often valid criticism, a **consensus** among **eyecare** specialists still places **visual** acuity at the top of the list for **being** the most **used** and useful visual test. As **an** efficient and **useful** test of vision, **visual** acuity has withstood the test of time.

The current CMV standard requires at **least 20/40 Snellen** acuity at distance in each **eye measured** separately either with or without **corrective lenses**. An additional requirement is **20/40 binocular** vision at distance. The level of **20/40** represents **an** arbitrary criterion, which is supported by a consensus that vision **poorer** than this level **introduces** risk into the **driving** task. A **review** of both state and international visual **standards** for driving found that **the 20/40** standard is representative of other standards and is, if anything, lenient in terms of currently accepted criterion values. The mode for state acuity standards for CMV **drivers** is **20/40** (40 of the **50** states), **and** for selected industrial countries the mode for **monocular vision** is **20/30**. At this time, no evidence or method can elicit **an** objective judgment **that an** acuity criterion other than the one already established by **consensus** should be selected for CMV drivers. On this issue, research evidence **presented in the** Synthesis of **the Literature (Appendix A)** showed **that** the difference **between visual** acuity scores for drivers without accidents, compared to drivers with accidents or citations, was not sufficient to support statistical **discrimination** against poorer drivers on this basis. However, **in** the absence of a **better performing** test that is **also** efficient and robust with **respect** to the level of technology and actions on the part of test **administrators**, visual acuity provided **the best and** simplest **method** of **obtaining a meaningful** measure of **vision**.

What **was** not **specified** in the standard were the conditions under **which the test** should **be** conducted. This area **is** important because acuity scores **can** vary **significantly, depending** on **factors such as the type** of test **used** (e.g., **Snellen** letters, **Rolling E**, and **Landolt C**), illumination level, **effective viewing distance**, and effective letter contrast. Whereas the acuity test is robust **relative** to many other **modes** of testing **under such** conditions, variation on the order of the difference between standards adopted by different **countries** or states **can** be expected (i.e., **20/20** to **20/50**). For this problem to be **minimized**, limits on test conditions **should be specified within** the **standard**. The guideline for this **specification** should conform to current routine **ophthalmological practice and** not exclude current **semiautomated** commercial **screening** devices such as **Mast/Keystone's DVS II**, **Titmus' Titmus II-DMV**, and Stereo Optical's **Optec 1000**. However, **even these devices** do not provide consistent results **on** acuity scores for **the** same or similar subjects. A model paragraph for **insertion** into the standard would be similar to the following one:

Test charts should **be** illuminated with white light (color **temperature** from **2500⁰ K** to **7500⁰ K**) at a level **well** within the photopic **range**. Luminance readings from the white part of **the** chart **should be between** **30 cd/m²** and **120 cd/m²**. **Optotypes** should **be presented** as black on

a white background. The Snellen optotype is the preferred target. However, other optotypes such as Sloan letters, numbers, rolling E, Landolt C and geometric patterns are acceptable. when other than the Snellen chart is used, the results of such test must be expressed in values comparable to the standard Snellen test. In recording distance vision, use 20 feet as normal. Report all vision as a fraction, with 20 as numerator and the smallest type read at 20 feet as the denominator. Note visual disorders. If the applicant wears corrective lenses, they should be worn while the applicant's visual acuity is being tested. If appropriate, indicate on the Medical Examiner's Certificate by checking the box, Qualified only when wearing corrective lenses."

Visual Fields

The field of view is the visual solid angle within which vision occurs or the area of physical space visible to an eye (or eyes) in a given position. Each eye has an independent field of view, which in a young normal observer extends about 140 degrees along the horizontal meridian (90 degrees in the temporal direction and 50 degrees in the nasal direction) and somewhat less in the vertical meridian; and both eyes together have a combined field of view that covers about 180 degrees horizontally. The combined field of view has a central region where the fields of view from each eye overlap and provide binocular vision capable of perceiving three dimensions. The overlapping field is approximately 100 degrees centered on the horizontal meridian.

In 1970, the CMV vision standard was revised to include a requirement for visual fields of "... at least 70 degrees in the horizontal meridian in each eye...." As reviewed under the Synthesis of the Literature (Appendix A), the intent of this portion of the 1970 revision of the visual field requirement was not clear. A portion of the intent of the 1970 revision appeared to be a restatement of the requirement in terms of monocular testing, which was the normal medical practice. However, the extensive overlapping of binocular fields meant that a binocular specification could not simply be divided by two to arrive at a monocular specification. One could not reasonably assume that the intent of the 1970 standard was to make the visual field requirement much less stringent than even the 1939 specification.⁽⁵⁾ In all probability, a simple error occurred and the monocular field should have been 140 degrees. Because of this ambiguity in the statement of the standard, a reevaluation of the wording and intent of the visual fields specification was necessary.

The following wording was recommended: "... field of vision of at least 120 degrees in each eye measured separately in the horizontal meridian." This correction would follow the intent of measuring each eye separately, but not be so stringent as to exclude drivers who do not exhibit clear pathology. A larger number is possible, up to the 140-degree limit of normal for a younger person, but if adopted would leave little room for normal variation with age and for errors in accuracy of testing or equipment calibration. Also believed unnecessary was a binocular

Geld **specification** since problems in **binocularity**, important to **driving**, would be discovered **through** routine **binocular** acuity **testing**. Moreover, the standard already stated **that** monocular drivers (or those with severe field deficits in one eye) were **specifically** excluded.

As with visual acuity, the conditions and methods for testing are **an** important **source** of **variance** for test **scores** measured in practice. The limitation of **the** standard to the **horizontal field** of view is already **specified**. This limitation is **justified in that** pathologic **decrease in** visual field extent important to driver safety **would** only rarely be **confined** exclusively to **the** vertical meridian. **One** can expect that **significant** decrease in visual **fields will** often be associated with deficits in other **visual** modalities **such** as acuity. Recent **studies** have shown a relationship **between** **carefully** measured static **full** fields and accident rates;⁽³⁴⁾ but even **with** reduced testing programs, **the** time and **resource** expenditure appears to outweigh any real advantage of **such** testing as a screening **procedure** on **all** drivers. The **philosophy** of the standard, thus far in its **evolution**, is **that** a **screening** exam should be performed on **all** applicants equally. Inclusion of expensive or **technologically** difficult exams would **run counter** to this well-accepted practice.

The **current** methods of testing horizontal **fields in the** **driver** screening context are **the confrontational** technique, **the** tangent screen (**both** usually employed as part of the medical exam), and variations on detecting a **small** light **stimulus** in a dark surround along **the** horizontal **meridian**. Large variations may **occur in the** luminance and size of the test objects, and the variations can affect the **measured** field extent. **These** tests are designed to measure the largest extent of the horizontal field only and **cannot** detect defects **within** the field or specify sensitivity in any **meaningful** way. The basic techniques are adequate for screening **purposes**, but **minimum** stimulus **conditions** should be **specified to eliminate** large variations in test results from one test situation to another. All commercial screening **devices** have adopted the technique of detecting a small bright light in a dark surround, and the variation among these devices is relatively **small**. Presented below **is** a **model** paragraph for insertion in the standard along **with the specification** of the visual **field** test conditions:

The visual **field** test **should** be conducted on **an** apparatus capable of testing the horizontal Geld of **view** to a minimum of 40 degrees nasally and **80** degrees **temporally** for each eye. The angular **subtense** of **the** test **object should** be between **10** minutes of arc and 2 degrees of arc. **The luminance** of the test object should be **between** 5 and **25 cd/m²**. **The** background **should** be **dark**.

Color Vision

Normal color vision is **trichromatic**; i.e., **only** three primary **colors** separated **sufficiently** in the spectrum **are** required for **an** observer to mix and match **all** other possible **colors**. The **normal** color observer can easily **distinguish** red, yellow, **and** green **in the** long-wavelength end of the spectrum. **However**, this **task** may be difficult **to** or **impossible** for certain **classes of observers** who do not have normal **photopigment absorption** in their middle or

long-wavelength **cone receptors**, or for individuals **with** acquired ocular disease. A defect **of this type** could conceivably **contribute** to unsafe **driving**. However, the largest class of color-defective observers, those **with** one of four types of **congenital red-green** defect, has been **studied** repeatedly in a driving context and **has** not shown poorer driver safety performance than normals. ^(35,36) **This** result might seem **surprising** since important driving information is conveyed **through** color-coded **traffic control signals** and devices. However, **even these** devices have been designed to **minimize** the color **discrimination** problem to the **class** of long-wavelength-defective drivers. The devices **accomplish** this task **mainly** through **the** standardized restriction of **the** green traffic signal to that part of **the** color space perceived as white (or gray) to **the** most severely red-green color defectives (dichromats). Thus, **the** green signal is readily distinguished from **the** red and yellow, **which** appear yellowish to **these** drivers. **Although red/yellow** confusions may still occur, they apparently are not serious enough to introduce a **significantly higher** level of risk **on** the part of **these** drivers. Position and other **noncolor cues** also **contribute** to safe **discrimination** of information conveyed by color traffic control devices.

As a practical matter, observers who are completely color-blind from bii (those who **cannot** reliably distinguish colors in **any** part of the spectrum, also referred to as **achromats**) **have** very poor **visual** acuity associated **with the** disorder. **Such** individuals are easily **identified** from bii or **will** certainly be screened **with a visual acuity** test; they do not require a **color** test for screening. **Similarly**, drivers who **acquire** color vision defects as a result of **ocular** disease **will** also tend to **exhibit** other, more **definitive** signs of the decrease **in visual** functional capacity. **Visual** acuity **loss**, **visual** field constriction, **loss** of **binocularity**, or general deterioration in health related to more systemic problems, **such** as diabetes **mellitus**, **will** be detected **through other** parts of the **vision** exam or **through the** medical exam.

In practice, the current color test standard does not screen out congenital red-green defective drivers, partly because the **ability** of red-green color-defective individuals varies **significantly** with the angle of stimulus **subtense**.^(35,36) For large angular **subtense** (more than 5 to 8 degrees, **depending** on the **observer**), even red-green dichromats can differentiate among red, green, **and** yellow spectral lights. **These** same observers are **totally unable** to distinguish **colors** in this spectral range for **small lights** subtending 2 degrees or **less**. Thus, dichromats typically “pass” a color test presenting large enough stimuli **that** are **well** saturated and reasonably **bright**, but fail any classic test of red-green **color** vision such as **pseudoisochromatic** plates (colored dots of one color **that** show a number or pattern within colored dots of **another** color) or **small field** spectral color matching (**anomaloscope** testing).

The current or past color vision standards were probably not stated **with** the intent of screening out the 8 percent of the male population who are congenitally color-defective in the red-green part of the spectrum. One **can** infer this conclusion partly from the loose wording of **the** standard, **which** most specialists would **recognize** as too lenient to provide efficient screening. Certainly a color standard for efficient screening could be specified. **This** course of action was not recommended. **The** literature on color vision and past experience of participation by **these** drivers **provided** no evidence **that would** warrant **the** exclusion of this class of drivers from **the** road **as** CMV or

private drivers. Instead of retaining the current ineffective standard or its revision, the color test requirement was deleted. Note that 11 of the 15 industrialized countries identified in the Synthesis of the Literature (Appendix A) do not specify a color test standard.

Visual Impairments and Disorders

Including items on visual pathology as well as functional tests of vision (visual fields and color vision) on the medical examination checklist has raised questions about the intent of the standard in these areas. On one hand, clear statements specifying minimum visual performance are present in the current standard, along with instructions on qualification to drive a CMV; i.e., the applicant must meet these minimum requirements. On the other hand, a long, but incomplete list of ocular pathology is presented as part of the medical exam and unclear instructions are presented about the intent of this part of the exam in terms of the disposition of the applicant if such conditions are noted

The ambiguity created by this dual specification needed to be resolved. Beyond noting potentially harmful ocular conditions found during the medical exam, the checklist should be complete and the items listed in the same order of medical importance. Moreover, a clear statement of the intent of this part of the exam should also be included. In other words, these conditions should be brought to the attention of the applicant so that treatment, where available, can be sought. Disqualification should not be made on the basis of noting one of these conditions. Instead, applicants should be disqualified for visual reasons only if they fall below the minimum visual performance level specified in the current standard. Virtually all pathologies noted on the checklist will eventually have consequences for vision that will be detected by the specified tests of visual performance, provided such tests are rigorous and uniform. This recommendation appears consistent with current practice.

The standard (CFR 391.43, 1985) states that when the following medical conditions involve visual consequences, they must be noted:

“Note ptosis, discharge, visual fields, ocular muscle imbalance, color blindness, corneal scar, exophthalmos, or strabismus, uncorrected by corrective lenses. Monocular drivers are not qualified to operate commercial motor vehicles under existing Federal Motor Carrier Safety Regulations.”

A form for recording this information at the physical examination is also specified in the standard:

Vision: For distance:

Right 20/____ Left 20/____

____ Without corrective lenses

____ With corrective lenses if worn

Evidence of disease or injury:

Right _____ Left _____
Color Test _____
Horizontal field of vision:
Right _____ Left _____

Definitions of the listed visual/medical **conditions** and their importance to driver safety **are** presented next. **Ptosis** refers to the drooping of the upper eyelid. Causes for **this condition** include lid muscle weakness, damage to the **oculomotor** nerve, and interference **with** the sympathetic nerves. However, **unless** the eyelid covers a **high** proportion of the pupil and consequently **would** affect image brightness or clarity, the **condition need not be noted**. **Discharge is a secondary** symptom of **blockage** of a tear duct, an eye **infection**, or **an allergic** reaction and can cause blurring of vision. However, **this** condition is frequently a temporary state and not **necessarily** worthy of **inclusion in** the standard. **Visual fields** is treated **as a specific** requirement **in** the standard. The need for separate notation **on** the exam form is unclear. **Specific recommendations** for visual fields are noted **in a preceding section**. **Ocular muscle imbalance** includes deviation of the eyes from their normally parallel position and **can** be of two types, paralytic (forward gaze, right **or** left lateral gaze) and **nonparalytic** (convergent or divergent). The individual **with** either condition may have trouble focusing at times; but **if** visual acuity and visual fields meet the **standards**, this condition does not usually need to be noted. **Color blindness is** questionable in **terms** of whether to note or include it **in** the standard, as discussed in a preceding section. **Corneal scar** is a **superficial** grayish white opacity in the **cornea**, secondary to an old **injury** or inflammation. If the individual **meets** the **visual** acuity and visual fields standards, **this condition** need not be reported. **Exophthalmos** is a forward protrusion of the **eyeball** from the socket. If it **involves** severe pressure from muscle tissue **on** the optic **nerve**, visual impairment or blindness can result. However, in the majority of individuals, **this** condition **exhibits** little effect **on visual** acuity and visual fields. Some individuals do complain of occasional **difficulty** in **focusing**, but this problem **does** not seem severe enough to be cause for **disqualification**. **Strabismus** is the **result** of muscle weakness that causes deviation of one eye **inwardly (esotropia) or outwardly (exotropia)**. **The condition** can cause **amblyopia** (**reduced** vision) **in** an otherwise normal eye caused by disuse of that eye; one eye becomes **"lazy"** and stops functioning to **full** capacity; thus **visual** acuity **in** that eye is reduced markedly by suppression of central (**foveal**) vision. If **visual acuity** and **visual** fields standards are met, this condition probably need not be reported.

With the exception of the condition of **monocularly**, the preceding **visual** conditions do not necessarily disqualify a driver from operating a CMV. The standard addresses only the need to "note" them. **These** conditions may or may not affect **an** individual's **ability** to drive or, for that matter, may or may not **inhibit** the individual's ability to pass **visual** acuity, horizontal field of vision, and color **vision** tests **specified** in the standard.

If the checklist is to be retained in a form similar to the current one, a number of other conditions should be included: **aphakia** (absence of **the** lens), cataract (opacity in the lens or cornea), conjunctivitis (**inflammation** of the **conjunctival** lining), glaucoma (an increased pressure on the eye due to excessive fluid within the eye), **macular** degeneration (deterioration of **the** membrane between the retina and the underlying layer of blood vessels), and abnormal refractive states (astigmatism, hyperopia, myopia, **presbyopia**).

Proposed Changes to the Federal Standard

Both the Federal standard changes proposed prior to **the** workshop and the **final** recommendations **are** shown in the **following** items.

Section 391.41 Physical **qualifications** for drivers.

- (a) A person shall not drive a motor **vehicle unless he(or she) is** physically qualified to do so and....
- (b) A person is physically qualified to drive a motor vehicle if that person....
- (3) Has **no** established medical **history** or clinical diagnosis of diabetes **mellitus** currently requiring insulin for control;....
- (10) Has distant visual acuity of at least **20/40 (Snellen)** in each eye without corrective **lenses or visual** acuity separately corrected to **20/40 (Snellen)** or better **with** corrective **lenses**, distant **binocular** acuity of at least **20/40 (Snellen)** in **both** eyes with or without **corrective** lenses, field of vision of at least **120** degrees in **each** eye measured separately **in** the horizontal meridian (**color standard deleted**);

In addition, Section **391.43⁽¹⁰⁾** states that **medical examination** can be performed by a licensed doctor of medicine or osteopathy, and a licensed ophthalmologist or optometrist can perform **those** parts of the medical exam **that** pertain to **visual** acuity, field of vision, and the ability to recognize colors as **specified** in CFR 49 paragraph (10) of 391.41(b). Few instructions for performing and recording the physical

examination are given, but instructions regarding specification of visual acuity, prohibition against monocular vision, contact lens tolerance, and certain common eye conditions are as follows:

Section 391.43 Medical examination; certificate of examination.

- (a) Except as provided in paragraph (b) of this section, the medical examination shall be performed by a licensed doctor of medicine or osteopathy.
- (b) Either a state licensing agency with standardized visual screening equipment or a licensed ophthalmologist or optometrist most ("may" deleted) perform so much of the medical examination as pertains to visual acuity, field of vision (requirement for color recognition deleted) as specified in paragraph (IO) of 391.41 (b).
- (c) The medical examination shall be performed, and its results shall be recorded, substantially in accordance with the following instructions and examination form:

Test charts should be illuminated with white light (color temperature from 25d.K to 7500⁰ K) at a level well within the photopic range. Luminance readings from the white part of the chart should be between 30 cd/m² and 120 cd/m². Optotypes should be presented as black on a white background. The Snellen optotype is preferred. However, other optotypes such as Sloan letters, numbers, rolling E, Landolt C, and geometric patterns are acceptable. When other than the Snellen chart is used, the results of such test must be expressed in values comparable to the standard Snellen test. In recording distance vision, use 20 feet as normal. Report all vision as a fraction with 20 as numerator and the smallest type read at 20 feet as denominator. If the applicant wears corrective lenses, these should be worn while applicant's visual acuity is being tested. If appropriate, indicate on the Medical Examiner's Certificate by checking the box, "Qualified only when wearing corrective lenses." The visual field test should be conducted on an apparatus capable of testing the horizontal field of view to a minimum of 40 degrees nasally and 80 degrees temporally for each eye. The angular subtense of the test object should be between 10 minutes of arc and 2 degrees of arc. The luminance of the test object should be equivalent to between 5 and 25 cd/m². The background should be dark. Note ocular pathologies (refer to recommended list). Monocular drivers are not qualified to operate commercial motor vehicles under existing Federal Motor Carrier Safety Regulations. If the driver habitually wears contact lenses, or intends to do so while driving, there should be sufficient evidence to indicate that he has good tolerance and is well adapted to their use. The use of contact lenses should be noted on the record."

PHYSICAL EXAMINATION

General appearance

Vision: For distance:

Right 20/_____ Left 20/_____

____ Without corrective lenses

____ With corrective lenses if worn.

Evidence of disease or injury:

Right _____ Left _____

(Color Test deleted)

Horizontal field of vision:

Right _____ Left _____

EXPERT OPINION SURVEY (DELPHI APPROACH)

An expert opinion survey was conducted in this task because of the dearth of reliable data relating a person's comprehensive visual assessment history-either clinical examination or screening by a Department of Motor Vehicles protocol-to that individual's driving record. Accordingly, a Delphi-type approach was used for initially identifying specific visual functions deemed most important for safely performing each of seven critical CMV driving tasks. With this information, the panel of experts collectively established minimum acceptable performance levels for each visual function for each driving task. Finally, the panel (1) indicated which visual disorders and ocular conditions should be noted on a physical examination form and which should require a follow-up exam by a vision specialist, then (2) provided a subjective (rating scale) evaluation of the relative safety of matched monocular and binocular drivers with respect to critical CMV driving task response capabilities.

The expert panel for this task, composed of the workshop participants identified in the following section, was first asked to indicate by order of importance three visual functions required for safely performing each of the following driving tasks:

- Maintaining safe speed for conditions (highway geometry/weather/visibility)
- Maintaining safe following distance
- Staying in lane/steering control

- **Merging/yielding in traffic** conflict situations (lane drop, ramp gore, intersection of driveway)
- **Changing lanes and passing**
- Complying **with traffic** control **devices** (signs, **signals**, and pavement markings)
- **Backing** up/parking operations.

In the judgment of senior project staff and as noted by **previous** researchers in this area, the above driving tasks may be cited as critical to safe CMV operation.

This expert evaluation was conducted using a **Delphi-type**, iterative **process** in which the most frequent response for **each** order position (most important, second **most** important, third most important) was tabulated for **each driving** task; this information was then made available to **each panel** member, and **further** responses from each person were requested as needed to resolve ties and achieve consensus for all **rankings**. Three iterations of **this** process were required, resulting in the **collective** judgments **summarized in** Table 2 (Appendix D provides the **evaluation** forms.)

Table 2. **Visual** Functions Judged Most Important for Safely Performing Seven **Critical** CMV **Driving** Tasks

Driving Task	Visual Function by Order of Importance		
	1	2	3
Maintaining safe speed for condition!	Visual fields	Motion perception	Contrast sensitivity
Maintaining safe following distance:	Depth perception, Stereopsis	Motion perception	viual fields
Staying in lane/steering control	Visual fields	Static acuity	Contrast sensitivity
Merging/Yielding in traffic conflict situations	viual fields	Visual search/ Attention	Motion perception
Changing lanes and passing	viual fields	Depth perception/ Stereopsis	Motion perception
Complying with traffic control device :	Static acuity	Visual fields	Contrast sensitivity
Backing up/Parking operations	Depth perception	viual fields	Contrast sensitivity

The **next** step in the evaluation process was to request that **each** member of the expert panel provide a minimum acceptable level of performance for all **visual** functions named in the consensus table of results for the previous round. This effort **yielded ambiguous** results. In some **cases**, the most appropriate metric for performance **capability** remains unresolved in the technical literature (e.g., visual search/attention,

contrast sensitivity), and in other cases a mix of qualitative and quantitative responses was provided (e.g., visual fields, motion perception, and depth perception).

Subsequently, only those functions that were addressed at the workshop and were to be used in the actual development of recommendations for a revised standard were further evaluated. This post workshop evaluation involved static visual acuity, visual fields, and color vision. For other functions identified in Table 2, a more precise determination of minimum acceptable performance levels is deferred until continuing research findings justify their formal incorporation into the Federal vision standard. This issue receives additional discussion in the concluding section of this report.

With respect to static acuity, visual fields, and color vision, panel members were asked to select from among alternative specific wordings suggested by their responses to the prior requests for input on this task.

For visual acuity, the selections were as follows:

1. "Has distant visual acuity of at least 20/40 (Snellen) in each eye without corrective lenses or visual acuity separately corrected to 20/40 (Snellen) or better with corrective lenses, and has distant binocular acuity of at least 20/40 (Snellen) in both eyes with or without corrective lenses." (Current vision standard)
2. "Has distant visual acuity (either with or without corrective lenses) of at least 20/40 (Snellen) in one eye and at least 20/100 (Snellen) in the other eye and has distant binocular acuity of at least 20/40 (Snellen) in both eyes with or without corrective lenses." (Goes back to earlier standard)
3. "Has distant visual acuity (either with or without lenses) of at least 20/40 (Snellen) in one eye and at least 20/200 (Snellen) in the other eye; and has distant binocular acuity of at least 20/40 (Snellen) in both eye.5 with or without corrective lenses.'
4. (Alternate wording) _____

For field of vision, the selections were as follows:

1. "Field of vision of at least 120 degrees in each eye measured separately in the Horizontal Meridian."
2. "Field of vision of at least 130 degrees in each eye measured separately in the Horizontal Meridian."
3. "Field of vision of at least 140 degrees in each eye measured separately in the Horizontal Meridian."
4. (Alternate wording) _____

For color vision, the selections were as follows:

1. The current visual standard for color (“the ability to recognize the colors of traffic signals and devices showing standard red, green, and amber”) should be dropped.
2. Retain the current visual standard (“the ability to recognize the colors of traffic signals and devices showing standard red, green, and amber”), but add “No test for color vision is specified.”
3. The ability to discriminate the standard color green used in traffic signals and devices from the other standard colors, red and amber. See instructions for performing color vision test in Section 391.43.”
4. (Alternate wording) _____

For visual acuity, 7 out of 11 panelists selected alternative 1; the remaining panelists selected alternative 3. For field of vision, 6 out of 11 panelists chose alternative 1; 3 panelists selected alternative 3; and 1 panelist each selected alternative 2 and 4 (their own wording.) For color vision, 6 out of 11 panelists selected alternative 2; 2 panelists each chose alternatives 3 and 1. One panelist did not select any of the alternatives.

From the consensus of expert opinion in these areas, it was indicated that alternative 1 for visual acuity, alternative 1 for visual fields, and alternative 2 for color vision were most preferred for a Federal vision standard for commercial vehicle operators.

A wide range of visual disorders and ocular conditions was listed in the evaluation requested of panel members as to which should be recorded on the physical examination form, which should not be recorded, which should be referred to a vision specialist, and which should not be referred to a vision specialist. These conditions included aphakia, astigmatism, cataract, conjunctivitis, corneal scar, exophthalmos, glaucoma, hyperopia, macular degeneration, myopia, ocular muscle imbalance, presbyopia, ptosis, retinopathy, and strabismus, plus any other condition that a panel member wanted to list.

Responses mandated the inclusion of aphakia, cataract, corneal scar, exophthalmos, macular degeneration, ocular muscle imbalance, ptosis, retinopathy, strabismus uncorrected by corrective lenses, and any other condition that the examiner deems important to note on a physical examination of a CMV driver. These conditions are accordingly written into the proposed recommendations.

Finally, the expert opinion survey addressed the question of the safety of monocular versus binocular drivers with respect to specified critical CMV driving tasks. Panel members were asked to respond to the ratings to estimate the relative performance capabilities of monocular versus binocular CMV drivers matched

on age, gender, education, and years and type of driving experience for each of the seven driving tasks identified previously: maintaining safe speed for conditions, maintaining safe following distance, staying in lane/steering control, merging/yielding in traffic conflict situations, changing lanes and passing, complying with traffic control devices, and backing up/parking operations. Relative safety ratings were provided on seven-point bipolar scales indicating the judged likelihood of safe performance under “reasonable worst-case” conditions. The least safe rating was ‘1’; the most safe rating was 7. Each panel member placed an “M” and a “B” to indicate, on a common rating scale, the judged likelihood of safe performance for matched monocular and binocular drivers, respectively, for a particular task. The actual rating scales distributed to panel members are provided in Appendix D.

Mean values for the rated safety of monocular and binocular drivers using this approach were calculated, and t-tests were conducted to indicate whether differences in the judged likelihood of safe performance for the two groups were reliable. Results of this procedure, using one-tailed tests of the hypothesis that binocular drivers would be judged higher (more likely to perform safely) than monocular drivers, demonstrated a significant difference in the predicted direction for:

- Maintaining safe following distance ($t=2.16$; $df=14$; $p<.05$)
- Merging/yielding in traffic conflict situations ($t=3.25$; $df=14$; $p<.01$)
- Changing lanes and passing ($t=3.23$; $df=14$; $p<.01$)
- Complying with traffic control devices ($t=2.65$; $df=14$; $p<.01$)
- Backing up/parking operations ($t=2.96$; $df=14$; $p<.01$)

Thus, the wording of a standard that *de facto* excludes monocular drivers by requiring distant visual acuity of at least 20/40 (Snellen) in each eye is supported by the ratings, which for five out of seven critical driving tasks defined in this research, demonstrate a significant perceived deficiency in the ability of such drivers to perform as safely as their binocular counterparts. (Note: The panelists thought that the two driving tasks in which safety would not be significantly reduced for the monocular CMV driver were maintaining safe speed for conditions and staying in lane/steering control.)

RISK ANALYSIS OF A VISUAL ACUITY CRITERION SHIFT

Existing models of driver behavior suggest that the function relating increased criterion accident risk to decreasing activity (criteria) will mimic one side of the normal probability curve, but assigning specific values to accident probability will depend upon further analysis of reduced visibility crash data for individual situations. However, even adopting the most liberal assumptions regarding driver response capability, it seems apparent that shifting the criterion for visual acuity can lead to a measurable increase in the probability of a crash whenever a CMV driver's vehicle control decisions in moderate-to-heavy traffic

conditions depend **upon** timely comprehension of guidance information **presented** by highway **signing**. certainly, given the goal to maintain or improve **the** level of service on existing highways **with** increasing **traffic** densities, **this** risk modeling approach **argues against any change** toward less **stringent visual** performance (acuity) criteria for operators of **CMVs**. One of the tasks for this project **was** to develop **an** assessment of the safety risk involved with various levels of vision **and** determine, to the **extent** practical, the potential risk associated with various performance criteria **on the** recommended vision standard.

Empirical evidence found could not reasonably quantify any **specific** risk (such as a crash rate) with a **specific visual performance** level (such **as 20/40 binocular** visual acuity). This task was reduced to performing **an analytical exercise on** a theoretical risk associated **with shifting** the pass/fail criterion for tests of CMV drivers' visual acuity. **Visual** acuity was selected for this analysis **because** of its prominence in traditional **vision** test protocols **and** its high **level** of face validity to everyday **driving** tasks. The **analysis** was specific to a **defined** operational context **and** relied upon **assumptions** about **those** situations as found in current models of driver response effectiveness.

This theoretical **analysis** case examined a **maneuver/decision** response **sequence** within the framework of decision sight distance models. **In** the analysis, a safe and **effective** driver response was dependent **upon** sign **legibility/comprehension** under freeway **operating** conditions, taking **into account** the increasing **attentional** demands for avoiding **traffic** conflicts-and the **corresponding** decrease **in attentional resources** available for road sign information processing-associated with this situation. The CMV operator, who was unfamiliar with the roadway **being travelled**, had to respond to guide sign information to successfully navigate his/her destination.

The focus of the **analysis** was to **describe** a **function** of relating increased risk of traffic conflicts/accidents to decreasing time **legibility distance** resulting from **driver visual acuities** worse than **20/20**. Appendix B describes the risk analysis model **in** detail.

WORKSHOP

The **objectives** of the **workshop** were to have the **panel** of **vision** and trucking industry experts review the **preliminary** draft **recommendations** for changes to the CMV **vision** standard, discuss **difficult** or unresolved issues concerning **proposed** revisions, and attempt to reach a **consensus**. Workshop issues were categorized into three areas: (1) review of data relevant to setting the criteria **levels** specified for visual functional tests **included** in **the** standard (visual acuity, visual **fields**, color **vision**, and **any** other visual **functions** that would be proposed for **inclusion**), (2) more **comprehensive specification** of testing procedures for each of the visual functions, and (3) **required documentation of visual disorders and impairments** identified at the time of exam.

Prior to the workshop, panelists were asked to review the Synthesis of the Literature (Appendix A) and Preliminary Recommendations, provide alternative suggestions on these recommendations, and prepare a two-page point-of-view paper summarizing their suggestions and recommendations for change to the CMV vision standard. These point-of-view papers were submitted to KETRON prior to the workshop and used to organize the presentation of issues at the workshop. Panelists were provided copies of all the other panelists' point-of-view papers prior to the workshop to help guide the discussion on issues that would be brought up at the workshop.

The workshop was held at the Westpark Hotel in Rosslyn, Virginia on June 24, 1991. Panelists were seated across from each other, six individuals at a table on each side of the room. The KETRON moderators were seated in the front of the room. Visitors were seated behind the panelists' tables. The list of attendees is included in Table 3.

Workshop schedule:

- Opening Remarks; Neill Thomas, OMC
- Introduction of Panelists
- "Fit for the Road" Video (FHWA, OMC)
- Purpose of Workshop; L.E. Decina, KETRON Moderator
- Presentation of Viewpoints
- Lunch
- Summary of Panelists' Viewpoints; Chris Johnson (Panelist Chairperson)
- Risk Analysis; Loren Staplin
- Remarks; James Scapellato, FHWA, OMC Director
- Consensus of Panelists' Viewpoints; M. E. Breton, KETRON Vision Consultant
- Closing Remarks
- Vision Screening Equipment Demonstrations.

The workshop was recorded by C.A.S.E.T. Associates and a transcript was sent to KETRON.

Table 3. Attendees at Vision Standards for CMV Operators Workshop

KETRON STAFF

Lawrence E. Decina, Principal Investigator (Moderator)
Michael E. Breton, Ph.D., Vision Consultant (Presenter)
Loren K. Staplin, Ph.D., Project Manager (Presenter)
Laverne P. Evans, Secretary

PANELISTS

Chris Johnson, Ph.D. (Panelist Chairman)
H. James McKnight, Ph.D.
Karlene Ball, Ph.D.
Cynthia Owsley, Ph.D.
Arthur Keeney, M.D.
Merrill Allen, O.D.
Neill Darmstadter
Frank Schieber, Ph.D.
Sandra Z. Salan, M.D.
Bernard Blair, M.D.
Raymond Briggs, Ph.D.
Clifford Anderson

VISITORS

Dick Schwab, FHWA, RLD (Co-COTR)
Neill Thomas, FHWA, OMC
Hal Hylton, FHWA, OMC
Claude Duquette, M.D., CCMTA, Canada
William Hark, M.D., FAA
John Eberhard, NHTSA
Dennis McEachen, FAA
Deborah Freund, FHWA, OMC
Carole Simmons, FHWA

C.A.S.E.T. Associates (Recorders)

Results of the workshop are summarized, by issue (visual function, testing procedure, diagnosis of other visual impairments and disorders), and presented as follows:

Visual Function

Visual Acuity—The majority of the panelists agreed that there was no compelling reason to change the binocular visual acuity standard from the current 20/40. Two panelists called for a stricter 20/25 binocular acuity standard with reasons relating to cab vibration effects and personal opinion. The monocular issue was debated at some length. Most panelists agreed that the available research results linking driver safety to lowered acuity in one eye were sufficient to change the current standard to allow monocular drivers or drivers with vision that is substantially worse in one eye. However, a consensus on the issue of monocularism was difficult to achieve because of the diversity of opinion on the panel.

Visual Fields—The majority of panelists agreed that some measure designed to screen for visual field defects was important for safety. Some panelists held the view that more rigorous testing, including the vertical meridian as a minimum, would be necessary to make the visual field screening effective. However, doubt was expressed about whether the commercial vision equipment currently available could be adapted to that purpose. The compromise position that was reached specified improved test equipment and procedures for testing along the horizontal meridian. Testing on the vertical meridian was not recommended at this time but was suggested for future consideration. Most of the panelists felt that screening along the horizontal meridian would be sufficient to detect for gross visual field disorders.

Color Vision—The majority of panelists agreed that there was inconclusive evidence that congenital red-green color-defective individuals were not safe drivers. Evidence to the contrary was cited. Standardization of traffic signal colors and the presence of other environmental cues have virtually eliminated most difficulties for the color-deficient individual. In addition, the current standard does not adequately specify how to test color vision for compliance with the standard. An efficient screening for red-green color-deficiency would be expected to eliminate 8 percent of all males who currently operate CMVs. It should be noted that some panelists felt strongly that eliminating a color vision standard would be very controversial, regardless of the lack of empirical evidence supporting it.

Testing Procedures—Most panelists agreed that the testing procedures for measuring acuity and visual fields needed to be more comprehensive. Visual acuity optotypes, background illumination, and target luminance should follow the 'Recommended Standard Procedures for the Clinical Measurement and Specification of Visual Acuity,' as published by the Committee on Vision, National Academy of Sciences (1980). Specifying visual field target size and luminance was recommended, and the need for a test procedure that would provide a repeatable and accurate measure of field limits in the horizontal meridian was discussed.

Reporting Visual Impairments and Disorder—It was generally agreed that the examining physician needs to report visual disorders and impairments, but these should not be the basis for disqualification. A definitive list of conditions was

not developed at the workshop. **However**, panelists were able to recommend **what** conditions **should** be included in the list in a post-workshop follow-up **survey**.

. **Special Concerns Raised** at the **Workshop—A** primary issue discussed at the workshop was whether current and alternative approaches would ever be able to determine visual criteria **levels** that would separate “good” from “bad” drivers. It was questioned whether large sample database studies could provide **an** objective basis. Suggested alternative objective approaches were simulation of **worse-case scenarios** and “ride-along” observations of real-world driving, The basic **factor** to be considered was the practical limitations for **using** such **approaches**.

PROPOSED REVISIONS TO THE STANDARD

The proposed revisions and recommendations to the current vision standard for CMV operators were based on findings from the literature review (Synthesis of the Literature in Appendix A), results of the Delphi approach, point-of-view papers from the panel of vision and industry experts, opinions and comments from workshop panelists and participants, and post-workshop follow-up opinions from panelists.

Revisions (ii boldface) were suggested for the visual requirements section of the Federal Standard (CFR 49, 391.41(b)(10), 1985 Physical Qualification for Drivers) and the testing procedures (CFR 49, 391.43 (Head-Eyes), Medical Examination; Certificate of Physical Examination).

VISUAL ACUITY

The current visual acuity standard is recommended. This recommendation is based on a lack of evidence or method for objective judgment that an acuity criterion-other than that already established and agreed upon by the majority of panelists and other vision experts-could be selected for CMV operators.

“Has distant visual acuity of at least 20/40 in each eye. without corrective lenses or visual acuity separately corrected to 20/40 or better with corrective lenses, distant binocular acuity of at least 20/40 in both eyes with or without corrective lenses.”

The testing procedure for visual acuity should be revised extensively and include type and size of target, contrast type, size, contrast and luminance of target are described, as well as background luminance and testing procedure.

The recommended procedure for testing visual acuity is based on the standard procedures recommended for clinical measurement as reported by the Committee on Vision of the National Academy of Sciences (1980). The standard optotype is the Landolt ring. However, other equivalent optotypes, such as the Sloan letters as a group, are acceptable. Logarithmic sizing should be used (i.e., successively larger sizes should be 126 times larger than the preceding size). Optotype letters should be black on white background with a minimum contrast of 0.85 and a luminance range for the white background of 85 to 120 cd/m². Under these conditions, acuity should be defined as the smallest size at which 7 out of 10 (or 6 out of 8) letters are correctly identified at a given distance. Effective viewing distance should not be less than 4 meters. Regardless of viewing distance, acuity should be specified in terms of a fraction with 20 as the numerator and the smallest type that could be read at 20 feet as the denominator (i.e., 20/20, or 20/40). Although the Snellen chart departs from the standard in several ways, it is acceptable if no practical means of following the recommended procedure is available. If the applicant wears corrective lenses, these should be worn while applicant's visual acuity is being tested. If appropriate, indicate on the Medical Examiner's Certificate by checking the box, 'Qualified only when wearing corrective lenses'.

(Specifications for reporting acuity and corrective lens status have not been revised.)

VISUAL FIELDS

The current field-of-vision standard was incorrect. The recommended standard should state:

"... field of vision of at least 120 degrees in each eye measured separately in the horizontal meridian,".

The normal, healthy eye actually has a range of 140 degrees in the horizontal visual field. The recommendation is slightly lower than 140 degrees in each eye to allow room for normal variation with age and for errors in accuracy of testing or equipment calibration. It was deemed unnecessary to specify a binocular field since problems in binocularity important to driving will be identified through the acuity test. No empirical evidence was found to justify 120 degrees as the minimum criterion. However, past medical recommendations and consensus on views identified at the workshop provided support for this recommendation.

Recommendations have also included a description of how to test the visual fields standard.

"The recommended procedure for testing visual fields requires equipment that is able to present a round, luminous stimulus of 0.15 to 0.25 degrees in angular extent on a low photopic background of 1 to 10 cd/m². Stimulus luminance should be 50 to 100 cd/m² and duration should be in the range of 100 to 200 msec. Subject fixation should be verifiable. Multiple presentation in random sequence under monocular test conditions must be possible. This will normally require separate test stimulus positions for determining temporal and nasal field limits. Testing must be monocular with one eye blocked. The test procedure should present the nasal and temporal (70 degrees to 80 degrees temporal and 50 degrees to 40 degrees nasal) a minimum of 3 times each in random alternating sequence. Responses are best recorded automatically. If the applicant wears corrective lenses, these are not required to be worn while applicant's visual fields are being checked."

COLOR VISION

The color vision standard presents a special problem because nearly 8 percent of male drivers will have a congenital red-green deficiency if tested appropriately. As stated previously, empirical evidence indicates that such individuals are no less safe to operate any type of motor vehicle than those with normal color vision. Nevertheless, the consensus view of the workshop panelists is that some form of color standard should be retained, but formal color testing should not be required. In place of formal testing, the medical examiner will determine subjectively that an individual can safely operate in the driving environment. This color information will be extracted by asking if the driver can respond "safely and effectively" to standard traffic signals and devices displaying colors. Individuals with color deficiency will be able to answer on the basis of color, shape, and position. The intent is not to exclude drivers with congenital red-green deficiency, and otherwise normal vision, on the basis of color discrimination alone.

The recommendation is a slight variation from the current standard and specifies that there is no specific color vision test required:

'... and the ability to respond safely and effectively to colors of traffic signals and devices showing standard red, green, and amber. No test for color vision is required.'

VISUAL DISORDERS AND IMPAIRMENTS

Visual and ocular disorders that the physician should note were discussed at the workshop and evaluated again by panelists in a post-workshop survey. It was determined that a portion of the current disorders should be eliminated and other disorders should be added. The following visual disorders and impairments were selected as important (recommended additions in boldface):

- aphakia
- cataract
- corneal scar
- exophthalmos
- glaucoma
- macular degeneration
- ocular muscle imbalance
- ptosis
- retinopathy, and
- strabismus uncorrected by corrective lenses.

In addition, "any other condition deemed important" should be added.

COMPLETE STANDARD

If all recommendations are accepted as visual standards for CMV operators, they could be incorporated in the Code of Federal Regulations as follows:

391.41 Physical qualifications for drivers.

(b) A person is physically qualified to drive a motor vehicle if that person . . .

(10) Has distant visual acuity of at least 20/40 in each eye without corrective lenses or visual acuity separately corrected to 20/40 or better with corrective lenses, distant binocular acuity of at least 20/40 in both eyes with or without corrective lenses, field of vision of at least 120 degrees in each eye measured separately in the horizontal meridian, and the ability to respond safely and

effectively to colors of traffic signals and devices showing standard red, green, and amber. No test for color vision is required.

391.43 Medical examination; certificate of physical examination.

- (a) Except as provided in paragraph (b) of this section, the medical examination shall be performed by a licensed doctor of medicine or osteopathy.**
- (b) A licensed optometrist may perform as much of the medical examination as pertains to visual acuity, field of vision and the ability to respond appropriately to traffic signals and devices as specified in paragraph (10) of 391.41(b).**
- (c) The medical examination shall be performed, and its results shall be recorded, substantially in accordance with the following instructions and examination form.**

INSTRUCTIONS FOR PERFORMING AND RECORDING PHYSICAL EXAMINATIONS

Head-Eyes

The recommended procedure for testing visual acuity is based on the standard procedures recommended for clinical measurement as reported by the Committee on Vision of the National Academy of Sciences (1980). The standard optotype is the Landolt ring. However, other equivalent optotypes, such as the Sloan letters as a group, are acceptable. Logarithmic sizing should be used (i.e., successively larger sizes should be 136 times larger than the preceding size). Optotype letters should be black on a white background of 85 to 120 cd/m². Under these conditions, acuity should be defined as the smallest size at which 7 out of 10 (or 6 out of 8) letters are correctly identified at a given distance. Effective viewing distance should not be less than 4 meters. Regardless of viewing distance, acuity should be specified in terms of a fraction with 20 as the numerator and the smallest type that could be read at 20 feet as the denominator (i.e., 20/20 or 20/40). Although the Snellen chart departs from the standard in several ways, it is acceptable if no practical means of following the recommended procedure is available. If the applicant wears corrective lenses, these should be worn while applicant's visual acuity is being tested. If appropriate, indicate on the Medical Examiner's Certificate by checking the box, "Qualified only when wearing corrective lenses." The recommended procedure for testing visual fields requires equipment that is able to present a round, luminous stimulus of 0.15 to 0.25 degrees in angular extent on a low photopic background of 1 to 10 cd/m². Stimulus luminance should be 50 to 100 cd/m² and duration should be in the range of 100 to 200 msec. Subject fixation should be verifiable. Multiple presentation in random sequence under monocular test conditions must be possible. This will normally require separate test stimulus positions for determining temporal and nasal field limits. Testing must be monocular with one eye blacked. The test procedure should present the nasal and temporal limits (70 degrees to 80 degrees temporal and 50 degrees to 40 degrees nasal) a minimum of 3 times each in a random alternating sequence. Responses are best recorded automatically. If the applicant wears corrective lenses, these are not required to be worn while applicant's visual fields are being checked.

Note aphakia, cataract, corneal scar, exophthalmos, glaucoma, macular degeneration, ocular muscle imbalance, ptosis, retinopathy, strabismus uncorrected by corrective lenses, and any other conditions deemed important. Individuals with no vision in one eye or vision below standards in one eye as specified in paragraph (1) of 391.41(b) are disqualified to operate commercial motor vehicles under existing Federal Motor Carrier Safety Regulations. If the driver habitually wears contact lenses, or intends to do so while driving, there should be sufficient evidence to indicate that the individual has good tolerance and is well adapted to their use. The use of contact lenses should be noted on the record.

PHYSICAL EXAMINATION

General appearance ...

Vision: For distance:

Visual Acuity:

Right 20/____ Left 20/____

____ Without corrective lenses

____ With corrective lenses if worn

Binocular 20/____

____ Without corrective lenses

____ With corrective lenses if worn

Horizontal field of vision (in degrees)

Right ____ Left ____

Appropriate Response to Traffic Signals/Devices:

Evidence of disease or injury:

Right ____ Left ____

DISCUSSION

This report reviews the important issue of providing empirical support for the visual test criteria as set forth in the CMV vision standard and evaluates progress in developing new methods of vision testing. Although much new material on driver safety and vision has accumulated since the last comprehensive revision of the CMV vision standard in 1970, the new data were found to provide almost the same level of empirical support as had existed previously. This finding continues to require reliance on an informed consensus to evaluate changes to vision test criteria, wording, and recommended procedures of the standard. New tests are currently being developed, and several discussed below show promise of improving on present techniques. However, no single new test or combination of tests was found to provide a level of information sufficiently superior to currently utilized techniques to warrant inclusion in the CMV standard at this time.

NEW AREAS OF VISION TESTING

Recent advances in technology and current research in visual assessment have supported the development of new methods and equipment for testing visual performance. Many of these newly emerging vision testing techniques have been scrutinized for inclusion in driver license applicant testing and renewal programs. Some of the more important of these visual tests are contrast sensitivity, low-contrast acuity, glare sensitivity and recovery, automated visual field testing, dynamic visual acuity, and useful field of view (UFOV). To date, none of these advances has had a major impact on routine vision screening of the kind appropriate for testing CMV drivers. In general, the thrust of research in this area has been to add coverage for factors neglected in the more traditional acuity, visual fields, and color tests. For example, contrast sensitivity measures the ability to resolve spatial detail, as does acuity, but does so at minimum contrast. Glare recovery measures acuity under conditions of an interfering light source. Low-contrast acuity presents a standard acuity test under lower light conditions. Full-field static perimetry measures threshold sensitivity at a large number of visual field locations. One of the most promising of the new approaches is that of combining nonvisual with visual factors as is done in the UFOV test.

Contrast sensitivity testing has been a prominent emerging visual assessment technology for almost two decades. Contrast sensitivity measures the ability of the visual system to detect variation in adjacent light and dark regions as a function of spatial frequency of how closely spaced the neighboring regions are. High spatial frequencies are closely spaced while low spatial frequencies are widely spaced. Contrast sensitivity measurements demonstrate that the ability to see targets of low spatial frequency is statistically independent of the ability to see high spatial frequency targets such as those presented in visual acuity testing. This measure provides a more complete picture of the performance of the visual system than does visual acuity alone. From an administrative standpoint, commercial vision screeners are available to measure minimum testing ranges of contrast sensitivity in a relatively brief period of time (4-5 minutes).⁽³¹⁾ However, full ranges of contrast sensitivity testing require more time and adequate space for viewing. Schieber⁽³⁷⁾ pointed out other shortcomings of contrast sensitivity testing, including difficulty in specifying the criterion level that

clearly separates the abnormal contrast sensitivity **function score** from the normal **score, difficulty** in determining the **number of measures** of contrast sensitivity necessary to make the **test accurate** enough for USC **in** screening and questionable **reliability** of contrast sensitivity measurements to **diagnose visual conditions** such as cataracts and glaucoma, as claimed by **the manufacturers**. More research **appears** necessary to **validate** the **relationship between** contrast **sensitivity** measurements **and visual performance necessary for** driving before **recommendations** can **be** made for incorporating contrast sensitivity **testing** into any **type** of vision standard or screening procedure for licensing of automobile or commercial vehicle operators.

Low-contrast acuity **testing also appears** promising for visual assessment. It **can** provide information about **visual disability** similar to that provided by **contrast** sensitivity. Low-contrast **optotypes** are substituted for **the high-contrast** letters normally **employed** in the acuity test. Proponents of the low-contrast acuity test **claim** that it rivals the contrast sensitivity **function measures** in terms of its ability for **making clinical diagnoses** of **visual** disorders such as cataracts, glaucoma, **diabetic retinopathy**, age-related **retinopathy**, and **ocular hypertension**. Low-contrast acuity **testing** is easy to administer and **score**. **In addition**, the **low-contrast optotypes** could be easily retrofitted into many of the vision **screeners** already **in** use by **driver-**licensing authorities.

Disadvantages of low-contrast acuity testing **include** the inability to temporarily **modulate** test stimuli (i.e., add a motion component) and the **difficulty** of automating a task that has a limited number of response alternatives (i.e., the 26 letters of the alphabet). Some of these disadvantages can be **overcome**. **However**, the most critical problem is **the** lack of research showing **the** relationship of low-contrast acuity scores to visual **performance needed** for safe **driving**.⁽³⁷⁾ This lack of **experience** with low-contrast acuity testing **in** the driving context **prevents** its incorporation into **the** draft recommendations.

Glare **sensitivity** testing has **emerged as a new** vision testing technology that could **benefit** driver vision screening programs. Glare is a problem for **all** drivers, but is of special **concern** for older drivers and can **be potentially** hazardous for **those wearing** contact **lenses**. Testing **in** this **area** has the potential for detecting **significant** but correctable **vision** problems. The **aged** are increasingly more likely to develop **cataractous or precataractous ocular** opacities that produce **marked deficits** in the ability to **see under** transient-illumination or high-illumination **conditions (e.g.,** opposing headlamps **during** nighttime driving, high-mast roadway lighting, driving toward the brightly illuminated sky at **dawn** or dusk). **Similarly**, contact **lens** wearers may suffer from **excessive** sensitivity to **glare resulting from** the **complications** of contact **lens** wear, possibly related to worn or **damaged** contact **lenses** or to **corneal inflammation secondary** to contact **lens wear**.⁽³⁷⁾ These **conditions are** susceptible to treatment. **CMV** drivers who **wear** contacts and have glare problems could **benefit from** such testing. Some commercial **glare sensitivity** testing **equipment** is available and these tests can **be** administered in a **small** amount of time. However, **no** empirical evidence

glare sensitivity performance with measures of driving performance has been reported. Acceptable levels of glare for driver safety have not been determined. This lack of generally accepted procedures and a consensus on cutoff criteria appropriate for CMV driver safety prevent including glare sensitivity testing from being included in recommendations for CMV visual requirements at this time.

Automated visual field testing has been proposed in recent years as a technology that could be used to greatly increase the sensitivity and validity of visual field testing in CMV driver licensing. Automated perimetry provides light detection threshold measurements at regularly spaced intervals throughout the visual field and has found a substantial clinical role in detection of retinal, optic nerve, and cortical disorders. Its automated feature improves upon the manual Goldmann type of visual field testing that has provided the clinical standard. These tests provide a vastly better assessment of visual field performance than the commercial screeners used by many state licensing agencies, which test only a few points along the horizontal field axis. However, the procedure takes up to 30 minutes to complete for both eyes and is tiring to the patient. Johnson and Keltner⁽²⁹⁾ have evaluated the relationship between the visual field deficits as measured by automated perimetry and driving performance, as well as the feasibility of using the device for mass driver screening. They report that drivers with visual field loss in both eyes have a traffic accident and conviction rate twice as high as that of age- and sex-matched observers and of patients with constricted visual fields as the result of retinitis pigmentosa. For this study, a reduced resting protocol was used so that the total testing time for a full-field static assessment in one eye would take less than 5 minutes. However, the high cost of equipment and the inability to incorporate other visual tests (such as visual acuity) in the same equipment make this technology impractical for inclusion in the CMV vision standard at this time.

Dynamic visual acuity testing has consistently shown promise for use in driver licensing vision testing but has failed to gain general application. Bailey and Sheedy⁽³⁴⁾ state that even though studies have shown dynamic visual acuity to be more strongly related to accident rate than other visual attributes, the correlation is not strong enough to justify its inclusion as a vision standard. The considerable amount of research devoted to dynamic visual acuity has not led to acceptance of standardized testing procedures by eyecare professionals or to incorporation of acuity testing into commercial vision screening equipment. As with glare and contrast sensitivity, the lack of wide acceptance and the difficulty of setting valid and defensible cutoff criteria for CMV drivers make this test impractical for inclusion in the CMV vision standard at this time.

The concept of testing for a useful field of view (UFOV) combines attentional factors with visual field measurements. The rationale behind this approach is that it is not the visual field that counts most for safety. It is rather the level of useful information that can be extracted from a given field configuration. In the UFOV test, the observer must discriminate the test object from similar test objects and report its position in terms of a limited number of locations in the field of view. The basis of discrimination can be varied. The UFOV test appears to depend on the earliest, preattentive (parallel-processing) stage of visual

attention. It tests a subject's ability to capture and direct attention to highly salient **visual** events, a skill which seems **crucial** for effective **driving**, especially for CMV drivers who **require** exaggerated lead times for hazard recognition. The UFOV test incorporates measures of divided attention, selective attention, **and** speed of visual information processing to **arrive** at **an overall** measure of **attentional** capacity. **This** approach is thought to represent more realistically the real-world situation in **which** visual judgments essential to driving safety must be made.

Correlations of UFOV test results ⁽³⁸⁾ with measures of **driving** safety are reportedly as **high as** $r=0.55$, which is considerably higher than reported for tasks dependent **only on** primary visual processing. The emerging **evidence** suggests further research to develop **assessment** approaches **incorporating attentional** as **well as** purely sensory visual **capabilities**. This area of investigation is expected to have a strong impact **on** revising standards for driver **qualifications**. However, several problems remain before this test can be considered for inclusion in the CMV vision standard. Even a **correlation** as high as $r=0.55$, as reported for the UFOV task, would not be sufficient to overcome the problem of a **high** false-positive rate, which is a problem for every **vision** test applied to the task of **discriminating** safe from unsafe drivers. **Second**, although equipment is currently being developed to **allow** use of **the** UFOV test in a rapid **screening context**, **specific criterion** levels for "good" versus "poor" UFOV **levels** relative to driver safety have not been clearly established. **In** addition, the nature of **this** task is **substantially** different from the one **currently** included in the CMV **vision** standard, and **present** experience is **insufficient** to judge the likelihood of **practical** acceptance by **both** testing agencies and the **CMV** industry.

This area of **research** is perhaps the most **promising** of those reviewed. The experience with UFOV testing and other techniques that **combine visual testing with** behavioral assessment shows that progress can be and has been made. That the current tests need improvement is not in question. The lack of progress in devising highly predictive tests that rely solely on visual performance **criteria** points out the need to **include** more than vision **in screening** for unsafe **drivers**.

ENFORCEMENT PROCEDURES

The basis for enforcement of the current CMV vision standard is the required medical exam. At present, the general **care** physician must perform or verify the specific **visual** tests for acuity, **visual** fields, and color perception, then note the list of **ocular** abnormalities. Physicians are not selected, trained, or **certified** **in** any **way** to perform these tasks as required for CMV driver **testing**, unless they have sought **training** voluntarily. An inescapable consequence of this arrangement is that testing will not be **carried out on** a satisfactorily uniform level. Several factors contribute to this **situation**: (1) free selection of **an** examining physician by a driver or employer, (2) uneven training **and** experience on the part of the physicians, and (3) **nonstandard** or inadequate equipment available to the examiner. These issues could be addressed individually, **and** in some states this approach **will** be **the** preferred course for **strengthening** enforcement of

the vision standard. However, a more practical, **effective**, and efficient approach in many of the most populous states may be to encourage the state licensing authority to adopt **vision** standards **in conformance** with the Federal standard and to test drivers on the state **level** for the class of vehicle **defined** as commercial at the Federal level. Many states are already in conformance with the Federal **vision** standards, or could be **with minor changes** to either their **vision** requirements or their vehicle class **definitions**. Moreover, the states that **are in conformance** are among the more **industrialized and populated** states and have a large proportion of the interstate commercial drivers. AU states require a vision exam for **license** application and **have** a **visual** acuity screening standard. However, only 72 **percent** of the states conduct periodic vision screening, which would be **necessary** for conformance to **the** CMV regulation. **In** addition, some states have different vision testing requirements by license class (e.g., passenger vehicle, intrastate **truck, school bus**), but most states would have to institute a **commercial classification** that included vehicles **defined** under the Federal **regulation**. An advantage and incentive for adopting this approach would **be** that drivers **in** states **where** the vision standard is met would be exempt from the vision part of the **medical** exam.

If the state enforcement option is not feasible for political, economic, or other **reasons**, licensed ophthalmologists or optometrists, **specifically** trained and knowledgeable on the Federal **CMV** vision standard, should **administer** the vision exam. It is most likely that **the** general practitioners and physicians who **are** not routinely familiar with the standards **would not** have **the vision equipment** necessary to **administer** the testing requirements **and** may be reluctant to **disqualify** **CMV** drivers. This reluctance may be based **on an unwillingness** to adhere to the requirements of the vision standard or because **this** action **might** jeopardize a long-term relationship with the patient and/or family.

Recommendations concerning enforcement are as follows: (1) **Wherever** feasible, have the **vision** part of the medical exam performed by **an** eye care specialist, **either an ophthalmologist** or optometrist; (2) Encourage state driver testing authorities to adopt both the Federal **Vision** Standard and the Federal **definition** of CMV drivers as a minimum for intrastate licensing and repeat testing, (3) when states are in **conformance** with the Federal standards, grant exemption **on** the vision part of the medical exam to that state's **CMV** drivers.

For documentation and proof of **visual** fitness, the medical examiner's **certificate** (medical card) should reflect that the visual tests and eye exam **were conducted** by a licensed **ophthalmologist** or optometrist. Date of examination, name of examiner, medical license number, **certificate** of qualification to test CMV vision standard license number, address of office and examiner's signature should be included as well. Requirements for **carrying** the medical card on **the** person and keeping a copy of the medical certificate in the **vehicle** should **be** left as **specified** in the current standard.

NEW APPROACH FOR PROVIDING EMPIRICAL SUPPORT

The reason for the apparent failure, even of large-scale correlational studies of vision scores and measures of driver safety, to provide empirical evidence useful in support of the vision standard does not reflect a lack of intense or directed effort. On the contrary, these studies were comprehensive and still failed to find definitive empirical results. This leads to the conclusion that the problem cannot be solved by broad-based correlational studies of their relationship to primary visually mediated performance. The fundamental reason is the extensive overlap of the vision test scores of safe and unsafe drivers coupled with the fact that most potential drivers with poor vision are already screened off the road by vision tests and cannot contribute to the statistical base. Vision is only one component of driver safety.

On the other hand, it is clear that some level of reduced vision is unsafe. Can other means be used to establish empirically meaningful limits? Two possibilities were discussed at the workshop. The first is to study worst-case simulated scenarios and the second is to employ a ride-along method for gathering real-world data on driving performance and mishaps. The worst-case simulation method might employ a full-scale driving course that presents simulated hazards and emergency situations of varying degrees of difficulty and at extremely high encounter rates compared to the real-world situation. This approach would produce driving errors, as data for measurement, at a rate high enough to be statistically useful for evaluating drivers with normal and less than normal vision. These data might provide a basis for setting minimum vision standards for given situations on the course. This approach would be extremely expensive and still present the problem of validating the course situations with real-world needs for safety. To some extent, this problem could be addressed by comparing scores of normal and below-normal vision drivers. Compared to worst-case simulation, the ride-along technique has the advantage of providing real-world data. However, a prohibitive amount of observer time would be required to accumulate meaningful data on the rare serious accidents that are the major safety concern (not to mention the danger to the observer). Data on more routine mistakes and mishaps would again suffer from the problem of establishing relevance to the incidence of more serious accidents.

An increasingly feasible technical alternative to either of the approaches just described is computer simulation of the driving task. This approach would have the advantage of presenting scenarios of varying type and degree of difficulty at the discretion of the researcher, and would present no danger, either to the driver or to the observer. Cost would be significant in the development phase, but would be much less than a real simulation at every level. The major problem is the degree of realism that could be achieved. Technology in the area of graphics presentation is improving rapidly and its cost is decreasing. If the problems of relating simulator performance to real-world safety considerations can be adequately addressed, this technology would appear to offer the greatest promise of providing additional support for the CMV vision standard.

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APPENDIX A

SYNTHESIS OF THE LITERATURE

This synthesis of the literature (originally the Task A Report) comprises the history of the vision standard, the intrastate vision standards, international standards guidelines of professional and government organizations, and evaluation of empirical evidence.

HISTORY OF THE VISION STANDARD

In the late 1930s, the Federal Government began regulating the vision standards for drivers of CMVs in interstate commerce. (These regulations have appeared in the Federal Register (FR) and the Code of Federal Regulations (CFR).) Since that time, the standard has been changed steadily in the direction of requiring more stringent visual capability. The vision standard for drivers of interstate trucks was specified originally in a general standard for medical fitness. The standard was very general and stated the following:

“Good eyesight in both eyes (either without glasses or by correction with glasses), including adequate perception of red and green colors” (Federal Register, 1923(c), c.1938).⁽¹⁾

By 1939, the standard was modified to contain specific minimum requirements for visual acuity, visual fields, and color vision:

“Visual acuity (either without glasses or by correction with glasses) of at least 20/40 (Snellen) in one eye, and 20/100 (Snellen) in the other eye; form field of not less than 45 degrees in all meridians from the point of fixation; ability to distinguish red, green, and yellow” (4, Federal Register, 2295, 1.22, June 7, 1939).⁽²⁾

Historical documentation confirms that the standard remained the same through 1944 (9, Federal Register, 192.2(b), 1944).⁽³⁾ It wasn't until 1964 that the standard was changed to include more stringent requirements in visual acuity and visual field. The minimum requirement for visual acuity now became: “... at least 20/40 (Snellen) in each eye In addition, the visual field requirement was restated to include only the horizontal meridian: form field of vision in the horizontal meridian shall not be less than a total of 140 degrees.’ The visual field specification does not require that each eye be tested separately, but appears to imply with the word ‘total’ that binocular coverage should add up to at least 140 degrees. The ability to distinguish color requirements (red, green, and yellow) did not change. The standard now stated that drivers requiring correction by glasses “...shall wear properly prescribed glasses at all times when driving. (29, Federal Register, 8420, 191.2(b), July 3, 1964).⁽⁴⁾

The standard was retied **again** in 1970 to **include** the words ‘distant’ and “**binocular**” in **specifying visual** acuity. The standard **now** stated that a driver must have’... distant visual acuity of at least **20/40 (Snellen)** in each eye...’ and “**...distant binocular** acuity of at least **20/40 (Snellen)** in both eyes **with or** without **corrective** leases.” However, the **field** of vision standard **was now** changed to “... at least 70 degrees in the horizontal meridian **in each** eye...,” which is **markedly** different from the 1964 standard requirement, “... not be less than a total of 140 degrees...” in the horizontal meridian. The intent of this 1970 revision to the **visual field** requirement is not dear. It appears that part of the intent of the 1970 revision was to restate the requirement in terms of monocular testing, which **is** the normal **medical** practice. However, the extensive overlapping of **binocular** fields means that a **binocular** specification **cannot** simply **be** divided by **two** to arrive at a **monocular specification**. It is certainly not **reasonable** to assume that the **purpose** of the 1970 standard was to make the **visual** field requirement **much less** stringent **than even** the 1939 **specification**. It is **also** not **certain** that a simple error was committed and that the **monocular field** was supposed to be 140 degrees. **Because** of this **ambiguity** in the statement of the standard, **which** is still **current**, a reevaluation of the wording and intent of the **visual** fields **specification** is **necessary**. **Additionally**, the 1970 **color** requirement was revised to specify traffic control devices and their **colors**. The wording changed from “abiity to **distinguish** colors red, green, and **yellow**” to “ability to **recognize** the **colors** of **traffic signals** and devices showing stand&d red, green, and amber” (35, Federal Register, **6463, 391.41 (b)(10), April 22, 1970**).⁽⁵⁾

Also in 1970, two separately dated changes were made to the requirement for drivers with prescription lenses. **First**, dated in **April** of 1970, the requirement for spectacles was relocated from the vision specification to Section: 392.2 (a) Spectacles to be **worn**.” The new regulation was stated as **follows**:

“A driver whose **visual** acuity meets **any** of the minimum requirements of section 391.41 of this subchapter **only** when he wears corrective lenses **shall** wear properly **prescribed spectacles** at **all** times **while** he is **driving**” (35, Federal Register, 6466, 3929 (a), April **22,1970**).⁽⁶⁾

Secondly, dated in November of 1970, the title of the **spectacle** section was changed to “Corrective lenses to **be worn**” in order to cover the wearing of contact **lenses**. The **regulation** now **included** a provision that a driver **could** wear prescribed contact lenses instead of prescribed spectacles. The provision **also** required the driver to ‘have a spare lens or set of lenses on his **person**” when driving.

The most current printing of the standard⁽⁷⁾ in the Code of Federal Regulations (49, CFR, 391.41 (b) (10), October 1, 1985) has not changed since November of 1970 and is described in the following paragraphs.

As part of the effort to update the vision standards, the Federal Highway Administration, Office of Motor Carriers (FHWA OMC) is addressing the correction of the possible error in the 70-degree horizontal meridian field.⁽⁸⁾

The Code of Federal Regulations, Subpart E-Physical Qualifications and Examinations Sections 391.41 to 391.49⁽⁹⁾ specifies medical standards required to be met by operators of CMVs in interstate commerce (see Appendix C). The commercial driver must be medically examined at least every 2 years and, while on duty, a driver must have a certificate showing that he or she has passed the required examination. The required examination encompasses the general health of the individual as well as setting specific standards for vision and audition. It also precludes individuals from driving if they have certain medical conditions such as specific heart conditions and, important for vision, diabetes mellitus which must be controlled by insulin.

The visual requirements for CMV drivers are included in Section 391.41⁽⁷⁾ and are stated as follows:

“Has distant visual acuity of at least 20/40 (Snellen) in each eye without corrective lenses or visual acuity separately corrected to 20/40 (Snellen) or better with corrective lenses, distant binocular acuity of at least 20/40 (Snellen) in both eyes with or without corrective lenses, Field of vision of at least 70 degrees in the horizontal meridian in each eye, and the ability to recognize the colors of traffic signals and devices showing standard red, green, and amber” (49, CFR, 391.41(b)(10), 1985).

In addition, Section 391.43⁽⁹⁾ states that the medical examination can be performed by a licensed doctor of medicine or osteopathy, and a licensed optometrist can perform as much of the medical examination as pertains to visual acuity, field of vision, and the ability to recognize colors as specified in CFR 49 paragraph (10) of 391.41(b). Few instructions for performing and recording the physical examination are given, but instructions regarding specification of visual acuity, prohibition against monocular vision, contact lens tolerance, and certain common eye conditions are as follows:

“When other than the Snellen chart is used, the results of such test must be expressed in values comparable to the standard Snellen test. If the applicant wears corrective lenses, these should be worn while applicant’s visual acuity is being tested. If appropriate, indicate on the Medical Examiner’s Certificate by checking the box,

‘Qualified **only** when wearing **corrective** lenses.’ In recording distance vision **use** 20 feet as normal. Report all vision **as** a fraction **with** 20 as numerator and the smallest **type** read at 20 feet as denominator. Note **ptosis**, **discharge**, visual fields, **ocular muscle** imbalance, color blindness, **corneal** scar, **exophthalmos**, or **strabismus** uncorrected by corrective lenses. **Monocular** drivers are not qualified to operate commercial motor **vehicles** under existing Federal Motor Carrier Safety Regulations. If the driver **habitually** wears contact lenses, or intends to do so while driving, there should be **sufficient** evidence to indicate that he has good tolerance and is **well** adapted to their use. The use of contact lenses **should** be noted **on the** record’ (49, CFR 391.43, 1985).

As **described** above a problem exists in the statement of **the visual** field requirement. The standards, as published in the Federal **Register**⁽⁵⁾ **since** 1970, **states** that a **70-degree** field of view is the **minimum** requirement for each eye. The Federal Highway **Administration** has taken the position that the **visual field** standard should specify that 140 degrees of visual field is required in each eye. However, the **evolution** of the **visual** field specification appears to leave some doubt as to what the **actual specification** of horizontal field extent should be. The later **section**, listing international **visual** standards, indicates that **there** is no obvious **consensus** on **visual** field requirement, **with** 5 countries or **provinces** of the 15 listed not **specifying** a standard, 5 not providing a **specific number** (stating only the **visual** field should **be** normal or **full**), and the 5 remaining **countries specifying** numbers between 120 and 150 degrees for **each** monocular field and 170 degrees for a **binocular** field.

The color vision requirement of the 1970 CMV vision standard also presents **the** problem of being unenforceable **on** a practical basis. **The** requirement now states that a driver must be able “... to recognize **the** colors of traffic signals and devices **showing** standard red, green, and amber.’ As stated, this requirement does **not** specify relevant **stimulus** parameters, **such** as stimulus size, **stimulus luminance**, and wavelength composition or **chromaticity** that are critical in determining whether different classes of **color-defective** observers **will** be able to pass the test. To a certain extent, the **wavelength** composition of **the** stimulus is inferred by **the phrase** “...**showing** standard red, green, and amber.” Presumably, the ‘standard’ referred to is that set by the National Bureau of Standards (NBS),⁽¹⁰⁾ **which specifies** the colors of **traffic** control signals in the United States.

Specific reference to **the** NBS or an interpretation of the color standard for the **purpose** of color testing would clear up that part of the stimulus problem related to **chromaticity specification**. However, an even more **difficult** problem would remain **which** relates to the visual angle of **subtense** of **the test** color and the intent of the CMV vision standard **in** restricting color-defective individuals

from driving. **This** problem arises because the **ability** of red-green color-defective **individuals** varies **significantly** with the **angle** of **stimulus subtense**.^(11,12) For large **angular subtense** (larger than 5 to 8 degrees, **depending** on the observer), even red-green **dichromats** can **recognize** the difference **between** red, **green**, and **yellow** spectral lights. These **same** observers are totally **unable** to **distinguish** colors **in** this spectral range for **small** lights subtending 2 degrees or less. **Thus** **dichromats** **will typically** “pass” a color test which presents large enough stimuli **that** are **well** saturated **and** reasonably bright, but **will** fail any classic test of red-green color **vision** **such** as **pseudoisochromatic** plates (colored dots of one color that show a **number** or pattern **within** colored dots of another color) or **small** field spectral color matching (**anomaloscope** testing).

If it **is** the intent of the color requirement of the **CMV** standard to **exclude** red-green **color-defectives** from driving (and this is doubtful for reasons stated above), then color testing methods must be **respecified** to accomplish this goal. Simply presenting colored circles printed on paper or viewing colored lights from a distance that **will produce** a large field of view **will not screen** out red-green color-defectives. In practice, **individuals in** this category are not **being** denied CMV licenses under current enforcement **conditions**. In fact, there seems to be no evidence that **would** warrant the **exclusion** of this **class** of drivers from the road

INTRASTATE VISION STANDARDS

Recommendations provided in this project may be partially based on the administrative ability of the states to manage vision screening programs for commercial drivers. Vision standards and testing procedures for acquiring and maintaining a license to operate a commercial vehicle intrastate were obtained from National Highway Traffic Administration (NHTSA) Guidelines for Motor Vehicle Administrators, State and Provincial Licensing Systems-Comparative Data⁽¹³⁾ and contact with administrators from state licensing bureaus. Table A.1 compares the state vision standards for intrastate CMV drivers.

Practically every state administers a vision test for individuals applying for any type of motor vehicle license. Vision standards vary slightly from state to state, but every state that conducts visual screening has a visual acuity requirement for intrastate commercial vehicle licensing. Other visual requirements vary considerably in different states, with many states requiring visual fields testing, and several requiring color testing. Some states even have a stereopsis requirement.

For the most part, state visual standards for intrastate commercial driver licensing are less stringent than the Federal standard for interstate commercial driver licensing. For example, even though a binocular (best corrected) visual acuity requirement of 20/40 is the standard in almost 50 percent of the states, less than 10 percent of the states deny a license for monocular vision. In addition, approximately 38 and 36 percent of the states have a visual field standard for each eye and both eyes, respectively. These standards range from 70, 90, and 140 degrees in each eye to 70, 110, 120, 140, and 180 degrees in both eyes. Nearly 24 percent of the states have a color perception standard and for most states the standards are for red, green, and amber. In addition, 12 percent of the states have a stereopsis standard.

Periodic vision screening is administered in 72 percent of the states. Discussions with licensing bureau administrators in nine of the larger populated states (CA, FL, MI, NJ, NY, NC, PA, TX, and VA) indicated that periodic vision testing varies. Reports indicated that three states require vision retesting every 2 years, five states require every 4 years, and one state requires every 5 years.

Table A1. Comparison of State Vision Requirements for CMV Operators

STATES	VISUAL ACUITY		VISUAL FIELD		COLOR	OTHER	RETEST
	Monoc	Binoc	Monoc	Binoc			
Alabama		20/70	No	No	No	No	No
Alaska		20/40	No	No	No	No	Periodic
Arizona		20/40	No	No	No	No	Periodic
Arkansas		20/50	NS	NS	NS	NS	NS
California		20/40	70,70	NS	R,G,A	NS	Periodic
Colorado		20/40	Yes	Yes	Yes	ST	Periodic
Connecticut		20/40	Yes	Yes	Yes	ST	No
Delaware		20/40	No	No	No	No	Periodic
Florida		20/70	No	No	No	No	Periodic
Georgia		20/60	140,140	140	No	No	Periodic
Hawaii		20/40	70,70	140	R,G,A	ST,EC	Periodic
Idaho		20/40	NS	NS	NS	NS	Periodic
Illinois		20/40	70,70	140	NS	NS	Periodic
Indiana		20/50	No	No	No	NS	Periodic
Iowa		20/70	No	No	No	NS	Periodic
Kansas		20/40	NS	NS	NS	NS	Periodic
Kentucky		20/45 PV	No	No	No	No	No
Louisiana		20/40	No	No	No	No	Periodic
Maine		20/40	NS	NS	NS	NS	No
Maryland		20/40	140,140	140	No	No	Periodic
Massachusetts		M/M	90,90	120	Yes	No	Periodic
Michigan		20/40	70,70	140	NS	NS	Periodic
Minnesota		20/40	NS	NS	NS	NS	Periodic
Mississippi		20/40	90,90	180	No	ST	No
Missouri		20/40	55,55	No	No	No	Periodic
Montana		20/40	75,75	No	Yes	ST	Periodic

Table A.1 Comparison of State Vision Requirements for CMV Operators (Cont'd.)

STATES	VISUAL ACUITY		VISUAL FIELD		COLOR	OTHER	RETEST
	Monoc	Binoc	Monoc	Binoc			
Nebraska		20/40	70,70	140	Yes	No	Periodic
Nevada		20/40	No	No	No	No	Periodic
New Hampshire		20/40	NS	NS	NS	NS	Periodic
New Jersey		20/40	70,70	No	R,G,A	No	NS
New Mexico		20/40	NS	NS	NS	NS	Periodic
New York		20/40	NS	NS	NS	NS	Periodic
North Carolina		20/50	No	70	Yes	No	Periodic
North Dakota		20/40	70,70	140	No	No	Periodic
Ohio		20/40	70,70	No	No	No	Periodic
Oklahoma		20/40	No	No	No	No	No
Oregon		20/40	No	110	No	No	No
Pennsylvania	No	20/40	No	140	No	No	No
Rhode Island		20/40	60,60	120	Yes	No	Periodic
South Carolina		PV	NS	NS	NS	NS	Periodic
South Dakota		20/40	No	No	No	No	Periodic
Tennessee		20/40	No	No	No	No	No
Texas		20/50	No	No	No	No	Periodic
Utah		20/40	NS	NS	Yes	ST	Periodic
Vermont		20/40 PV	NS	NS	NS	NS	No
Virginia		20/40	100,100	100	No	NS	Periodic
Washington		20/40	No	140	R,G,A	No	Periodic
West Virginia		20/40	No	No	No	No	No
Wisconsin		20/40	70,70	140	No	No	Periodic
Wyoming		20/40	No	No	No	No	Periodic

Key to Table 1: Visual acuity is expressed in Snellen notation; visual field is given in degrees along the horizontal meridian; color abbreviations: R = red, G = green, A = amber, Y = yellow, and B = blue; abbreviations for other conditions: AK = aphakia, DP = diplopia, EY = eye coordination, HM = high myopia, NB = night blindness, NG = nystagmus, and ST = stereopsis (absence of); NS = standard not specified; No = no standard; PV = default to private vehicle standard.

INTERNATIONAL VISION STANDARDS

The United States vision standard for CMV drivers has evolved over a period of more than 50 years to meet the perceived requirements of American roads. During this same period, similar standards have been evolving in other industrialized countries, but not necessarily in driving environments comparable to those found in the United States. It is impossible to know the extent to which the standards in the industrialized countries have influenced each other during their evolution. Certainly, it is reasonable to assume that some transfer of information has occurred, especially among English-speaking countries and countries of the European community. However, regardless of the history of how this information was spread, a survey comparing specific vision standards for drivers of CMVs in the industrialized countries can shed some light on the limits of vision thought to be reasonable by different national organizations. The results of this survey are presented next.

Current information on foreign vision standards of CMV drivers was obtained through correspondence with international standards, medical, and commerce organizations in January and February of 1991. In addition, vision standards for countries in the European Common Market were obtained from the British Association of Optometrists⁽¹⁴⁾ and from a 1985 review article by Charman.⁽¹⁵⁾ Table A.2 provides a summary of international vision standards for a selection of industrialized countries considered to be representative of the spectrum of response. Standards for visual acuity, visual fields, color vision, other conditions, and retesting are listed in the table.

Review of the foreign vision standards for CMVs revealed a wide disparity among the countries that offered information on visual standards. Visual acuity for each eye is specified with most countries requiring more than the current 20/40 Federal requirement. Only a few countries have binocular acuity requirements that are more stringent than the Federal 20/40 requirement. For visual fields, most countries state that the drivers have "normal" fields or "full" fields. Only 4 of 15 countries specified the visual field range for each eye (e.g., 120, 125, and 150 degrees). Most of the countries do not have a requirement for color, 2 of 15 did specify requirements for red, green, blue, amber, and yellow. Vision standards for CMV drivers vary significantly from country to country. Nine of 15 countries have other visual requirements, such as stereopsis, and will deny licensure for visual disorders and impairments such as aphakia, ametropia, diplopia, myopia, night blindness, and nystagmus. Eight of 15 countries reported that they require periodic checks for vision. The time between rechecks ranges from annually to every 2, 3, or 5 years. Some countries do not start periodic vision programs until drivers reach certain ages (e.g., 50, 60, or 65).

Table A.2. Summary of International Vision Standards for CMV Operators

COUNTRY/ Province	VISUAL ACUITY		VISUAL FIELD		COLOR	OTHER	RETEST
	Monoc	Binoc	Monoc	Binoc			
Australia / Queensland	20/30 20/30	NS	NS	170	R,A,G	Deny Aphakes	NS
South	20/30 20/40	NS	Normal + 45	NS	NS	Deny Aphakes	3 yrs
West	20/30 20/60	20/30	NS	NS	NS	NS	NS
Victoria	20/40 20/40	NS	NS	NS	NS	NS	3 yrs >60, 1 yr
Belgium	20/40 20/65	NS	125 125	NS	Deny Protano pe	Deny NB,NG, DP	3 yrs
Canada /Ontario	20/30 20/50	NS	120 120	NS	NS	NS	3 yrs >65, 1 yr
Denmark	20/40 20/80	NS	NS	NS	NS	NS	NS
Italy	20/27 20/50	NS	Normal Normal	NS	Normal	Normal Stereop	NS
Japan	20/40 20/40	20/25	NS	NS	R,Y,B	Normal Stereop	NS
Netherlands	20/25 20/40	20/25	150 150	NS	NS	Deny NB,DP	>50, 5 yrs
Sweden	20/25 20/50	NS	Normal Normal	NS	NS	NS	2 yrs
Switzerland	20/20 20/25	NS	Normal	NS	NS	Deny NB,ST,H M	5 yrs >50, 3 yrs
United Kingdom	20/30 20/40	NS	Full Full	NS	NS	Deny DP,HM,A P	NS
West Germany	20/20 20/25	NS	NS	NS	NS	NS	NS
EEC	20/27 20/40	NS	No Field Loss	NS	NS	Deny DP,NB	Periodic

Key to Table 2: Visual acuity is expressed in Snellen notation; visual field is given in degrees along the horizontal meridian; color abbreviations: R = red, G = green, A = amber, Y = yellow, and B = blue; abbreviations for other conditions: AK = aphakia, DP = diplopia, HM = high myopia, NB = night blindness, NG = nystagmus, and ST = stereopsis (absence of); NS = standard not specified

GUIDELINES OF PROFESSIONAL AND GOVERNMENT ORGANIZATIONS

This section presents vision **recommendations** for CMV operators by the American Medical Association (AMA) and the U.S. Department of **Transportation**, National Highway **Traffic** Safety **Administration**, and American Association of Motor **Vehicle** Administrators (**USDOT**, **NHTSA**, and **AAMVA**).

VISION RECOMMENDATIONS OF THE AMA

The task of enforcing the Federal **vision** standard for operators of **CMVs** falls primarily to medical doctors **who** have a **minimal amount** of **training in** methods for visual testing. The AMA has **historically** participated in **setting** the Federal **vision** standards **and** has **provided guidelines**⁽¹⁶⁾ for vision testing to its members. The guidelines published **in** 1986 differ from the Federal **vision** standard in **excluding high-power spectacle** lenses (**10** diopters or greater) and in requiring **visual** acuity in **each** eye of **20/25** or **better** compared to **20/40** for the CMV standard. In addition, other **visual** disorders are **discussed, including stereopsis, nighttime vision, diplopia, and oscillopsia**, but **specific** recommendations for **excluding drivers with** these conditions are avoided.

Class I drivers are **qualified** to operate any **vehicle, including large**, heavy articulated **trucks** and **vehicles**, and trucks transporting hazardous **materials**, such as **fuel, chemicals, explosives**, and radioactive **substances**. Excerpts **from** the AMA vision **recommendations** for **Class I** drivers only are given **below**:

- **Central Visual Acuity**—Central **visual** acuity should **be** assessed at a standard distance of **20** feet **with** optimal **refractive correction**. The assessments **should exclude** the **use of extremely** high-power **spectacle lenses in the range** off **10 diopters (D)**, **binoculars**, telescopes or low-vision-aid spectacles or compound **magnifying** systems, because such lenses distort **and reduce the visual fields** of the wearer. **In all instances**, the driver's acuity **should** be demonstrated **promptly**.

It is recommended that **drivers** in Class I have central **visual** acuity of **20/25** or better **in** each eye **with** or without **conventional** spectacle **correction**. Spectacle correction of **10 D** or more **in** either eye should **be** **disqualifying**. A **driver** may **be** tested with contact lenses if he or she can **wear** them **all** day.

- **Field of Vision**—The **Goldmann 30-centimeter radius bowl** perimeter has become the **reference** standard for testing **visual** fields **since** its **introduction in** 1945. However, **less** cumbersome and **less** expensive equipment may be used

In testing fields of vision, the examiner may use confrontation testing with eye-to-eye fixation by examiner and examinee. The examiner measures awareness of a cotton-tip applicator or a moving finger at the periphery and compares it with his or her own visual fields, which must be normal.

Alternate methods of testing utilize the American Automobile Association's table model field-of-vision tester, which is 20 inches in diameter and encompasses approximately 220 degrees horizontally; the Titmus push-button perimeter arc, adapted to the top surface of a Titmus vision tester, the simple hand-held Schweigert and Spiller rotating arc perimeters; and the hand-held C Perimeter. For screening purposes, the testing is confined to the horizontal arc and utilizes a 3-millimeter white target against a 330-millimeter radius arc or a Goldmann perimeter using the III 4e target.

For Class I drivers, each eye is tested separately while the other eye is obscured by an opaque occluder, preferably one that is tied around the head. The patient's spectacles or contact lenses should be worn during the visual field examination. Each eye should have visual field recognition throughout an arc of 140 degrees or more. Individuals wearing spectacles with lenses exceeding 10 D or utilizing heavy spectacle frames generally cannot meet this standard.

- Color Vision—The completely color-blind or achromatic individual usually has poor central visual acuity and also may have visual field loss. The widespread modification of adding yellow to red and adding blue to green traffic signals has reduced the problem of red-green visual confusion, even in persons with significant deficiencies of red or green sensitivity.

Class I drivers should be able to distinguish the basic traffic control colors, red, green, and amber, with each eye separately.

- Stereopsis—Stereopsis is almost exclusively a function of near vision and it is tested by near-range equipment, such as a Verhoeff stereopter, the Wirt-Titmus double-printed polaroid vectograms, or random dot stereograms. Distance depth perception in driving does not relate to near-range stereopsis and it can be satisfactorily tested only with a road driving test. Testing of this function is not required to determine a driver's medical qualifications.
- Nighttime Vision—Nighttime or mesopic visual functions...are classified as (1) night vision or central acuity under reduced illumination; (2) glare tolerance or central acuity against a standardized glare light source; and (3) glare recovery time, as expressed in seconds necessary to regain satisfactory night vision after exposure to disabling glare. Economical and reliable testing procedures are not generally available and results often are not reproducible.

(For Class I drivers)...the physician testing nighttime vision should attempt to detect morphologic and structural alterations of the eye that are known to affect it and its mesopic functions, such as corneal opacities; dystrophies or scars affecting the pupillary portion of the cornea; lens opacities, particularly those involving the pupillary or central portion of the lens; pigmentary degeneration of the retina;

optic atrophy, degeneration of the **maculae**; or **significant arteriosclerotic**, diabetic, or hypertensive **retinopathy**.

- **Diplopia and Oscillopsia**—**Binocular** vision and fusion are the **product** of highly **specialized** and **precise** neurological **functions**. Factors known to impair these **functions** are **alcohol** ingestion, hypoxia, and fatigue. Individuals vary **greatly** in their **fusional capacities** and in their tolerance of the **impairing** factors. A driver who develops diplopia soon **will** learn to close **an** eye to suppress one of **the** images. The occurrence of diplopia is relatively rare, but its presence could **interfere with** the safe operation of a motor vehicle.

Among the **many neurological** diseases that may **produce** diplopia is multiple sclerosis. A **high** proportion of patients **with** that condition have **nystagmus** of a rapid, jerky **type** that may **cause** some blurring of the visual image. **Gaze** palsies of **supranuclear** origin **and** conditions **involving** the **extraocular** muscles or sixth cranial **nerve** also **can cause** diplopia. **Ptosis** due to a condition **affecting** the third nerve may reduce the **visual** field. Acute optic neuritis reduces vision on the side of the affected **nerve**; symptoms may clear **in** days or weeks but **recurrences are** frequent.

To **be medically qualified** for a Class I . . . license, the driver **should** have a **waiver** from the **examining** physician based **on long-standing** functional adaptation.

- ✍ **Transient States Affecting Vision**—(The **guidelines describe** reasons for transient **obscuring** of vision, including **physiological** disorder, **dilating** pupils during **eye exams**, **temporary monocular** states, and problems with **contact lenses**. However, **no specific recommendations** are made for Class I or other **class** drivers.)

MSION RECOMMENDATIONS OF USDOT/NHTSA/AAMVA

The U.S. Department of Transportation and National Highway **Traffic** Safety **Administration, in cooperation with** the American Association of Motor **Vehicle** Administrators, published a **1980 booklet** entitled 'Guidelines for Motor Vehicle **Administrators; Functional** Aspects of Driver Improvement-A Guide for State Medical Advisory **Boards.**'⁽¹⁷⁾ This handbook provided a set of **vision** recommendations for **all** drivers who are otherwise medically capable of operating commercial **vehicles**, including heavy trucks. The recommendations differ from those in the Federal vision standard but are the same as **those** in the **AMA** standard for **visual** acuity (**i.e., 20/25** or better is required **in** each eye, not **20/40** as **specified** in **the** Federal standard). However, **visual** fields are the **same** as **those** in the Federal vision standard (**i.e., 140** degrees for **each** eye **in** the horizontal field). In addition, **color identification** is the same as that in **the** Federal vision standard and AMA recommendations (**i.e., ability to distinguish red, green, and yellow/amber**). The **booklet**

provides recommendations for visual acuity, visual fields, ocular motility, color discrimination, depth perception, dark adaptation, refractive states, and strabismus (crossed eyes). The recommended requirements for Medical Category I drivers (covering commercial motor vehicles) are as follows:

- Visual A&y-Prompt central visual acuity is required to interpret traffic signs and cues at usual speeds. Central visual acuity for distance should be recorded using the Snellen notation. The individual should have the ability to coordinate use of both eyes and have conventionally corrected visual acuity in each eye of at least 20/25. Periodic reevaluation is recommended.
- Monocular Visual Acuity-Recommend that license be denied to those with monocular vision.
- Binocular Horizontal Visual Field-Each eye tested separately must have a horizontal visual field of 140 degrees or more. Periodic reevaluation is recommended
- Ocular Motility-Drivers with a history of intermittent or uncontrolled diplopia should not be licensed.
- Color Discrimination-Individuals with defective color vision may be considered. Can have some degree of color blindness, but has the ability to discriminate red, green, and yellow traffic signals. Periodic reevaluation is recommended.
- Depth Perception-No recommendations are given.
- Dark Adaptation/Glare Tolerance-It is recommended that the overall visual behavior of individuals with cataracts, retinal abnormalities, chronic pupillary constrictions, or other known causes of glare intolerance or poor dark adaptation be carefully evaluated before such individuals are recommended for unrestricted licensure.
- Refractive States-Myopia (nearsightedness), hyperopia (farsightedness), and astigmatism (distorted, but constant for all viewing distance) can usually be compensated for and need not be considered as problems. Likewise, presbyopia (inability to focus clearly at near) is natural to aging and is not of licensing concern if compensated or corrected.
- Strabismus(crossed eyes)-The strabismic person should be evaluated based upon visual acuity and normal visual fields the same as a binocular person.
- Use of Telescopic Lenses-It is recommended that telescopic device applicants not be licensed except upon individual review and evaluation by a medical advisory board

EVALUATION OF EMPIRICAL EVIDENCE

Vision standards for commercial driving have evolved in parallel with those for private motor vehicles. Although the performance demands on commercial drivers considerably exceed those placed on an average private passenger vehicle operator, the recommended CMV vision standards that apply to both differ only in relatively minor ways. A typical state CMV standard rests on the specification of a minimum binocular visual acuity performance which varies from 20/70 (3 states) to 20/40 (40 states). In comparing private vehicle and CMV standards, it is noted that at least 40 states require 20/40 binocular vision for CMV drivers compared to 38 states requiring 20/40 for drivers of private vehicles. Thus, the difference between the private and commercial requirements is small and confined to a very few states. The Federal CMV vision standard farther specifies a minimum visual field in the horizontal meridian. In general, the state CMV standards fall below the Federal CMV standard. Only 19 states have monocular visual field standards as required in the Federal standard. Similar to acuity, states have slight variations in visual field requirements for private vehicle operators, compared to CMV requirements. Seventeen states have monocular field standards for private vehicle drivers compared to 19 for CMV drivers. Eighteen additional states have binocular field standards for both private and CMV drivers.

The evolution of visual performance standards has been guided by a clearly perceived need to specify adequate visual capacity to assure public safety in a task obviously dependent on vision. However, this process has been able to draw little from an empirical base which was almost nonexistent at the start of the process and has encountered considerable difficulty in adding information of clear practical significance since that time. A reading of the historical data in this area leads to the conclusion that original standards were based on a consensus of expert opinion at that time. Major original contributors to this consensus were (1) the medically oriented fields of ophthalmology and optometry, and (2) research scientists concerned with problems of human visual psychophysics. Inter- and influence from both of these sources remain strong to the present. However, during the intervening period, a separate identifiable research and engineering community has evolved that both coordinates and conducts research in direct support of standard-making and the regulatory process. This discipline (traffic engineering and safety) is multidisciplinary in nature, drawing from the medical, engineering and scientific fields, and has presided over the accumulation of a very large base of data on problems related to safety and efficiency in virtually all matters pertaining to private, commercial, and public motor vehicle use.

DRIVING PERFORMANCE RECORD

A major research effort commenced to identify and measure the relationship among many aspects of visual performance and accessible indicators of driving safety. These studies often take the form of a *post hoc analysis* of data already accumulated through routine driver registration testing and record keeping. However, some studies have introduced innovative controlled vision testing methods into the driver testing routine, designed to obtain data on a broad scale which could then be correlated with the driving record over time. Since the early 1960s, numerous research projects have been conducted to study the relationship between vision test results for operators of motor vehicles and their driving performance record (i.e., accidents and violations). Most of these studies were initiated to determine what visual skills best correlate with driving performance in an attempt to recommend to state licensing agencies the most practical vision tests to administer to license applicants and renewals. Many of the studies focused on vision tests that were easily accessible through commercial vision screening devices. However, some of the studies involved developing customized vision testing apparatus and some used clinical equipment that would be impractical for mass vision screening in a licensing bureau environment. Most of the research focused on the passenger vehicle operator; only a few investigated the visual and driving performance of the CMV operator.

A summary of the most significant research efforts in the area of vision performance of passenger vehicle operators versus their driving performance record is presented next. Then, the more limited evidence describing a relationship between visual performance of CMV operators and their driving performance record is examined. Last, the discussion focuses on aging and visual pathology as they relate to driving.

Passenger Vehicle Operator

(1) **Burg Studies**—One of the earliest, most comprehensive studies on the relationship between vision and the driving performance record was conducted by Burg⁽¹⁸⁻²¹⁾ on more than 17,500 drivers over a 3-year period in the 1960s. Driving habits (annual mileage reported), age, and gender were reported in addition to information on their vision test performance. In Burg's studies, the following vision tests were examined: dynamic visual acuity (ability to perceive details of an object when there is relative motion between the observer and the object); static visual acuity (ability of the observer to perceive details of a stationary object); lateral visual field (extent of the observer's side vision when looking straight ahead); lateral phoria (aim of the eyes in the horizontal plane); low-light

recognition thresholds, glare recovery (length of time required to perceive an object after being subjected to glare); and sighting dominance (individual's preferred eye). Of the vision tests analyzed in relation to traffic convictions and accidents (reported), statistically significant correlations found between vision and the driving performance record which were nevertheless extremely weak. Burg reported that mileage and age were the most powerful predictors of traffic accidents and convictions. A later analysis of the Burg data by Hills and Burg in 1977⁽²²⁾ revealed a small but significant correlation between accident rates for drivers over age 54 and their static/dynamic visual tests and glare recovery tests.

Many of the research studies from the 1960s concluded that accident and violation records were only slightly predictable from visual performance measures and that factors such as age, sex, and exposure mileage were better predictors of driving records than any visual characteristics. (19,22,39)

(2) **Mark I Vision Tester**—In the early 1970s, the U.S. Department of Transportation was developed an interest in the results of the Burg studies. They initiated a series of investigations designed to develop a battery of vision tests that were more functionally related to driver performance and safety, and which could lead to the development of a vision testing device for use in screening driver's license applicants or renewals. In this study, Henderson and Burg⁽²³⁾, after reviewing prior literature and analyzing earlier data, provided a systematic analysis of the visual requirements for driving. Through use of a prototype vision testing device (MARK I), the following visual functions were regarded as important to USC in the study:

- Static visual acuity (normal illumination)
- Central angular movement
- ✍ Central movement-in-depth
- Useful peripheral vision
- Static acuity (low-level illumination)
- ✍ Field of view
- ✍ Eye movement and fixation
- Dynamic visual acuity

. Accommodation faculty

Glare sensitivity

Over 600 license renewal operators were screened on the MARK I. Accident statistics were collected for the preceding 3 years for each operator. Results showed a moderate, consistent age-related decline for all the visual functions. Significant age-related loss in visual ability was reported for static acuity under normal and low illumination, glare, and dynamic acuity. However, the correlational analyses conducted to assess the potential predictive validity of the MARK I displayed many significant correlations in the direction of poor visual performance statistically related to a good driving record. Further analyses revealed the age factor as an extraneous variable causing this outcome. Older drivers with the experience and ability to compensate for their lost visual functions, plus their greatly reduced driving mileage, had considerably fewer accidents than their younger, better-sighted counterparts. The U.S. Department of Transportation, encouraged by some of the results of the MARK I, decided to continue its research to develop a valid vision screening device to be employed as standard equipment in a typical motor vehicle department field office.

(3) Mark II Vision Tester-Upon developing a new device (MARK II) that was relatively compact, durable, and affordable (as well as having such features as a much shortened administrative testing time, and the entire instructions, testing, and scoring procedure computer-automated), initial testing by Shinar⁽²⁴⁻²⁶⁾ performed initial testing using 890 licensed operators. The results revealed very low correlations between accident rate measures and visual performance. In fact, no significant correlation existed between vision and driving record for the 25 to 54 age group. Additional testing indicated that poor dynamic and static visual acuity under low levels of illumination was most consistently related to accidents; poor static acuity under low levels of illumination was related to nighttime accidents. There was also a relationship between central angular movement and accident involvement. In addition, none of the single vision tests was significantly associated with accident involvement for all age groups, but each test was significantly associated with accident involvement for one or more of the age groups. Results indicated that the reliability and stability of the vision test scores had to be increased before pass/fail criteria could be analyzed. Overall results between the battery of vision tests and the driving statistics were inconclusive and really did not establish a clear-cut relationship between specific visual tests and the driving record.

(4) **Visual Acuity**-Important work, **correlating visual** acuity test scores of **13,700** drivers with self-reported accidents during the previous **12-month** period, was carried out in the **mid-1970s** by **Hofstetter**.⁽²⁷⁾ Data **were collected** nationally **over** a period of **10** years by **means** of a survey taken in a variety of settings and **population**. Additional support was provided from the **Auxiliary** to the American Optometric **Association**, using six available commercial vision screeners. Accident **rates** for persons with acuity in the lower quartile of the measurements were compared to rates for persons **with** acuity above the median measurement. Drivers in **the** lower **visual** acuity **group** were found to be twice as likely to **have had three** accidents in the previous **year** as **those with** acuity above the **median**, and **50** percent more likely to **have** had two accidents. No **significant** differences were found **between** the lower acuity and higher acuity drivers when **only** one accident was used as the criterion of comparison. This **study** provides evidence of a connection **between** poorer **visual** acuity and increased accident frequency. These results apply **only** to the very poor **visual** performers compared to the best **in the driver** cohort. **Hofstetter** **estimated** the visual acuity lower quartile cutoff for young drivers at **20/25** and for older drivers at **20/60**. However, the quartile cutoffs are arbitrary and **cannot** be interpreted **in** terms of a criterion for routine driver screening.

Davison⁽²⁸⁾ reviewed literature **on the relationship** of **vision** tests to **driving record** in the **late** 1970s. 'He concluded that **weak** but statistically **significant positive** associations with the driving record could be **consistently** documented for dynamic **visual** acuity, angular movement detection, detection of movement-in-depth, and static **visual** acuity. The review found no statistically significant **associations** with **driving records** for the following vision **tests**: color vision, stereoscopic acuity, muscle imbalance, and **visual fields**. Davison concluded **that these** last four **vision tests** are poor predictors of **accident** rates and are of doubtful **value** in a routine driver **screening** environment.

In 1985, Davison⁽²⁹⁾ conducted **vision tests** (visual acuity, **vertical/lateral** muscle balance, **binocular fusion**, and color perception) on **1,000** motorists. **These** motorists were randomly stopped in and **around** a town in England and asked to volunteer for a **vision test** and provide information on driving record, vision examination history, and **other** demographic information. He **found significant** positive **associations** between accidents and right-eye or left-eye visual acuity and **binocular** acuity for all drivers and a relationship between

accidents and vertical **heterophoria** for drivers age 55 and over. (He also found a relationship between accidents and **heterophoria** [binocular muscle imbalance] and accidents.)

(5) **Visual Fields**-The visual field test used in driver screening measures only the outermost limits of the **horizontal** meridian in response to a clearly super-threshold (**bright**) **stimulus**. Studies on **visual** fields in the 1970s by Council and Allen⁽³⁰⁾ did not show a **significant** relationship between the test results and the drivers' records. The Council and Allen study involved a very large driver cohort in which **visual field** measurements were compared with accident rates for 52,000 drivers. This study found that only 1 percent of drivers recorded a horizontal field of 120 degrees or less, and that the accident rate for these drivers was no higher than for those whose fields were greater than 120 degrees. Earlier studies by Danielson⁽³¹⁾ involved a much smaller driver cohort (680 drivers) and also reported no significant relationship between **horizontal** and central **visual** fields and the accident performance record.

Evaluation of **visual** fields for medical purposes has advanced to the level of using computer-automated techniques to **measure brightness** detection thresholds for a grid of up to 80 or more **locations** throughout the potential field of vision. In 1980, Keltner and Johnson⁽³²⁾ used automated static **perimetry** to screen more than 500 drivers for any evidence of **visual field** loss. This technique found that approximately 5 percent of the motorists had **significant** visual field loss compared to only 1 percent found to have a noticeable deficit in the study by Council and Allen using the **horizontal** meridian test. In addition, Keltner and Johnson report that subjects over age 65 have four to five times the incidence of **visual field** deficits of younger patients. For the Keltner and Johnson study, field loss was **defined** as substantial depression of all or part of the peripheral visual field and/or an **inability** to detect two or more **adjacent** visual field points (**scotoma**). This project was **extended**⁽³³⁾ to compare the **visual field** loss of 10,000 volunteer drivers with **accident/conviction** histories. For this **larger** study, it was found that drivers with **visual** field loss in both **eyes** had accident and conviction rates that were twice as high as those for drivers with **normal visual fields**. The results were **statistically significant**. These authors suggest that decreased **performance** on a **visual** fields test is most likely to result from age-related decreases in retinal illumination and other **acquired** vision impairments which are more **common** in older age groups (such as glaucoma, degenerative myopia, diabetic **retinopathy**, and **retinal** detachment).

In the mid-1980s, North⁽³⁴⁾ conducted a review of studies comparing the relationship between the extent of visual field and driving performance. He reported that Johnson and Keltner's study in 1983⁽³³⁾ showed evidence to support the relationship between visual fields and safe driving, while the majority of other similar studies comparing accident records and visual fields performance had not. This may have been attributed to the use of nonstandard perimetric tests that had not been validated, inadequate controls over the subject's fixation, and limited testing of only two locations on the horizontal meridian of the visual field. North reported that the lack of relationship found between the extent of visual field and driving performance could be due to poor study methodology and motorists with visual defects limiting their driving to favorable conditions.

(6) Glare Sensitivity—Studies on glare sensitivity were conducted in the 1970s. Henderson and Burg⁽²³⁾ and Shinar et al.⁽²⁵⁾ were unable to show any significant relationships. In addition, Gerstle et al.⁽³⁵⁾ were unable to show a significant correlation between glare sensitivity scores and accident type, yet reported that drivers with a glare problem modified their driving behavior (i.e., reduced night driving). Wolbarsht, in 1977,⁽³⁶⁾ tested 1,500 driver's license applicants and renewals for glare sensitivity at three veiling glare ratios (background:target) of 2:1 (high glare), 4:1 (medium glare), and 8:1 (low glare). He used a modified commercial vision screener with a customized overlying glare source of controllable intensity. The results showed no significant correlation between glare scores and driving performance, although the average glare sensitivity scores did increase with age. He recommended that drivers 50 years of age and older be periodically checked for elevated glare sensitivity because of their tendency toward elevated scores, even though his data could not be used to set glare screening criteria. He also found that monocular drivers tended to have elevated glare sensitivity.

(7) Contrast Sensitivity—A recent study⁽³⁷⁾ was completed for the Pennsylvania Department of Transportation (PennDOT), to determine the value and feasibility of periodic vision screening during license renewal. Decina et al. examined the relationship of three vision measures (static visual acuity, horizontal visual fields, and contrast sensitivity) to accident and violation records for 12,483 drivers who were unaware that they would be tested. It was discovered that drivers who failed the PennDOT visual standard or scored below "normal" on the contrast sensitivity test were at a significantly higher risk for

accidents in the two oldest age groups (66 to 76 and 76+), but not in younger groups. However, researchers found no significant relationship between poor vision performance on each of the vision tests analyzed separately and accident and violation records.

In summary, clear-cut, strong correlations between vision tests and driving records of passenger vehicle operators have been difficult to establish because of the statistical distribution of drivers (age, sex, driving environment, driving experience, driving behavior) and indeterminate causes of traffic accidents. Difficulties in trying to relate driving performance to visual capabilities have been suggested in the literature as follow:

- Vision is only one of many factors influencing driving performance,
- Some of the vision tests used in studies do not really relate to the visual requirements of driving,
- Reliability of criteria used to measure driving performance may be low,
- Research methods may have used unrepresentative samples of the driving population, and
- Individuals with visual difficulties place self-imposed limits on their driving, thus reducing their exposure to the risk of an accident.

Commercial Motor Vehicle Operators

The literature reviewed in the preceding section relates to passenger vehicle driven. In general, the conclusions regarding the strength and existence of a statistical relationship from these studies can be applied in the context of CMV driving. However, since the demands of commercial driving are greater than those for passenger vehicle driving and the consequences of errors are greater, criteria for CMV drivers are more appropriately set based on evidence compiled in the commercial driving context. The studies that are reviewed next apply specifically to the CMV driver's task.

In 1973, Henderson and Burg attempted to relate CMV driving skills to the visual tests included in the Mark I Vision Tester.⁽²³⁾ Their goal was to establish a sound scientific basis for

minimum visual standards for the Bureau of Motor Carrier Safety. The relative importance of different **aspects** of **the** driving task was established by **examining** the literature, **interviewing** truck **drivers**, observing truck drivers **in action**, and conducting a systematic examination of the driving task. **These** authors established a hierarchy of importance for the **visual functions** selected as most important. Weights **were assigned** to various driving behaviors and to each visual function according to its judged importance to the **driving** behavior. Those **visual** functions judged to be most important to the truck driving task and necessary to **an analysis** comparing visual performance and accidents and violations were:

- Static **Visual** Acuity,
- ✍ **Dynamic Visual** Acuity,
 - Perception of **Angular** Movement,
 - Perception of Movement-in-Depth,
- **Visual Field**,
 - Movement in Depth and Steady, **Saccadic**, and Pursuit **Fixations**,
 - Glare Sensitivity, and
 - ✍✍ **Angular Movement**.

In the study that followed (on 236 CMV drivers), **these** authors reported a **statistically significant** relationship between poor **visual performance** on some tests **and** accident involvement. Most important among the **specific measures** of visual **performance** found to **have** a relationship to accidents **were** perception of movement **and** dynamic visual acuity. However, no correlation was found **between** static visual acuity or field of **view** and accident **frequency for** commercial drivers **in** this relatively small sample.

Although visual field has **not** been **shown** to correlate with driver **performance** in passenger vehicles, it seems unreasonable to assume that **very large** amounts of visual field loss **are** consistent with safe **driving**, especially in **heavy commercial** vehicles. **Monocular drivers** represent one important extreme, in exhibiting total **visual field** loss in **one eye with** relatively **normal** function in the other. **McKnight et al.**⁽³⁸⁾ studied the vision skills of monocular and **binocular** truck drivers. Consistent with **common-sense expectation**, they **found** that the **monocular driver** showed deficiencies on a **number** of clinical visual measures. However, **no differences were** found between

monocular and binocular drivers in tasks of actual driving performance (information interpretation, hazard detection, visual search, lane keeping, clearance judgment, and gap judgment). The one exception, in which a deficit was seen, was with information interpretation; defined as the distance at which signs could be read during both day and night driving in a controlled road test. The binocular drivers were able to read road signs at significantly greater distances than were the monocular drivers. It is interesting to note that the performance on this measure did not correlate significantly with the clinical measure of static visual acuity. Based on the lack of significant differences obtained from the other performance measures that correlated significantly with acuity, it was concluded that an individual's style of driving was a more predictive measure of accident involvement than was his visual status.

In a more recent attempt to correlate visual performance with accident record, Rogers, Ratz, and Janke in 1987⁽³⁹⁾ studied the driving records of visually impaired and nonimpaired heavy-vehicle operators. The purpose of the project was to determine whether the Federal vision standard can be justified based on the traffic safety record of these drivers. The records of over 16,000 heavy-vehicle operators registered by the California DMV were examined. Measures of driving performance consisted of Z-year total accidents and convictions associated with incidents involving commercially registered vehicles. Visually impaired operators were categorized into two subgroups of substandard static acuity; (1) moderately visually impaired (corrected acuity between 20/40 and 20/200 in the worse eye, 20/40 or better in the other), and (2) severely visually impaired (corrected acuity worse than 20/200 Snellen in the worse eye, 20/40 or better in the other). Nonimpaired drivers met current Federal acuity standards (corrected acuity of 20/40 or better in both eyes). Results of the analysis, adjusted for age, showed:

- Visually impaired drivers had a significantly higher incidence of total accidents and convictions and commercial-plate accidents and convictions than did the nonimpaired drivers.
- Moderately impaired drivers had a significantly higher incidence of commercial-plate accidents than did nonimpaired drivers.
- The incidence of total accidents did not significantly differ between the nonimpaired and moderately impaired drivers either before or after adjusting for age.
- Severely impaired drivers had a significantly higher incidence of commercial-plate convictions than did nonimpaired drivers.
- Nonimpaired and moderately impaired drivers did not significantly differ on commercial-plate convictions.

- **Drivers** licensed to operate any **combination** of heavy vehicles had a **higher** incidence of total accidents **and** convictions **and** commercial-plate accidents **than** did those licensed to operate **single** vehicles **having three or more** axles.

These **findings** led to **qualified** support for **the** current Federal standard, particularly **regarding** exclusion from **driving** of the **severely** impaired. Less support is offered regarding **the** restriction of moderately **visually** impaired **heavy-vehicle** operators.

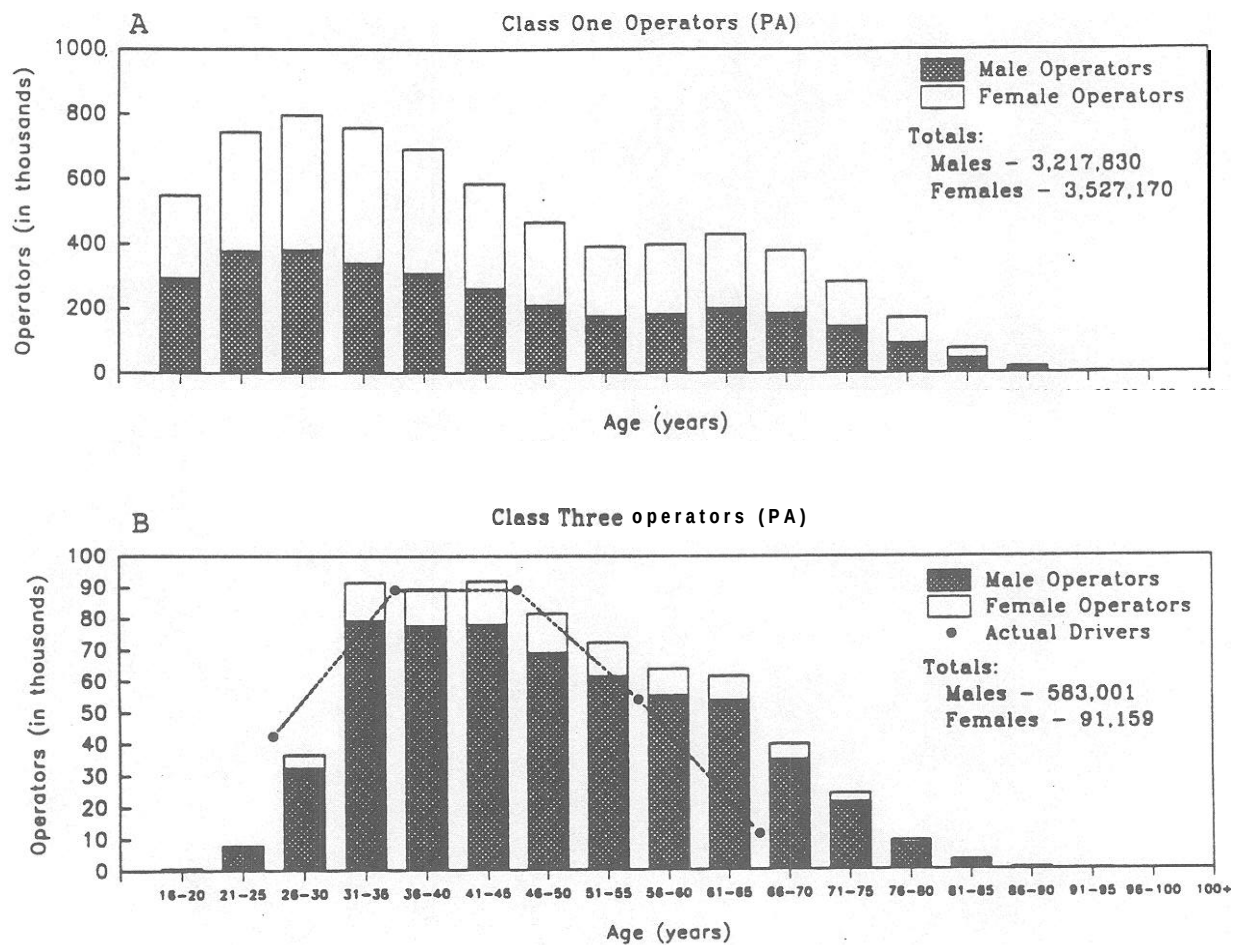
The **studies** reviewed previously represent a substantial **accumulation** of data **on the** relationship of vision to driver **performance**. No **single study provides support** for **definitive changes** to the **current** Federal commercial **vehicle** vision standard. **Nevertheless**, it is equally apparent **that changes in** terms of both more and **less** stringent requirements **in** several **performance areas** should **be** carefully evaluated at this time with the minimum aim **of** encouraging further empirical work. **Additionally**, it is apparent **that a large** gap exists between **the** stated Federal standard **and** its **uniform** and effective implementation **at the** level of **routine** practical **testing**. **Even though little evidence** appears to exist to support a **substantial** and **direct** relationship **between** vision and driver safety, much evidence **has been** accumulated to support **the** hypothesis **that** vision **contributes in** a **critical** way **in** interaction with **other** factors to **influence** **highway** safety.

Normal Aging and Visual Pathology

Beyond the age of **50**, **the** effects of aging **begin** to have a noticeable impact on **visual performance**. The aging process is not **well understood**, but its effects **on** vision **are** a slow **decline in** performance, that is manifested as a gradual **shift** toward **less** optimal performance **in** the normal **mean** for **an** age group as age increases. This **shift in** performance **has little practical** impact at **first**; but **if persons over the age of 65 are compared to those under 40**, a very noticeable **difference in performance** is evident. It is unclear how this gradual deterioration **affects** driver safety. Added to this normal **aging process** is **the increased** incidence of disease-related **pathology in the eye**, which is the most important **contributor** to serious **visual deficits**. Driver safety is **more clearly** linked to disease-related **decline in** vision since **this** is **likely** to be **more** rapid and **profound than** the **decline associated** with **normal aging**. This **section** is a review of studies relating **aging and** disease to driver **performance**, with **an** attempt to assess **the** impact of **these processes** on **commercial driver performance**.

However, the impact of **aging** on the visual **capabilities** of **the CMV** driver is mitigated **considerably** by the fact **that** the older drivers are **underrepresented on the road**. **Figure A.1** illustrates **this** point for **all** licensed **Pennsylvania** drivers. **Figure A.1(A)** shows the **distribution** of private **passenger** licenses (Class One), by age, for the approximately 6.7 million Class I and **III** **licensed** operators. The largest **proportion** of **licensed** driven **occurs** in the **20** to **40** age groups. **Above this** age there **is** a decline that levels off **until** about **the age** of **65**, **where** a second decline occurs. The **corresponding distribution** for **CMV** drivers (Class **Three**) is shown in **Figure A.1(B)**. One immediate difference is the approximately **6:1** ratio of males to **females** compared to the roughly **50-50** split for passenger licenses. Of greater **significance** to **visual capabilities** are the **reduced proportions** of **licenses** at the **age** extremes. The **20** to **30** age group is very much **underrepresented** compared to passenger licenses and **the** oldest age groups **above 65** **also fall** off more rapidly. **Nevertheless**, the proportion of **CMV** licensed drivers over the age of **50** and up to age **65**, where **visual capabilities begin** to decline noticeably, is still quite comparable to that of **passenger** car drivers. If **these** drivers were to participate in **the** actual driving task in proportion to their **licenses**, the problem of aging and vision could be as **significant** as it would be for the general driver cohort. However, other evidence, **such as** that represented by the superimposed dashed line in **Figure A.1(B)**, points to a possible decline **in** older driver participation **on the** road in comparison to the number of licenses held. The **dashed line labeled** Actual Drivers represents 1989 survey data⁽⁴⁰⁾ from the Regular Common Carrier **Conference** Organization. These data on age are taken from truckers **actually on** the road **during** a certain period. The **survey** data indicate a **severe** reduction **in the** proportion of **CMV** drivers over the age of **50** **actually on** the road Further study may show that drivers with greater **loss** of **visual capabilities** are **even** more severely **underrepresented**, although **this** is **only** speculation at this time.

Many studies⁽⁴¹⁻⁴³⁾ have evaluated the **driving performance** of visually impaired automobile drivers—defined by the U.S. Department of Health and Human **Services** as **persons** with the **inability** to see **newsprint with corrective lenses** or with no useful vision in one or both eyes; **individuals** with cataracts, glaucoma, color **blindness**, detached retina, and other eye **diseases** are **included**. Conditions of these individuals may or may not significantly interfere with the driving function. Drivers with color blindness can **usually** adapt **quite well** to the driving task. **However, visually** impaired drivers **with** such **conditions** as **cataracts**, glaucoma, or extremely poor vision (not better than **20/200** with **corrective** lenses) may be a serious risk to **themselves** and **others** on the highways. These studies were conducted by state licensing agencies that have been **usefulness** of their medical



**Figure A.1(A) Licensed Private Passenger Car (Class 1) and
(B) Commercial and Heavy Vehicle Operators (Class 3) in Pennsylvania by Age**

review programs for the licensed automobile driver. The studies have assessed the effects of driver medical reexamination programs, medical advisory board reviews, state licensing agency evaluations and state license renewal application programs.

In 1972, Pascarella et al.⁽⁴¹⁾ studied the effects of the North Carolina Driver Medical Evaluation Program upon the accident and violation rates of medically evaluated automobile drivers. Over 4,100 drivers, who were medically evaluated and had their driving privileges restricted, suspended, or unchanged, were studied during a 2-year period. Accidents and selected violation records were collected over a year's time in both retrospective and prospective periods relative to the driver's induction into the evaluation process. In addition, a control group of over 9,400 randomly selected licensed categories included vision. The results of the study indicated that drivers with diagnosed visual defects had improved their driving record (i.e., less accidents/violations after the medical evaluation). However, their accident rates before and after evaluation were still significantly higher than those of the control population.

Another study by Lippman in 1979⁽⁴²⁾ for the Texas Health Department evaluated the effectiveness of the Texas Medical Advisory Board's (MAB) review of automobile drivers with chronic medical conditions. The study dealt with 19,000 medically impaired driver cases, including the visually impaired, that were reviewed by the MAB for 2 years. In addition, driving records on the reviewed drivers were obtained from the State Department of Public Safety for 1 year prior to MAB review and 1 year thereafter. The number of accidents and moving violations for MAB cases was determined and compared with state average numbers of accidents and moving violations in the entire population of drivers in Texas. The total effect of the MAB review for the visually impaired was a 76 percent reduction in accident rate and a 65 percent improvement in violation rate. The authors noted that the beneficial effects of the MAB action started at about 30 years of age. From age 40 on, the effects of the MAB action were so beneficial that the accident rates were parallel and even better than the statewide average. It seemed that the effects of the MAB action increased proportionally with age.

Popkin et al.⁽⁴³⁾ reexamined the impact of the North Carolina Driver Medical Evaluation Program on the driving performance of medically impaired automobile drivers entering the program in the early 1980s. Pre- and post-evaluation periods were established for persons who had medical reviews and a sample of more than 6,900 drivers was used. Visual disabilities were included in the categories of medically impaired. Results showed that drivers in all of the disability groups experienced a decrease in crash involvement rates after medical program evaluation. Drivers with

certain disabilities, including vision, had post-review crash rates similar to the general driving population Popkin concluded that the medical review program did significantly improve the driving performance of drivers with medically impaired conditions, but that these drivers still had more accidents than the general driving population

These studies demonstrated improvement in the driving safety of medically impaired drivers after intervention by a licensing agency. In general, accident rates of the impaired drivers were significantly reduced after intervention, but were still higher than those of the normal population. Violation rates did not show improvement after intervention and were still higher than those of the normal population.

UNDERLYING STATISTICAL ASSUMPTIONS

The purpose of this section is to present a statistical model that makes explicit some of the major assumptions underlying much of the empirical work previously reviewed. The goal of the empirical research has been to establish the nature of the relationship between measures of visual performance and driving safety. The results of this work generally lead to the conclusion that the direct link between visual performance and measures of driver safety, such as history of accidents and citations for moving violations, is weak. When correlations have been found, values have been low and very large numbers of drivers have been needed in the analysis to demonstrate statistical significance. Results such as these have been considered disappointing and an intense effort has been devoted to finding "better" methods of measuring both visual performance and driver adequacy in the hope that more robust relationships will emerge. The brief analysis that follows is an attempt to provide insight into why these generally disappointing results have been obtained. A model of statistical reasoning known as signal detection theory (see Egan⁽⁴⁴⁾) has been adapted to the problem of detecting unsafe drivers within a population of safe drivers on the basis of visual performance. This model has come to be accepted as representing important aspects of a discrimination task. The signal detection model was developed initially in the context of detecting an electronic signal in the presence of noise (defined as anything in the signal domain that is not the signal), and has been applied widely and successfully in the analysis of psychophysical tasks such as those used to test vision.

Figure A.2 illustrates the signal detection paradigm as it applies to the vision and driving problem. The discrimination task is to identify "bad" drivers on the basis of a visual performance score. In Figure A.2, the distribution of scores obtained on a test of vision (e.g., visual acuity, visual

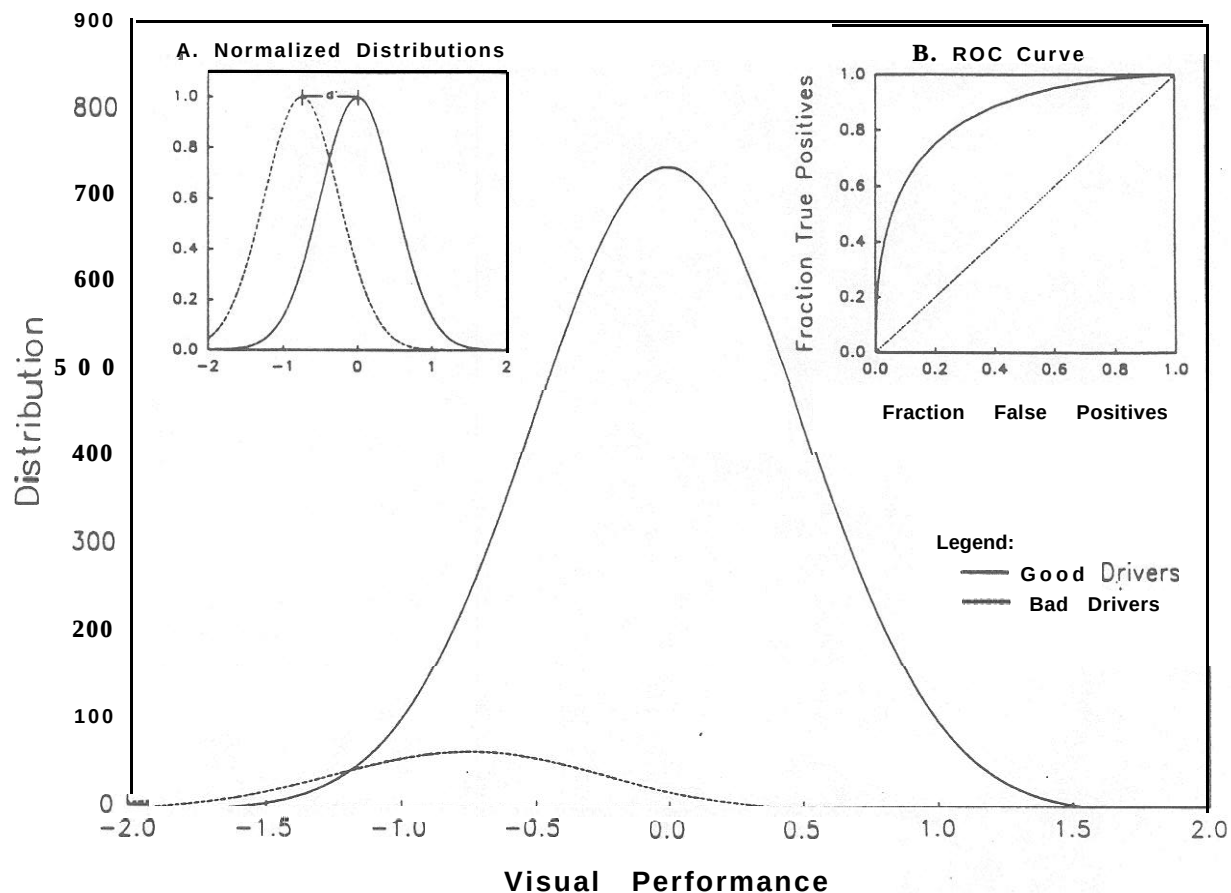


Figure A.2 Distributions of Visual Performance Scores for "Good" and "Bad" Drivers and the Associated ROC Curve

fields, and contrast sensitivity) by good drivers is shown as a solid line. The distribution for the same test for bad drivers is shown as a broken line. The definition of bad drivers is not specified but can be any definition appropriate to the purpose, such as accident rate or moving violations. An important point to notice is the overlap in the distributions. In other words, many bad drivers can have good vision and vice versa. This overlap, which is well documented for every measure of visual performance in relation to safe driving, is at the heart of the discrimination problem. The greater the overlap that exists between the good and bad driver populations, the more difficult the discrimination task will be. The heights and areas under the main distribution curves are in rough proportion to the number of good and bad drivers in the population, using statistics derived from a study of 12,483 Pennsylvania drivers done by Decina et al.⁽³⁷⁾ However, the signal detection scheme

is better understood for groups of **equal** numbers (normalized **distributions**) **within** the population that **differ** only **in the** characteristic **under** study (driving safety **in** this case). This **situation** is illustrated **in** inset A of **Figure A.2**, where the **difference in means** for the two driver groups is labeled **d'**. **Larger** values of **d'** correspond to less overlap **in** the good and bad driver **populations** and to a better ability of the model to **discriminate** bad from good drivers at any **criterion** or cutoff value of the visual test. **Thus**, weak **correlations** found between **vision** and driving performance might be explained by extensive overlap **between** vision scores of good and bad drivers **and** by correspondingly **small d' values** **and** conversely, less overlap will correspond to **stronger correlations**.

Detailed **knowledge** of the test score distributions permits **quantifying** the predictive **value** for driver performance of **any visual** test by **constructing** the receiver **operating characteristic** (ROC) for **the** two distributions (good and bad drivers) of the **vision** scores **under study**. This is done **in** inset B of **Figure A.2** by **counting and** then plotting the number of bad drivers (**true** positives) that **occur** compared to the number of good drivers (false positives) that **occur** below different values of the visual **performance** score. The ROC curve that results is the solid **line** above the **diagonal** in inset B. It shows graphically the ratio of **true** positives to **false positives** at every value of the test score. In this **example**, at low test **values**, the rate of **accumulating** hits (**true** positives) exceeds the rate of **accumulating** false positives **and** yields a **large** value for the slope of the ROC **curve** **up** to the point at which the slope is parallel to the **diagonal** (dashed line **from** lower left to upper right of the graph). Beyond this point, false positives accumulate more rapidly than hits and the slope of **the** ROC **curve** declines. **The** positive diagonal **represents** a ROC **in which signals cannot** be **distinguished** from noise or the line which **corresponds** to **chance discrimination**. This would occur when the **distributions** for both bad and good **drivers** overlap to **the extent** that they are **coincident**. In general, the area under the ROC between the **curve** and the diagonal is directly **proportional** to the **ability** of the test score to **discriminate** the target **population**, **in this** case, bad **drivers**. **Thus**, the **area under the ROC curve can be used as an index to measure how well a given test can perform a discrimination**. This result is used **next** to **examine** data on the **relationship** of **visual acuity and visual field** to driver safety **in two** sets of data: (1) acuity **scores** from the **12,483** drivers of the **Decina et al. study⁽³⁷⁾**, and (2) **visual field** scores from the Council and Allen **study⁽³⁰⁾** of **52,000** North **Carolina** drivers.

Figure A3 shows **the distributions** of visual acuity by age **found in** the **Decina** data set. As shown there **is no** difference between drivers up to age 54 and after that age, progressively more drivers score below **20/20**. This distribution is also notable **in that** it does not **return** to **zero** on the right side. **This is an artifact** of the testing and recording **procedure that** assigns every driver with

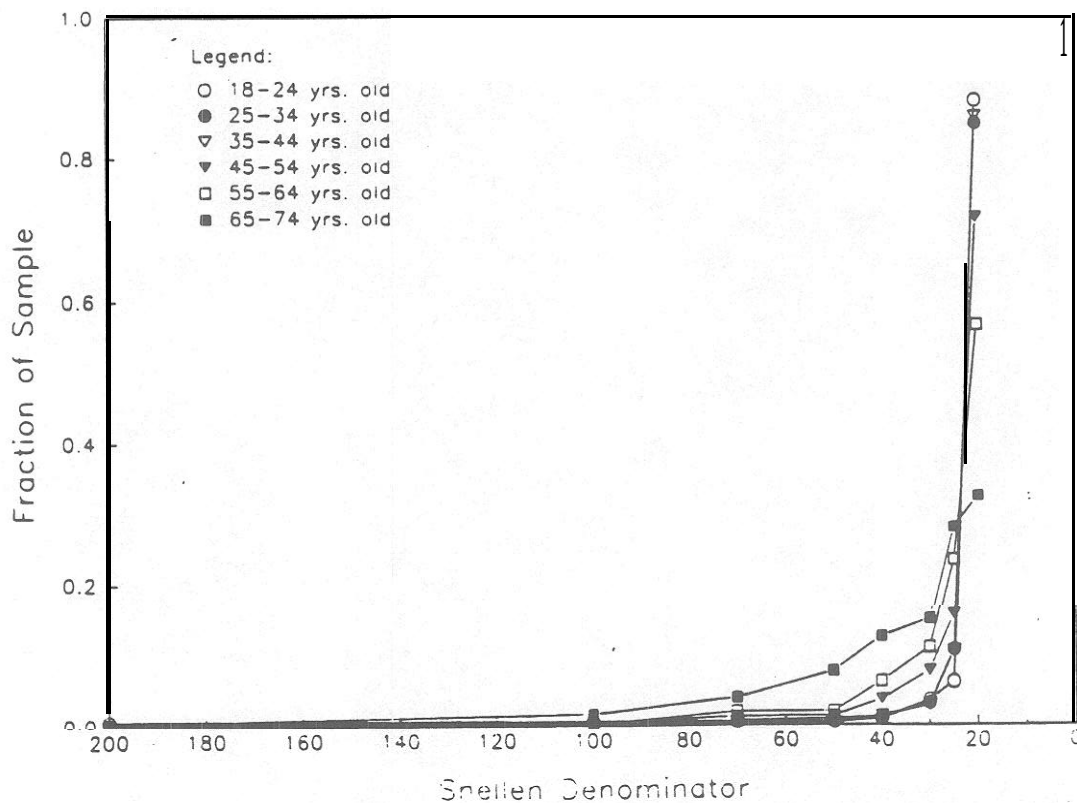


Figure A.3. Distributions of Snellen Visual Acuities at Different Ages

20/20 or better to the 20/20 category. Testing with finer gradients near 20/20 and recording results that are better than 20/20 will show a return to zero frequency at better acuities. However, the distribution will remain sharply peaked near 20/20 and fall off much more rapidly above 20/20 than below (see Hofstetter⁽²⁷⁾ for examples of acuity distribution shapes). Nevertheless, the distributions can provide a basis for comparison of good and bad drivers since most of the information critical to establishing the nature of the ROC curve is contained in the overlap to the left of 20/20. Figures A.4 and A5 illustrate this point. Figure A.4 plots the visual acuity scores of pooled data for 25 to 44 year olds recorded for both good (open squares) and bad drivers (open triangles) on the same graph. The inset shows an enlarged view of the distributions for scores of 20/40 and below.

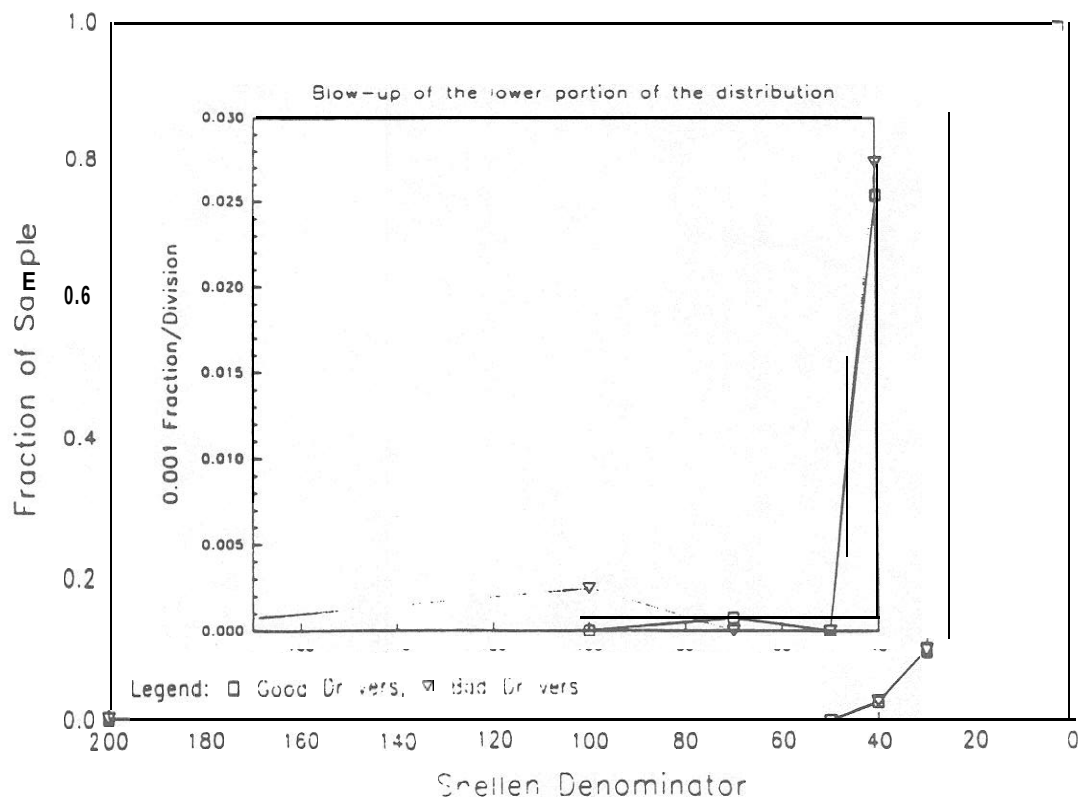


Figure A.4. Acuity Score Distributions for 'Good- and 'Bad' Drivers in the 25 to 44 Age Group

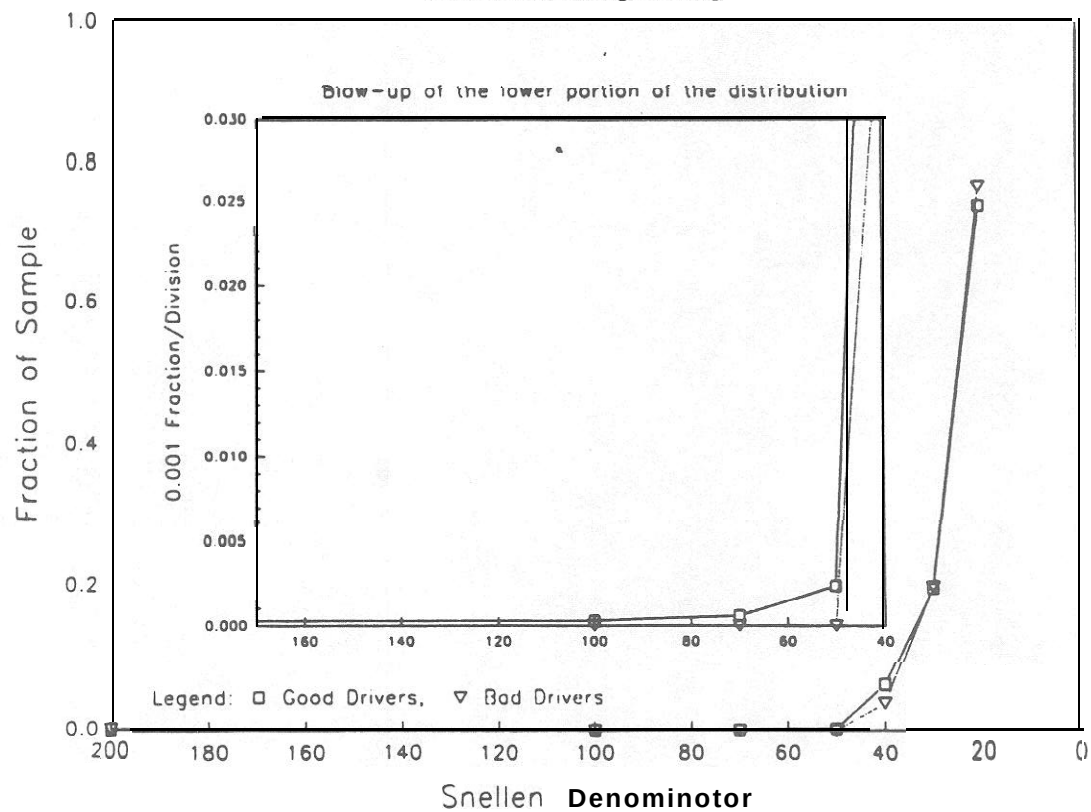


Figure AS. Acuity Distributions for 'Good' and 'Bad' Drivers in the 45 to 64 Age Group

The **overlap** is **almost** complete, **with** only a **marginal excess** of bad drivers **over good** at 20/100. A **similar** pattern is **seen** in **Figure AS**, which **shows** data pooled for 45 to 64 year **olds**. Here, the fraction of bad drivers **with 20/20 vision** slightly exceeds that of **good drivers**. The ROC **curves** corresponding to these **distributions** are **virtually** coincident **with** the positive diagonal. The areas under the ROC **curves** are **.50** and **.48** for the **two age** groups, indicating **no discrimination** ability for this test **with this population** of drivers.

A further **analysis is** shown in **Figures Ab, A7, and A.8** for **visual field** scores for the 52,000 drivers of the **Council and Allen study**⁽³⁰⁾. **Again**, the distributions of the **visual field** scores for the **subgroups** of **good** and bad drivers are almost completely overlapping, and the areas under the ROC **curves** are **.50** and **.50**, **again** indicating no **discrimination** power for this **variable**.

Examination of the **score distributions** for a test of **vision in defined good** and bad driver populations provides **insight** into the problem of predicting driver **performance** from test scores. The extensive overlap of the well-behaved (relatively smooth) distributions derived from **the** extensive **Decina** and Council and **Allen** data **sets** indicates that the vision tests administered to

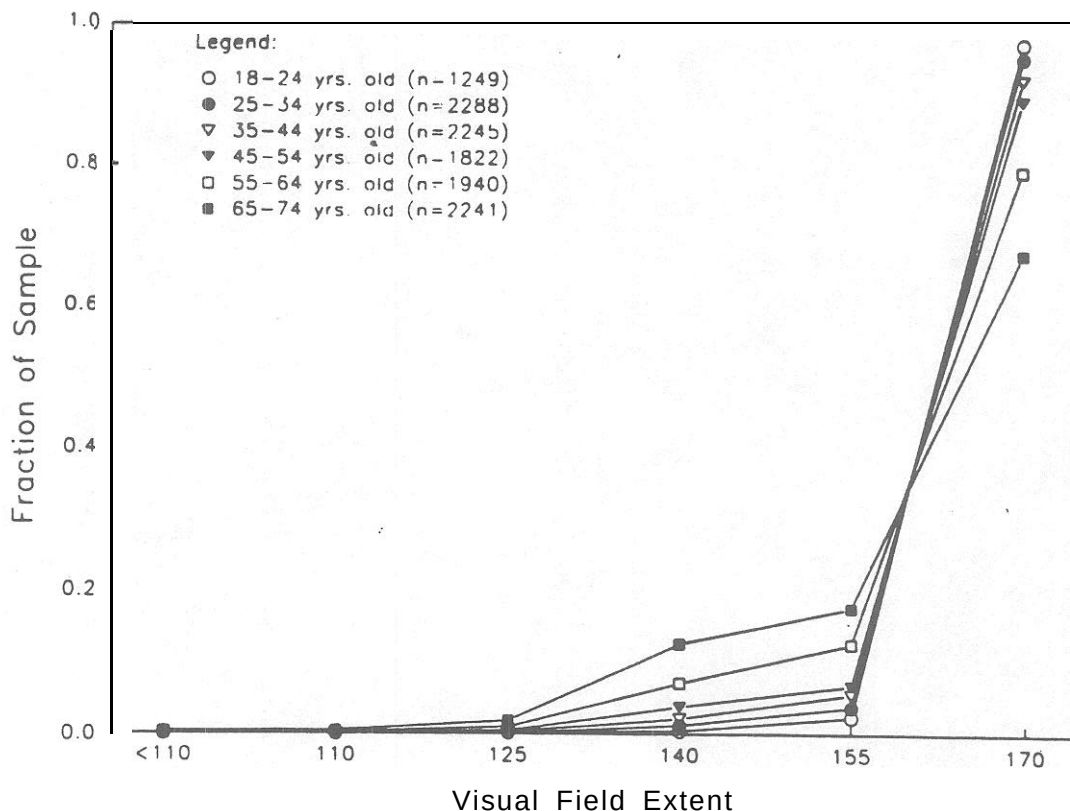


Figure Ab. Distributions of Extent of Visual Field

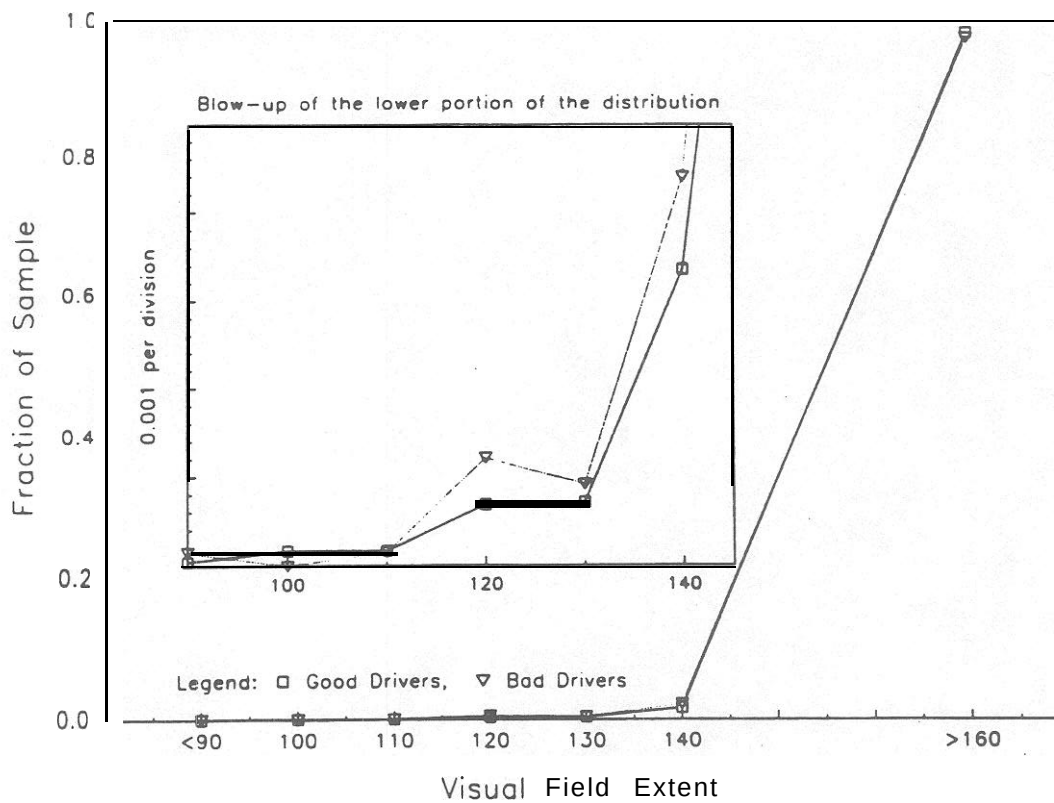


Figure A.7. Visual Field Scores for "Good" and "Bad" Drivers for 26 to 40 Age Group

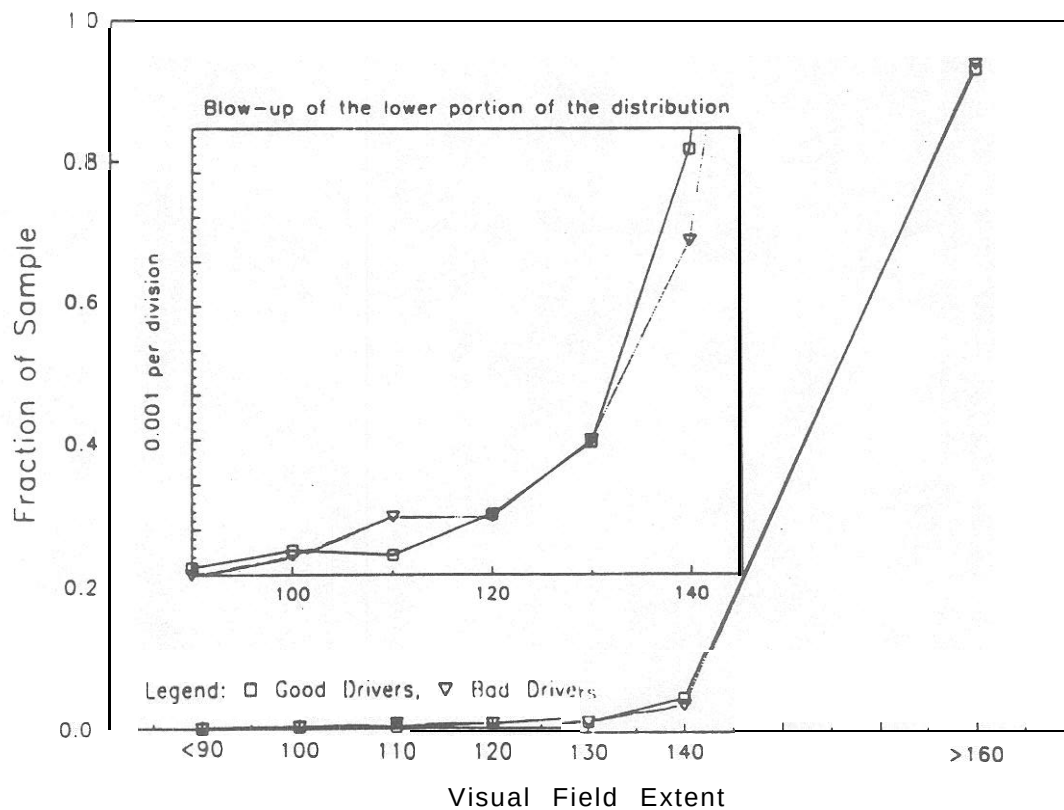


Figure A.8. Visual Field Scores for 'Good' and 'Bad' Drivers for 41 to 60 Age Group

these drivers **cannot** be used to distinguish **reliably** between good **and** bad drivers as **they** have been **defined** here. **This** situation is somewhat more extreme **than the** one reported by Henderson and Burg,⁽²³⁾ **who found significant** correlations for **both** static **and** dynamic acuity **visual** test scores. However, it is **worth noting that there** was no correlation found for **visual field and** the correlation for static acuity **was very** low.

Do **these results mean that** visual tests can never be used effectively to **screen** out poor drivers? Moreover, do **these results mean that visual** testing is **essentially** ineffective at maintaining safety **on** the roads? Several points must be made before **answers can** be offered for **these** questions. **In** particular, a strong argument can be made **that the driver** populations tested **in the Decina** and Council and Allen **studies**, and **in** most others, do not represent **the full range** of **visual capabilities** for potential drivers, **nor** do **they** represent **the full** range of driver **capabilities**, particularly at the low end of **the** visual performance scale. Potential drivers with **vision below the minimum** standard **are underrepresented** through two **mechanisms**. **First**, previously **licensed** drivers have been **prescreened** for **vision** below **the** standard (for **the Pennsylvania** drivers of the **Decina** study, this **was only at** the time of initial **licensing**). To **the** extent **that** the **screening** exam was accurate and vision remained stable in **the** intervening time, **the** driving record of previously licensed **drivers** reflects performance under conditions of **good vision**. For **drivers** falling below **the** vision standard at the time of retest, it is **unclear** how **much** of their driving record **should** be considered to have occurred **under** conditions of good vision or under the poorer vision **found at the** time of retesting. **In** general, a discrepancy of **this** kind **will** favor **producing** more overlap in the **distributions**. However, this problem is **diminished** to some **extent in the Decina** study because only accidents and convictions in **the** preceding **3-1/2 years** were **included**. Restricting **the** time **horizon** for data in **this** way **works in** the **direction** of improving probable correlation of the tested vision with that **actually present at the** time of **the** recorded accident or violation. Second, potential **new** drivers **with** vision **obviously** below the standard will be less likely to submit to a driving **test which** they **most** likely **will fail**. **These** drivers do not accumulate **driving** records **that can** be correlated **with** their vision and **are left** out of **virtually all studies** appearing **in the** literature.

Problems associated **with exclusion** of drivers **with** poor vision from **the** driver database, however, do not **seriously** weaken **the** conclusion **that** tests of visual performance **have** low **power** to disaimiite **poor** or unsafe drivers from safe drivers in **those** presenting themselves for examination. That **visual testing alone cannot** disaimiite unsafe drivers, **even though vision** is **necessary** to **driving**, is fundamental to **the** safe driving **problem**.

EMERGING TRENDS IN APPLIED VISION RESEARCH

The problems noted previously indicate that, at present, **tests** of visual performance have **low** power to **discriminate** poor or **unsafe** drivers from safe **drivers**. One prominent conclusion to **be drawn** from **these** data is that factors **other** than vision must contribute to accidents; this is supported by **the** observation that the same fraction of **accident-involved** and safe drivers has **20/40** or better vision. A paradigm—the “useful **field of view**”—for explaining how vision may contribute in **conjunction** with other factors to produce accidents has been the focus of recent investigations by **Ball et al.**⁽⁴⁵⁾ and Sloan, **Owsley** and **Ball**.⁽⁴⁶⁾ This work has **focused on vision**, attention, and elderly driver accident experience, but has obvious applications to the **CMV** driver assessment problem. **An** overview of this work is **described** in a **research** problem statement prepared by the Basic Research Subcommittee of the TRB **Older Driver** Task Force (**A3T52**)⁽⁴⁵⁾ and is **briefly** summarized here.

“Driver inattention” has long been cited as an underlying cause of vehicle crashes **in the elderly**.⁽⁴⁷⁾ In addition, many older adults have deficits **in their attentional skills**.^(48, 49) Three **recent** retrospective **studies** have demonstrated **that** visual **attentional** problems are good predictors of **poor** driving performance in **older** adults. **The first study**⁽⁵⁰⁾ examined how accident frequency (from state **records**) in 53 older drivers was related to **visual/cognitive capacities** at a number of different **levels**, such as **ocular** disease, **visual sensory function**, **visual** attention, and mental status. The best predictor of **accident** frequency was a model incorporating a **composite** measure of **visual** attention (the size of the **useful** field of view) and mental **status**, **which** together accounted for **20** percent of the variance. This model was **much** stronger **than those** reported **in** earlier studies on **vision and** driving that **assessed** only **visual** sensory function, and excluded **measures** of information **processing skills** at higher **levels**.

The **useful** field of **view** (**UFOV**), the best correlate of accident frequency **in the** aforementioned study, **refers** to the **area** of the **visual** field in **which** information **can be** rapidly extracted without eye **and** head **movements**.⁽⁴⁸⁾ It **involves** the **earliest, preattentive (parallel-processing)** stage of visual attention **which** is used to **quickly** capture and direct attention to highly salient **visual events**, a **skill** that seems **crucial** for effective driving, **especially** for **CMV** drivers who require **exaggerated** lead times for **hazard** recognition. The UFOV test **incorporates** measures of

divided **attention**, selective attention, and speed of visual information **processing** to **arrive** at an overall **measure** of **attentional** capacity. In **this** study, the older drivers with restrictions in the size of **the useful** field of view had **15 times** more intersection accidents **than** those with normal visual **attention**.

Obviously, a **test** of visual attention like the UFOV makes use of **information** coming through the visual **sensory** channel. For example, **individuals** in the previous **study** who had serious **visual field loss** **also** had a serious impairment **in** the **useful** field of view. On the other hand, visual **sensory** field loss was not a **necessary** and **sufficient** condition for a constricted UFOV. **Many** older adults who had impairments in the UFOV had normal **visual** fields. Thus, the UFOV depends on the integrity of **visual** sensory information, and **on** other **processing** skills, such as attention. In this sense, it is a more **comprehensive** measure of information processing ability than **visual sensory** status alone.

A **second and** more recent **large** sample study (over **300** older drivers) by **this research** group **has confirmed** that the UFOV is a good predictor of accident problems, **with** the correlation **between** accident **frequency** and UFOV **size exceeding** $r=0.55$.⁽⁵¹⁾ A **correlation** of **this** magnitude **between** driver **capability** and **crash** involvement is **virtually** unprecedented, underscoring the **importance** of **these** findings. This emerging evidence suggests **that** further research to develop **assessment** approaches incorporating **attentional** as **well as purely** sensory visual **capabilities** will be a fruitful area of **investigation**, **with** a strong potential impact **on** the **evolution** of new standards.

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APPENDIX B

RISK ANALYSIS OF A VISUAL ACUITY CRITERION SHIFT

An analytic exercise was **conducted** in this task to estimate the **change in** risks associated with **shifting** the **pass/fail** criterion for tests of **CMV driven' visual** acuity. **Functional** deficits in **any** of the **visual** capabilities identified **in** the previous expert **survey** as necessary for safe **performance** **could logically** be tied to **an** increased risk of accidents; visual acuity was chosen for the present **analysis** because. of its prominence in traditional vision test **protocols** and its high **level** of face validity to everyday driving tasks. Also, it should be noted that this analysis is **specific** to a defined operational **context**, as described below, and **necessarily relies** upon assumptions in that **situation** as found in **current** models of driver response effectiveness.

In particular, this analysis **case examines** a **maneuver/decision response** sequence within the **more general** framework of **decision** sight distance **models**.⁽¹⁾ In the present analysis, a safe and **effective** driver **response** depends upon sign **legibility/comprehension** under **freeway** operating **conditions**, taking into account the **increasing attentional demands** for avoiding traffic **conflicts** and the **corresponding** decrease **in attentional** resources available for road sign information **processing** **associated** with this situation. A **driver unfamiliar with** the roadway **been travelled**, who must respond to guide sign information to **successfully** navigate to his/her destination, is **also** assumed.

The performance context for this analysis is an **actual** section of highway **in** southern New Jersey, State Route **130**. **This** highway section has **three lanes** of travel **in** each **direction**; it is a **level**, tangent section with recorded **1989** average **daily traffic (ADT)** of 55,860 vehicles' and **unobstructed** sight distance to the overhead **guide** signs **which** are the key visual targets in this **analysis**. **The subject in this analysis is a CMV driver travelling southbound on** Route **90** West, the Betsy Ross Bridge leading to **Philadelphia**. In this **case**, the exit for NJ Route **90** is from the **left** lane. Two **sets** of **guide** signs direct the driver in this **situation**: **an** initial pair of overhead **signs** identifies Route **130** South through **lanes and the** left exit for Route 90, while a later **sign** conveys exit information for Route 90 **West only**. The initial pair of **signs** is **positioned** approximately 925 feet (282 meters) upstream of **the exit gore**; the later **exit** marker is positioned approximately 125 feet (38 meters) **upstream** of the exit gore. These **highway** sign targets are displayed **in Figure B.1**.

Also shown in Figure B.1 is a time/distance scale useful for tracking a driver's approach to the **exit point** (t_0, d_0), to the extent that a **response sequence timeline marking** the relative locations of key behavioral **events/maneuvers can** be defined. The **actual** vehicle movements required to safely

pcrs. **comm.**, NJDOT **Traffic** Services Dept., October 9.1991

accomplish the left exit in the situation as described above are straightforward: the CMV driver must change lanes twice—from the far right to the center to the far left lane—in a safe, controlled manner, then exit the highway at the ramp gore.

Driver Task

CMV operator travelling in right lane of 3-lane divided highway must respond to signing information as presented at S_1 and S_2 to exit from left lane at t_0 .

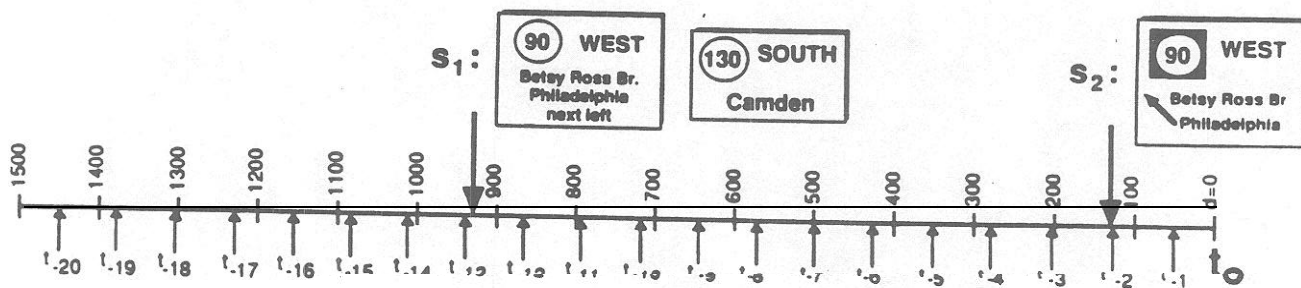
Operating Conditions

85%-ile speed: 50 mi/h (73 ft/s)

peak volume: headway = 2.5 s

visibility: daytime, clear

highway: dry, level, tangent section



NOTE: 1 ft = .3049 m

Figure B.1. Sign Position Indicated by Time (seconds) and Distance (feet) Upstream of Exit Points (t_0, d_0)

The **perceptual** and cognitive components of the driver's behavior **as** required to effect lane changes in a 'safe, controlled **manner**' are more problematical. While straightforward to define **in** a **qualitative** sense, the precise time requirements and the **extent** to which such information processing **operations** can be achieved in parallel are highly dependent upon moment-to-moment **traffic** conditions and the **resulting attentional** demands on the driver.

This analysis postulates discrete events in the response sequence **timeline**. These events include the detection/recognition of the initial overhead sign and **the** reading/comprehension of its message; the CMV driver's decision (choice reaction time) to **initiate** a lane change from the **right to the** center lane; the completion of **the first** lane change **maneuver**; the driver's decision (choice **RT**) to initiate a lane change from the center to **the left** lane; the completion of the second **lane change maneuver**; the driver's **reading/comprehension** of the later **sign's** message and accompanying decision (choice **RT**) to initiate an exit maneuver, and the **vehicle's** actual movement.

To estimate time requirements-and corresponding distances **travelled** at the **85 percentile** speed of **50 miles/hour (73 feet/second)**-for each event **in** the response sequence, current models of driver information **processing**^(1,2) were **consulted**, supplemented by field **observations** of CMV lane-change operations **on** I-95 in the Philadelphia area. **Based** on the field observations, 5.0 seconds is a representative value for the elapsed **time** from the instant the **left** front tire of a CMV cab crosses a lane line until the trailer has completely moved into the adjacent lane at **50 miles/hour**. For this analysis, it is assumed that peak volume **traffic** conditions will not permit a driver to execute both **lane** changes in a **continuous fashion**; rather, the **first lane change** will be completed; **then** a search for potential conflict vehicles **will** be performed before initiating the second lane **change**. Assuming separate vehicle maneuvers, the total time allocated to lane **change** maneuvers in this response sequence **timeline** is thus 10.0 **seconds**.

Another element of driver behavior to **account** for in this response sequence is **the** reading time for the critical information **on the initial** overhead guide **sign** (see St in **Figure B.1**). These critical elements **include the** route **designation (NJ 90)**, the cardinal direction (**WEST**), and the guidance information (**next left**). The name (Betsy Ross Br.) and destination (Philadelphia), which are also likely to be **scanned**, are not essential to an appropriate vehicle control **response** in this **situation**. (It is **not** the intent in this **analysis** to demonstrate **unrealistically** stringent requirements for driver visual **capability**; this approach **suggests using** minimum information requirements, **translating** to minimum reading times **and**, therefore, minimum required **legibility** distances.)

The reading and comprehension time for this sign (S₁) is both a function of the driver's expectations and sign content. Since it is assumed that the CMV driver is searching for this guidance information, the sign may be described as a search conspicuity target.⁽³⁾ This heightens the target value of the sign and further supports the logic above, whereby a minimum reading time for the sign is suggested as most appropriate for this analysis. Based on guidelines attributed to Dudek and Forbes reported by Perchonok and Pollack,⁽⁴⁾ a range of 25 to as much as 6.0 seconds would be required to read the critical information identified in the preceding paragraph. In consideration of the facilitative effect for processing this test due to the driver's expectation that a sign of this nature will appear-i.e., the search conspicuity target-a minimum reading time of only 2.5 seconds is postulated for this analysis. Again, it is not the intent in this analysis to rely on exaggerated estimates of driver response times that result in unrealistically long reading distance requirements.

Another perspective on this stage of processing is that of "percept&-reaction" time. Because this left exit situation is not commonplace, it is assumed that the driver is not expecting to make this maneuver. Therefore, the reading and comprehension time may be estimated fairly using the perception-reaction time of 2.5 seconds which is cited by AASHTO* and is incorporated into serial processing models such as the decision sight distance model.⁽¹⁾

Additional time requirements for the decisions to actually initiate each lane change depend upon the traffic density and the effectiveness with which the CMV driver can use the mirror system on the vehicle. A great deal of variability in this RT component may be introduced by moment-to-moment changes in the traffic flow. Using the most optimistic assumptions about driver visual search efficiency-and further postulating the availability of an acceptable gap under existing operating conditions-a "best-case" estimate of 1.5 seconds for the choice RT to initiate each lane change will be used for this analysis (see *NHTSA Driver Performance Data Book*).

Finally, the reading/comprehension time for the critical information on the later overhead guide sign (S₂ in Figure B.1) must be taken into account. Again, this may be characterized as a "search conspicuity" target that the driver expects to see. The information contained in this sign also is expected; thus, the component of sign comprehension is reduced to a "yes/no" decision as to

**Handbook on Geometric Design for Highways*, American Association of State Highway and Transportation Officials, 1984.

whether the **presented** information **confirms** the driver's understanding of the earlier sign's information (**S₁**). Accordingly, only 15 seconds are allocated to **this** stage of the exit **response** sequence-that is, **only the** minimum time required to read the critical detail **on** the sign **legend**: no separate "decision time" is **postulated** here.

A **cumulative** estimate of the **time/distance** necessary to safely **perform all** the component processes **in** this **response** sequence may now be derived, **consistent** with the assumption and **justifications** articulated previously. Working **backwards from the** exit gore, **identified** as **t₀** and d=0 in **Figure B.1**, the response **timeline** is as follows:

<u>Driver Performance Requirement</u>	<u>Associated Time Intervals</u>
● Driver initiates exit maneuver in time for cab to leave left lane of highway and move onto ramp at exit gore point.	t₀ to t-1.0
● Driver reads critical information on sign S₂ .	t-1.0 to t-2.5
● Driver performs lane change #2 (center lane to left lane).	t-2.5 to t-7.5
● Choice XT for lane change X2 (visual search , gap judgment , decision to initiate maneuver).	t-7.5 to t-9.0
● Driver performs lane change X1 (right lane to center lane).	t-9.0 to t-14.0
● Choice RT for lane change X1 (visual search , gap judgment, decision to initiate maneuver).	t-14.0 to t-15.5
● Driver reads/comprehends critical information on sign S₁ .	t-15.5 to t-18.0
● Driver detects/recognizes sign S₁ and selectively attends to this target	prior to t-18.0

Based on this **analysis** approach, it may thus be argued that safe **and** effective **performance** of an exit under these **circumstances** requires sign **S₁** of **320** to 390 feet (**98** to 119 meters).

The **angular subtense** for the Y-inch (lowercase) letters on sign St **defines** an acuity of 20/20 (Snellen) at 320 feet (98 meters). The **conclusion** may thus be reached that **any** reduction of a driver's acuity below 20/20 **will result** in an increased risk of a conflict in this situation-up to the point where the driver acquires the critical **information** so late **that** the required **lane-change maneuvers will not** be **attempted**. Qualitatively **describing** the relationship **between declining** acuity and increasing risk, within **this** bounded interval, is **addressed** next.

Missing a required exit from a limited access highway, with **the** need for additional **travel** in an **unfamiliar area** to correct this navigational **error**, is a potentially costly mistake for a CMV operator. It is, therefore, assumed in this analysis that **some** delay in **reading/comprehension** of the **critical** St information **will not necessarily result in** a driver decision to postpone the required route **change**, but instead **will result** in an attempt to **accomplish** the exit **in** a shorter time frame than **needed** for safe **performance**. **Eventually**, however, a **sufficient** delay **in** reading sign St-given **moderate-to-heavy** traffic volumes-may be **so long** that the maneuver **will not be** attempted. For this analysis, the **range** of St reading **distances** and associated points **in** the response sequence **timeline shown** in **Figure B.1** will be bounded by the **distance** at which lowercase text is **legible** to a **driver** with 20/20 vision ($t_{17.0}$ second) and the **actual** position of the initial **overhead** sign presenting the exit information of interest ($t_{12.7}$ second). In other **words**, it is assumed **that** a driver who fails to read/comprehend **the** critical **information** on **sign S**, by the time **he/she reaches** the sign **will not** attempt **the** exit maneuver **in** question in **this analysis**. The focus of **the analysis** is to describe a **function** of relating increasing risk of **traffic conflicts/accidents** to decreasing St legibility distance **resulting** from driver visual **acuity** worse. **than 20/20**.

With a driver visual acuity of 20/20 in this performance context, it has been argued previously that the available **time** at **85 percentile operating speed** is **sufficient** for **all** required components **in** the response (exit) sequence to be safely accomplished. This does not mean that traffic **conflict/crash probability** is **zero** under these **circumstances**, but that a near-zero minimum value is attained. **As** acuity **worsens**, legibility distance **decreases**, response time is **shortened**, and increasing **likelihood** of conflicts/crashes is a logical prediction.

At **best**, present understanding of the problem **will allow** specification of the **shape** of the **function** relating the **variables** described above. Change in legibility with distance is a linear function; however, factors other than legibility **alone influence** a driver's decision to proceed (or not to proceed) with the lane-change **maneuvers** required **in** this situation. Given the desire to predict

likelihood of a driving behavior, taking decisional/judgmental processes as well as sensory (acuity) processes into account, a normal distribution curve would seem most appropriate. As noted above, the response interval is bounded by the position of the first overhead sign (S_1); it is assumed that a decision to proceed with the lane-change maneuvers needed to accomplish the freeway exit would never occur later than this time/distance on the response sequence timeline in Figure B.1, since the driver would effectively have no advance knowledge of the upcoming exit if the initial sign had not been read. Therefore, it is suggested that the function relating increasing crash risk to decreasing acuity in this performance context is best represented by the right half of the normal curve, as shown in Figure B.2. This indicates that a small decrement in acuity would result in only a modest increase in accident risk, but further decrements would result in a dramatic increase in accident risk until some asymptotic level is reached near the cutoff point associated with the position of the initial overhead sign (S_1).

Additional data and analyses are required to calibrate this function and permit the assignment of absolute values to the axis in Figure B.2 indicating accident probability. To limit the values assigned to this function, it may be reasonable to inspect crash data for nighttime clear conditions, nighttime heavy rain conditions, and nighttime fog conditions on the same section of roadway over comparable periods of time. Each of these diminished visibility conditions reduces the preview time of advance sign information to a driver, with increasing reductions in preview time moving from the nighttime clear to the fog conditions. These data may thus serve as a useful analog to the progressive reduction in preview time resulting from lowered acuity in the present analysis case.

In conclusion, shifting the criterion for visual acuity may be expected to result in a measurable increase in probability of a crash whenever a CMV driver's vehicle control decisions depend upon timely comprehension of guidance information presented by highway signing, and moderate-to-heavy traffic conditions increase both the real-time processing load of the driver and the likelihood that sudden or erratic maneuvers will result in conflict with other vehicles. Existing models of driver behavior suggest that the function relating increased accident risk to decreasing acuity (criteria) will mimic the normal probability curve, but assigning specific values to accident probability will depend upon further analyses of reduced visibility crash data for a given operational situation.

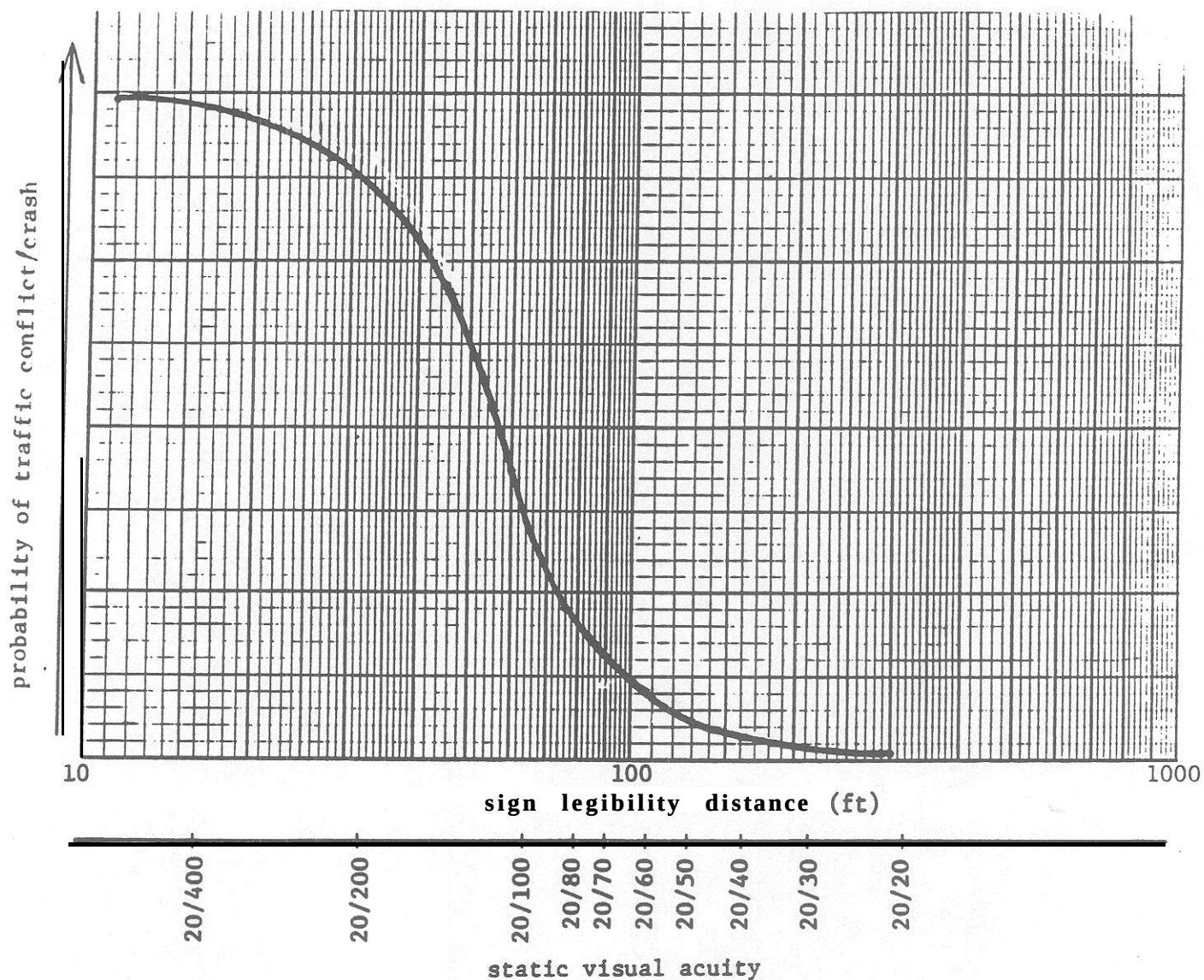


Figure B.2. Candidate Accident Probability Curve for Decreasing Visual Acuity for Present Analysis case.

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APPENDIX C

**FEDERAL REGULATIONS FOR PHYSICAL QUALIFICATIONS AND
EXAMINATIONS FOR CMV DRIVERS
(49 CFR 391.41 TO 391.49, OCTOBER 1, 1985)**

(h) A copy of the certificate required by paragraph (g) of this section shall be given to the person who was examined. The motor carrier shall retain, in the driver qualification file of the person who was examined—

(1) The original, or a copy of, the certificate required by paragraph (g) of this section;

(2) The questions asked on the examination; and

(3) The person's answers to those questions.

[35 FR 19182, Dec. 18, 1970, as amended at 36 FR 223, Jan. 7, 1971; 39 FR 20795, June 14, 1974]

§ 391.37 Equivalent of mitten examination.

(a) In place of, and as equivalent to, the written examination required by § 391.35, a person who seeks to drive a motor vehicle may present, and a motor carrier may accept, a valid certificate ~~as written~~ ~~issued pursuant to paragraph (g) of that section within the preceding 3 years.~~

(b) If a motor carrier accepts a certificate as equivalent to the written examination, it shall retain a legible copy of the certificate in its files as part of the driver's qualification file.

(c) A motor carrier may require any person who presents a certificate as equivalent to the written examination to take the written examination prescribed in § 391.35 or participate in any other instructional process designed to acquaint him with the provisions of Parts 390 through 397 of this subchapter.

[35 FR 6460, Apr. 22, 1970, as amended at 35 FR 17420, Nov. 13, 1970]

Subpart E—Physical Qualifications and Examinations

§ 391.41 Physical qualifications for drivers.

(a) A person shall not drive a motor vehicle unless he is physically qualified to do so and, except as provided in § 391.67, has on his person the original, or a photographic copy, of a medical examiner's certificate that he is physically qualified to drive a motor vehicle.

(b) A person is physically qualified to drive a motor vehicle if that person—

(1) Has no loss of a foot, a leg, a hand, or an arm, or has been granted a waiver pursuant to § 391.49;

(2) Has no impairment of:

(i) A hand or finger which interferes with prehension or power grasping; or

(ii) An arm, foot, or leg which interferes with the ability to perform normal tasks associated with operating a motor vehicle; or any other significant limb defect or limitation which interferes with the ability to perform normal tasks associated with operating a motor vehicle; or has been granted a waiver pursuant to § 391.49.

(3) Has no established medical history or clinical diagnosis of diabetes mellitus currently requiring insulin for control;

(4) Has no current clinical diagnosis of myocardial infarction, angina pectoris, coronary insufficiency, thrombosis, or any other cardiovascular disease of a variety known to be accompanied by syncope, dyspnea, collapse, or congestive cardiac failure.

(5) Has no established medical history or clinical diagnosis of a respiratory dysfunction likely to interfere with his ability to control and drive a motor vehicle safely;

(6) Has no current clinical diagnosis of high blood pressure likely to interfere with his ability to operate a motor vehicle safely;

(7) Has no established medical history or clinical diagnosis of rheumatic, arthritic, orthopedic, muscular, neuro-muscular, or vascular disease which interferes with his ability to control and operate a motor vehicle safely;

(8) Has no established medical history or clinical diagnosis of epilepsy or any other condition which is likely to cause loss of consciousness or any loss of ability to control a motor vehicle;

(9) Has no mental, nervous, organic, or functional disease or psychiatric disorder likely to interfere with his ability to drive a motor vehicle safely;

(10) Has distant visual acuity of at least 20/40 (Snellen) in each eye without corrective lenses or visual acuity separately corrected to 20/40 (Snellen) or better with corrective lenses, distant binocular acuity of at least 20/40

(Snellen) in both eyes with or without corrective lenses, field of vision of at least 70° in the horizontal Meridian in each eye, and the ability to recognize the colors of traffic signals and devices showing standard red, green, and amber;

(11) First perceives a forced whispered voice in the better ear at not less than 5 feet with or without the use of a hearing aid or, if tested by use of an audiometric device, does not have an average hearing loss in the better ear greater than 40 decibels at 500 Hz, 1,000 Hz, and 2,000 Hz with or without hearing aid when the audiometric device is calibrated to American National Standard (formerly ASA Standard) Z24.5-1951.

(12) Does not use . Schedule I drug or other substance identified in Appendix D to this subchapter, an amphetamine, . narcotic, or any other habit-forming drug; and

(13) Has no current clinical diagnosis of alcoholism.

[35 FR 6460, Apr. 22, 1970, as amended at 35 FR 17420, Nov. 13, 1970; 36 FR 223, Jan. 1, 1971; 36 FR 12857, July 8, 1971; 43 FR 56900, Dec. 5, 1978; 51 FR 17571, May 13, 1986]

§ 391.43 Medical examination; certificate of physical examination.

(a) Except as provided in paragraph (b) of this section, the medical examination shall be performed by a licensed doctor of medicine or osteopathy.

(b) A licensed optometrist may perform so much of the medical examination as pertains to visual acuity, field of vision, and the ability to recognize colors as specified in paragraph (10) of § 391.41(b).

(c) The medical examination shall be performed, and its results shall be recorded, substantially in accordance with the following instructions and examination form:

¹ A copy of the Schedule I drugs and other substances may be obtained by writing to the Director, Bureau of Motor Carrier Safety, Washington, DC 20590, or to any Regional Office of Motor Carrier and Highway Safety of the Federal Highway Administration at the address given in Part 390 of this subchapter.

INSTRUCTIONS FOR PERFORMING AND RECORDING PHYSICAL EXAMINATIONS

The examining physician should review these instructions before performing the physical examination. Answer each question yes or no where appropriate.

The examining physician should be aware of the rigorous physical demands and mental and emotional responsibilities placed on the driver of a commercial motor vehicle. In the interest of public safety the examining physician is required to certify that the driver does not have any physical, mental, or organic defect of such a nature as to affect the driver's ability to operate safely a commercial motor vehicle.

General information. The purpose of this history and physical examination is to detect the presence of physical, mental, or organic defects of such a character and extent as to affect the applicant's ability to operate a motor vehicle safely. The examination should be made carefully and at least as complete as indicated by the attached form. History of certain defects may be cause for rejection or indicate the need for making certain laboratory tests or a further, and more stringent, examination. Defects may be recorded which do not, because of their character or degree, indicate that certification of physical fitness should be denied. However, these defects should be discussed with the applicant and he should insure correction, particularly of those which, if neglected, might lead to a condition likely to affect his ability to drive safely.

General appearance and development. Note marked overweight. Note any posture defect, perceptible limp, tremor, or other defects that might be caused by alcoholism, thyroid intoxication, or other illnesses. The Federal Motor Carrier Safety Regulations provide that no driver shall use a narcotic or other habit-forming drugs.

Head-eyes. When other than the Snellen chart is used, the results of such test must be expressed in values comparable to the standard Snellen test. If the applicant wears corrective lenses, these should be worn while applicant's visual acuity is being tested. If appropriate, indicate on the Medical Examiner's Certificate by checking the box, "Qualified only when wearing corrective lenses." In recording distance vision use 20 feet as normal. Report all vision as a fraction with 20 as numerator and the smallest type read at 20 feet as denominator. Note ptosis, discharge, visual fields, ocular muscle imbalance, color blindness, corneal scar, exophthalmos, or strabismus, uncorrected by corrective lenses. Monocular drivers are not qualified to operate commercial motor vehicles under existing Federal

Motor Carrier Safety Regulations. If the driver habitually wears contact lenses, or intends to do so while driving, there should be sufficient evidence to indicate that he has good tolerance is well adapted to their use. The use of contact lenses should be noted on the record.

Ears. Note evidence of mastoid or middle ear disease, discharge, symptoms of aural vertigo, or Meniere's Syndrome. When recording hearing, record distance from patient at which a forced whispered voice can first be heard. If audiometer is used to test hearing, record decibel loss at 500 Hz, 1,000 Hz, and 2,000 Hz.

Throat. Note evidence of disease, irreparable deformities of the throat likely to interfere with eating or breathing, or any laryngeal condition which could interfere with the safe operation of a motor vehicle.

Thorax-heart. Stethoscopic examination is required. Note murmurs and arrhythmias, and any past or present history of cardiovascular disease, of a variety known to be accompanied by syncope, dyspnea, collapse, enlarged heart, or congestive heart failures. Electrocardiogram is required when findings so indicate.

Blood pressure. Record with either spring or mercury column type of sphygmomanometer. If the blood pressure is consistently above 160/90 mm. Hg., further tests may be necessary to determine whether the driver is qualified to operate a motor vehicle.

Lungs. If any lung disease is detected, state whether active or arrested; if arrested, your opinion as to how long it has been quiescent.

Gastrointestinal system. Note any diseases of the gastrointestinal system.

Abdomen. Note wounds, injuries, scars, or weakness of muscles of abdominal walls sufficient to interfere with normal function. Any hernia should be noted if present. State how long and if adequately contained by truss.

Abnormal masses. If present, note location, if tender, and whether or not applicant knows how long they have been present. If the diagnosis suggests that the condition might interfere with the control and safe operation of a motor vehicle, more stringent tests must be made before the applicant can be certified.

Tenderness. When noted, state where most pronounced, and suspected cause. If the diagnosis suggests that the condition might interfere with the control and safe operation of a motor vehicle, more stringent tests must be made before the applicant can be certified.

Genito-urinary. Urinalysis is required. Acute infections of the genito-urinary tract, as defined by local and State public health laws, indications from urinalysis of uncontrolled diabetes, symptomatic albumin-urine in the urine, or other findings indicative of

health conditions likely to interfere with the control and safe operation of a motor vehicle, will disqualify an applicant from operating a motor vehicle.

Neurological. If positive Romberg is reported, indicate degrees of impairment. Pupillary reflexes should be reported for both light and accommodation. Knee jerks are to be reported absent only when not obtainable upon reinforcement and as increased when foot is actually lifted from the floor following a light blow on the patella, sensory vibratory and positional abnormalities should be noted.

Extremities. Carefully examine upper and lower extremities. Record the loss of impairment of a leg, foot, toe, arm, hand, or fingers. Note any and all deformities, the presence of atrophy, semiparalysis or paralysis, or varicose veins. If a hand or finger deformity exists, determine whether sufficient grasp is present to enable the driver to secure and maintain a grip on the steering wheel. If a leg deformity exists, determine whether sufficient mobility and strength exist to enable the driver to operate pedals properly. Particular attention should be given to and a record should be made of, any impairment or structural defect which may interfere with the driver's ability to operate a motor vehicle safely.

Spine. Note deformities, limitation of motion, or any history of pain, injuries, or disease, past or presently experienced in the cervical or lumbar spine region. If findings so dictate, radiologic and other examinations should be used to diagnose congenital or acquired defects; or spondylolisthesis and scoliosis.

Recto-genital studies. Diseases or conditions causing discomfort should be evaluated carefully to determine the extent to which the condition might be handicapping while lifting, pulling, or during periods of prolonged driving that might be necessary as part of the driver's duties.

Laboratory and other special findings. Urinalysis is required, as well as such other tests as the medical history or findings upon physical examination may indicate are necessary. A serological test is required if the applicant has a history of luetic infection or present physical findings indicate the possibility of latent syphilis. Other studies deemed advisable may be ordered by the examining physician.

Diabetes. If insulin is necessary to control a diabetic condition, the driver is not qualified to operate a motor vehicle. If mild diabetes is noted at the time of examination and it is stabilized by use of a hypoglycemic drug and a diet that can be obtained while the driver is on duty, it should not be considered disqualifying. However, the driver must remain under adequate medical supervision.

The physician must date and sign his findings upon completion of the examination.

EXAMINATION TO DETERMINE PHYSICAL CONDITION OF DRIVERS

Driver's name _____ ☐ New Certification
Address _____ ☐ Recertification
Social Security No. _____
Date of birth _____ Age _____

Yes	No	Health History
☐	☐	Head or spinal injuries.
☐	☐	Seizures, fits, convulsions, or fainting.
☐	☐	Extensive confinement by illness or injury.
☐	☐	Cardiovascular disease.
☐	☐	Tuberculosis.
☐	☐	Syphilis.
☐	☐	Gonorrhea.
☐	☐	Diabetes.
☐	☐	Gastrointestinal ulcer.
☐	☐	Nervous stomach.
☐	☐	Rheumatic fever.
☐	☐	Asthma.
☐	☐	Kidney disease.
☐	☐	Muscular disease.
☐	☐	Suffering from any other disease.
☐	☐	Permanent defect from illness, disease or injury.
☐	☐	Psychiatric disorder.
☐	☐	Any other nervous disorder.

If answer to any of the above is yes, explain:

PHYSICAL EXAMINATION

General appearance and development:
Good _____ Fair _____ Poor _____

Vision: For distance:

Right 20/ _____ Left 20/ _____

☐ Without corrective lenses.

☐ With corrective lenses if worn.

Evidence of disease or injury:

Right _____ Left _____

Color Test _____

Horizontal field of vision:

Right _____ Left _____

Hearing:

Right ear _____ Left ear _____

Disease or injury _____

Audiometric Test (complete only if audiometer is used to test hearing) decibel loss as
500 Hz _____, at 1,000 Hz _____, at 2,000 Hz _____

Throat _____

Thorax _____

Heart _____

If organic disease is present, is it fully compensated? _____

Blood pressure:

Systolic _____ Diastolic _____

Pulse: Before exercise _____

Immediately after exercise _____

Lungs _____

Abdomen:

Scars _____ Abnormal masses _____

Tenderness _____

Hernia: Yes _____ No _____

If so, where? _____

Is truss worn? _____

Gastrointestinal:

Ulceration or other disease:

Yes _____ No _____

Genito-Urinary:

Scars _____

Urethral discharge _____

Reflexes:

Romberg _____

Pupillary _____ Light R _____ L _____

Accommodation Right _____ Left _____

Knee Jerks:

Right:

Normal _____ Increased _____ Absent _____

Left:

Normal _____ Increased _____ Absent _____

Remarks _____

Extremities:

Upper _____

Lower _____

Spine _____

Laboratory and other Special Findings:

Urine: Spec. Gr. _____ Alb. _____

Sugar _____

Other laboratory data (Serology, etc.) _____

Radiological data _____

Electrocardiograph _____

General comments _____

(Date of examination)

(Address of examining doctor)

(Name of examining doctor (Print))

(Signature of examining doctor)

NOTE: This section to be completed only when visual test is conducted by a licensed ophthalmologist or optometrist.

(Date of examination)

(Address of ophthalmologist or optometrist)

(Name of ophthalmologist or optometrist (Print))

(Signature of ophthalmologist or optometrist)

(d) If the medical examiner finds that the person he examined is physically qualified to drive a motor vehicle in accordance with § 391.41(b), he shall complete a certificate in the form prescribed in paragraph (e) of this section and furnish one copy to the person who was examined and one copy to the motor carrier that employs him.

(e) The medical examiner's certificate shall be in accordance with the following form:

MEDICAL EXAMINER'S CERTIFICATE

I certify that I have examined (driver's name (print)) in accordance with the Federal Motor Carrier Safety Regulations (49 CFR 391.41 through 391.49) and with knowledge of his duties, I find him qualified under the regulations.

☐ Qualified only when wearing corrective lenses.

A completed examination form for this person is on file in my office at _____
(Address)

(Date of examination)

(Name of examining doctor (Print))

(Signature of examining doctor)

(Signature of driver)

(Address of driver)

If the driver is qualified only when wearing a hearing aid, the following statement must appear on the medical examiner's certificate: "Qualified only when wearing a hearing aid." If a medical examiner determines a waiver is necessary under § 391.49, the following statement shall appear on the medical examiner's certificate: "medically unqualified unless accompanied by a waiver."

[35 FR 6460, Apr. 22, 1970, as amended at 35 FR 17420, Nov. 13, 1970; 36 FR 8452, May 6, 1971; 36 FR 12857, July 8, 1971; 43 FR 56900, Dec. 5, 1978; 46 FR 53418, Oct. 29, 1981]

§ 391.45 Persons who must be medically examined and certified.

Except as provided in § 391.67, the following persons must be medically examined and certified in accordance with § 391.43 as physically qualified to drive a motor vehicle:

(a) Any person who has not been medically examined and certified as physically qualified to drive a motor vehicle;

(b) Any driver who has not been medically examined and certified as qualified to drive a motor vehicle during the preceding 24 months; and

(c) Any driver whose ability to perform his normal duties has been impaired by a physical or mental injury or disease

[35 FR 6460, Apr. 22, 1970, as amended at 36 FR 223, Jan. 7, 1971]

§ 391.47 Resolution of conflicts of medical evaluation.

(a) *Applications.* Applications for determination of a driver's medical qualifications under standards in this part will only be accepted if they conform to the requirements of this section.

(b) *Content.* Applications will be accepted for consideration only if the following conditions are met.

(1) The application must contain the name and address of the driver, motor carrier, and all physicians involved in the proceeding.

(2) The applicant must submit proof that there is a disagreement between the physician for the driver and the physician for the motor carrier concerning the driver's qualifications.

(3) The applicant must submit a copy of an opinion and report including results of all tests of an impartial medical specialist in the field in which the medical conflict arose. The specialist should be one agreed to by the motor carrier and the driver.

(i) In cases where the driver refuses to agree on a specialist and the applicant is the motor carrier, the applicant must submit a statement of his agreement to submit the matter to an impartial medical specialist in the field, proof that he has requested the driver to submit to the medical specialist, and the response, if any, of the driver to his request.

(1) In cases where the motor carrier refuses to agree on a medical specialist, the driver must submit an opinion and test results of an impartial medical specialist, proof that he has requested the motor carrier to agree to submit the matter to the medical specialist and the response, if any, of the motor carrier to his request.

(4) The applicant must include a statement explaining in detail why the decision of the medical specialist identified in paragraph (b)(3) of this section, is unacceptable.

(5) The applicant must submit proof that the medical specialist mentioned in paragraph (b)(3) of this section was provided, prior to his determination, the medical history of the driver and an agreed-upon statement of the work the driver performs.

(6) The applicant must submit the medical history and statement of work provided to the medical specialist under paragraph (b)(5) of this section.

(7) The applicant must submit all medical records and statements of the physicians who have given opinions on the driver's qualifications.

(8) The applicant must submit a description and a copy of all written and documentary evidence upon which the party making application relies in the form set out in 49 CFR 336.37.

(9) The application must be accompanied by a statement of the driver that he intends to drive in interstate commerce not subject to the commercial zone exemption or a statement of the carrier that he has used or intends to use the driver for such work.

(10) The applicant must submit three copies of the application and all records.

(c) *Information.* The Director may request further information from the applicant if he determines that a decision cannot be made on the evidence submitted. If the applicant fails to submit the information requested, the Director may refuse to issue a determination.

(d)(1) *Action.* Upon receiving a satisfactory ~~the~~ the Director shall notify the parties (the driver, motor carrier, or any other interested party) that the application has been accepted and that a determination will be made.

A copy of all evidence received shall be attached to the notice.

(2) *Reply.* Any party may submit a reply to the notification within 15 days after service. Such reply must be accompanied by all evidence the party wants the Director to consider in making his determination. Evidence submitted should include all medical records and test results upon which the party relies.

(3) *Parties.* A party for the purposes of this section includes the motor carrier and the driver, or anyone else submitting an application.

(e) *Petitions in review.* *burden of proof.* The driver or motor carrier may petition to review the Director's determination. Such petition must be submitted in accordance with § 386.13(a) of this chapter. The burden of proof in such a proceeding is on the petitioner.

(f) *Status of driver.* Once an application is submitted to the Director, the driver shall be deemed disqualified until such time as the Director makes a determination, or until the Director orders otherwise.

(49 U.S.C. 304, 322; 18 U.S.C. 831-835; Pub. L. 93-633, 88 Stat. 8156 (49 U.S.C. 1801, et seq.); 49 CFR 1.48, 301.60)

[42 FR 18081, Apr. 5, 1971, as amended at 42 FR 53966, Oct. 4, 1977]

591.49 Waiver of certain physical defects.

(a) A person who is not physically qualified to drive under § 391.41(b)(1) or (2) and who is otherwise qualified to drive a motor vehicle, may drive a motor vehicle, if the Regional Director, Motor Carrier Safety has granted a waiver to that person.

(b) A letter of application for a waiver may be submitted jointly by the person who seeks a waiver of the physical disqualification (driver applicant) and by the motor carrier that will employ the driver applicant if the application is granted. The application must be addressed to the Regional Director, Motor Carrier Safety for the region in which the coapplicant motor carrier's principal place of business is located. The address for each regional office is listed in § 390.40 of this subchapter. *Exception.* A letter of applica-

tion for a waiver may be submitted unilaterally by a driver applicant. The application must be addressed to the Regional Director, Motor Carrier Safety for the region in which the driver has legal residence. The address of each regional office is listed in § 380.40 of this subchapter. The driver applicant must comply with all the requirements of paragraph (c) of this section except paragraphs (c)(1)(i) and (iii). The driver applicant shall respond to the requirements of paragraph (c)(2)(i) to (v) of this section, if the information is known.

(c) A letter of application for a waiver shall contain—

- (1) Identification of the applicant(s):
 - (i) Name and complete address of the motor carrier coapplicant;
 - (ii) Name and complete address of the driver applicant;
 - (iii) The Federal Highway Administration Motor Carrier Identification Number, if known; and
 - (iv) A description of the driver applicant's limb impairment for which a waiver is requested.

(2) Description of the type of operation the driver will be employed to perform:

- (i) State(s) in which the driver will operate for the motor carrier coapplicant (if more than 10 States, designate general geographic area only);
- (ii) Average period of time the driver will be driving and/or on duty, per day;
- (iii) Type of commodities or cargo to be transported;
- (iv) Type of driver operation (i.e., sleeper-team, relay, owner operator, etc.); and

(v) Number of years of experience operating the type of vehicle(s) requested in the letter of application and total years of experience operating all types of motor vehicles.

(3) Description of the vehicle(s) the driver applicant intends to drive:

- (i) Truck, truck-tractor, or bus make, model, and year (if known);
- (ii) Drive train;

(A) Transmission type (automatic or manual—if manual, designate number of forward speeds);

(B) Auxiliary transmission (if any) and number of forward speeds; and

(C) Rear axle (designate single speed, 2 speed, or 3 speed).

(iii) Type of brake system:

(iv) Steering, manual or power assisted;

(v) Description of type of trailer(s) (i.e., van, flat bed, cargo tank, drop frame, lowboy, or pole);

(vi) Number of semitrailers or full trailers to be towed at one time

(vii) For passenger-carrying vehicles, indicate seating capacity of vehicle; and

(viii) Description of any vehicle modification(s) made for the driver applicant; attach photograph(s) where applicable.

(4) Otherwise qualified:

(i) The coapplicant motor carrier must certify that the driver applicant is otherwise qualified under the regulations of this part;

(ii) In the case of unilateral application, the driver applicant must certify that (s)he is otherwise qualified under the regulations of this part.

(5) Signature of applicant(s):

(i) Driver applicant's signature and date signed;

(ii) Motor carrier official's signature (if application has a coapplicant), title, and date signed. Dependent upon the motor carrier's organizational structure (corporation, partnership, or proprietorship), the signer of the application shall be an officer, partner, or the proprietor.

(d) A letter of application for a waiver shall be accompanied by:

(1) A copy of the results of the medical examination performed pursuant to § 391.43;

(2) A copy of the medical certificate completed pursuant to § 391.43(e);

(3) A medical evaluation summary completed by either a board qualified or board certified physiatrist (doctor of physical medicine) or orthopedic surgeon;

NOTE: The coapplicant motor carrier or the driver applicant shall provide the physiatrist or orthopedic surgeon with a description of the job tasks the driver applicant will be required to perform.

(i) The medical evaluation summary for a driver applicant disqualified under § 391.41(b)(1) shall include:

(A) An assessment of the functional capabilities of the driver as they relate to the ability of the driver to perform normal tasks associated with operating a motor vehicle; and

(B) A statement by the examiner that ~~the applicant~~ is capable of demonstrating precision prehension (e.g., manipulating knobs and switches) and power grasp prehension (e.g., holding and maneuvering the steering wheel) with each upper limb separately. This requirement does not apply to an individual who was granted a waiver, absent a prosthetic device, prior to the publication of this amendment.

(1) The medical evaluation summary for a driver applicant disqualified under § 391.41(b)(2) shall include:

(A) An explanation as to how and why the impairment interferes with the ability of the applicant to perform normal tasks associated with operating a commercial motor vehicle;

(B) An assessment and medical opinion of whether the condition will likely remain medically stable over the lifetime of the driver applicant; and

(C) A statement by the examiner that the applicant is capable of demonstrating precision prehension (e.g., manipulating knobs and switches) and power grasp prehension (e.g., holding and maneuvering the steering wheel) with each upper limb separately. This requirement does not apply to an individual who was granted a waiver, absent an orthotic device, prior to the publication of this amendment.

(4) A description of the driver applicant's prosthetic or orthotic device worn, if any, by the driver applicant;

(5) Road test:

(i) A copy of the driver applicant's road test administered by the motor carrier coapplicant and the certificate issued pursuant to 1391.31 (b) through (g); or

(ii) A unilateral applicant shall be responsible for having a road test administered by a motor carrier or a person who is competent to administer the test and evaluate its results.

(6) Application for employment:

(i) A copy of the driver applicant's application for employment completed pursuant to § 391.21; or

(ii) A unilateral applicant shall be responsible for submitting a copy of

the last commercial driving position's employment application s/he held. If not previously employed as a commercial driver, so state.

(7) A copy of the driver applicant's waiver of certain physical defects issued by the individual State(s), where applicable; and

(8) A copy of the driver applicant's State Motor Vehicle Driving Record for the past 3 years from each State in which a motor vehicle driver's license or permit has been obtained.

(e) *Agreement.* A motor carrier that employs a driver with a waiver agrees to:

(1) We promptly (within 30 days) with the Regional Director, Motor Carrier Safety such documents and information as may be required about driving activities, accidents, arrests, license suspensions, revocations, or withdrawals, and convictions which involve the driver applicant. This applies whether the driver's waiver is a unilateral one or has a coapplicant motor carrier;

(i) A motor carrier who is a coapplicant must file the required documents with the Regional Director, Motor Carrier Safety for the region in which the carrier's principal place of business is located; or

(ii) A motor carrier who employs a driver who has been issued a unilateral waiver must file the required documents with the Regional Director, Motor Carrier Safety for the region in which the driver has legal residence.

(2) Evaluate the driver with a road test using the trailer the motor carrier intends the driver to transport or, in lieu of, accept a certificate of a trailer road test from another motor carrier if the trailer type(s) is similar or accept the trailer road test done during the Skill Performance Evaluation if ~~is similar~~ ~~type(s)~~ ~~prospective~~ motor carrier;

Note: Job tasks, as stated in paragraph (e)(3) of this section, are not evaluated in the Skill Performance Evaluation.

(3) Evaluate the driver for those nondriving safety-related job tasks associated with whatever type of trailer(s) will be used and any other nondriving safety-related or job-related

ed tasks unique to the operations of

(4) Use the driver to operate the type of motor vehicle defined in the waiver only when the driver is in compliance with the conditions and limitations of the waiver.

(f) The driver shall supply each employing motor carrier with a copy of the waiver.

(g) The Regional Director, Motor Carrier Safety may require the driver applicant to demonstrate his or her ability to safely operate the motor vehicle(s) the driver intends to drive to an agent of the Regional Director, Motor Carrier Safety. The waiver form will identify the power unit (bus, truck, truck-tractor) for which the waiver has been granted. The waiver forms will also identify the trailer type used in the Skill Performance Evaluation; however, the waiver is not limited to that specific trailer type. A driver may use the waiver with other trailer types if a successful trailer road test is completed in accordance with paragraph (e)(2) of this section. Job tasks, as stated in paragraph (e)(3) of this section, are not evaluated during the Skill Performance Evaluation.

(h) The Regional Director, Motor Carrier Safety may deny the application for waiver or may grant it totally or in part and issue the waiver subject to such terms, conditions, and limitations as deemed consistent with the public interest. A waiver is valid for a period not to exceed 2 years from date of issue, and may be renewed 30 days prior to the expiration date.

(i) The waiver renewal application shall be submitted to the Regional Director, Motor Carrier Safety for the region in which the driver has legal residence. If the waiver was issued unilaterally, if the waiver has a coapplicant, then the renewal application is submitted to the Regional Director, Motor Carrier Safety for the region in which the coapplicant motor carrier's principal place of business is located. The waiver renewal application shall contain the following:

(1) Name and complete address of motor carrier currently employing the applicant;

(2) Name and complete address of the driver;

(3) Effective date of the current waiver;

(4) Expiration date of the current waiver;

(5) Total miles driven under the current waiver;

(6) Number of accidents incurred while driving under the current waiver, including date of the accident(s), number of fatalities, number of injuries, and the estimated dollar amount of property damage;

(7) A current medical examination report;

(8) A medical evaluation summary pursuant to paragraph (d)(3) of this section if an unstable medical condition ~~exists~~ All handicapped conditions classified under § 391.41(b)(1) are considered unstable.

~~NOTE: Refer to paragraph (d)(3)(ii) of this section for the condition under § 391.41(b)(2) which may be considered~~

(9) A COPY of driver's current State motor vehicle driving record for the period of time the current waiver has been in effect;

(10) Notification of any change in the type of tractor the driver will operate;

(11) Driver's signature and date signed; and

(12) Motor carrier coapplicant's signature and date signed.

(j) Upon granting a waiver, the Regional Director, Motor Carrier Safety will notify the driver applicant and coapplicant motor carrier (if applicable) by letter. The terms, conditions, and limitations of the waiver will be set forth. A motor carrier shall maintain ~~the~~ copy ~~of the~~ waiver in its driver qualification file. A copy of the waiver shall be retained in the motor carrier's file for a period of 3 years after the driver's employment is terminated. The driver applicant shall have the waiver (or a legible copy) in his/her possession whenever on duty.

(k) The Regional Director, Motor Carrier Safety may revoke a waiver after the person to whom it was issued is given notice of the proposed revocation and has been allowed a reasonable opportunity to appeal.

(l) Falsifying information in the letter of application, the renewal ap-

§ 391.51

plication, or falsifying information required by this section by either the applicant or motor carrier is prohibited.

(Approved by the Office of Management and Budget under control number 2125-0080)

[48 FR 38487, Aug. 24, 1983, as amended at 49 FR 38293, Sept. 28, 1984; 50 FR 49851, Dec. 6, 1985; 51 FR 12621, Apr. 14, 1986]

Subpart F—Files and Records

§ 391.51 Driver qualification files.

(a) Each motor carrier shall maintain a driver qualification file for each driver it employs. A driver's qualification file may be combined with his personnel file.

(b) The qualification file for a driver who has been a regularly employed driver of the motor carrier for a continuous period which began before January 1, 1971, must include:

(1) The medical examiner's certificate of his physical qualification to drive a motor vehicle or a legible photographic copy of the certificate;

(2) The Regional Federal Highway Administrator's letter granting a waiver of a physical disqualification, if a waiver was issued under § 391.49;

(3) The note relating to the annual review of his driving record required by § 391.25;

(4) The list or certificate relating to violations of motor vehicle laws and ordinances required by § 391.27; and

(5) Any other matter which relates to the driver's qualifications or ability to drive a motor vehicle safely.

(c) The qualification file for a regularly employed driver who has not been regularly employed by the motor carrier for a continuous period which began before January 1, 1971, must include:

(1) The documents specified in paragraph (b) of this section;

(2) The driver's application for employment completed in accordance with § 391.21;

(3) The responses of State agencies and past employers to the motor carrier's inquiries concerning the driver's driving record and employment pursuant to § 391.23;

(4) The certificate of driver's road test issued to the driver pursuant to

49 CFR Ch. III (10-1-87 Edition)

§ 391.31 (e), or a copy of the license or certificate which the motor carrier accepted as equivalent to the driver's road test pursuant to § 391.33; and

(5) The questions asked, the answers the driver gave, and the certificate of written examination issued to him pursuant to § 391.35, or a copy of a certificate which the motor carrier accepted as equivalent to a written examination pursuant to § 391.37.

(d) The qualification file for an intermittent, casual, or occasional driver employed under the rules in § 391.63 must include—

(1) The medical examiner's certificate of his physical qualification to drive a motor vehicle or a legible photographic copy of the certificate;

(2) The certificate of driver's road test issued to the driver pursuant to § 391.31(e), or a copy of the license or certificate which the motor carrier accepted as equivalent to the driver's road test pursuant to § 391.31;

(3) The questions asked, the answers the driver gave, and the certificate of written examination issued to him pursuant to § 391.35, or a copy of a certificate which the motor carrier accepted as equivalent to a written examination pursuant to § 391.37; and

(4) The driver's name, his social security number, and the identification number, type, and issuing State of his motor vehicle operator's license.

(e) A using carrier's qualification file for a driver who is regularly employed by another motor carrier, and who is employed by the using carrier in accordance with § 391.65 of this part, shall include a copy of a certificate, as prescribed by § 391.65(a)(2) of this part, by the regularly employing carrier that the driver is fully qualified to drive a motor vehicle.

(f) Except as provided in paragraphs (g) and (h) of this section, each driver's qualification file shall be kept at the motor carrier's principal place of business for as long as a driver is employed by that motor carrier and for 3 years thereafter.

(g) Upon a written request to, and with the approval of, the Director, Regional Motor Carrier Safety Office, for the region in which a motor carrier has his principal place of business, the carrier may retain one or more of its

APPENDIX D

EXPERT OPINION SURVEY FORMS

INSTRUCTIONS

We have provided a list of selected driving task components that are used by commercial motor vehicle operators. For each driving task, identify by order of importance three visual functions that are necessary for safely performing these driving tasks.

VEHICLE MANEUVER/DRIVING TASK

DRIVING TASK	VISUAL FUNCTION		
	1	2	3
MAINTAINING SAFE SPEED FOR CONDITIONS (HIGHWAY GEOMETRY/WEATHER/VISIBILITY)			
MAINTAINING SAFE FOLLOWING DISTANCE			
STAYING IN LANE/STEERING CONTROL			
MERGING/YIELDING IN TRAFFIC CONFLICT SITUATIONS (LANE DROP, RAMP GORE, INTERSECTION OR DRIVEWAY)			
CHANGING LANES AND PASSING			
COMPLYING WITH TRAFFIC CONTROL DEVICES (SIGNS, SIGNALS AND PAVEMENT MARKINGS)			
BACKING UP/PARKING OPERATIONS			

INSTRUCTIONS

In this continuation of the expert rating exercise you are asked to provide two kinds of responses. First, the matrix below shows the results of your (collective) judgment with respect to which visual functions are most important for each specified driving task. So far, so good. Now we would like you to identify the minimum acceptable level of performance for each visual function ranked 1, 2, and 3 for each driving task. If, for example, you wish to use the same performance level every time a given function appears in the matrix, just write it in once under that function and leave the other boxes labeled with that function blank. Call Larry Decina or Loren Staplin if you have any questions.

Next, we ask you to provide ratings estimating the relative performance levels to be expected for matched (on age, sex, experience, IQ, etc.) monocular and binocular drivers for each of the seven CMV driving tasks identified below. Please place two marks on each bipolar scale and label them "M" and "B" for monocular and binocular, respectively. Also, please assume that differences in response capability, if any, are due solely to monocular versus binocular status when marking your ratings on each scale; i.e., the same drivers in the same "reasonable worst-case" situation are faced with identical vehicle control demands, and are equally equipped to respond in all capacities except for monocular versus binocular status.

Thank you for your help in completing this expert opinion survey. Please return these pages by mail or fax by July 8, 1991, if possible, and no later than July 15.

1. FILL IN MINIMUM ACCEPTABLE PERFORMANCE LEVELS FOR EACH INDICATED VISUAL FUNCTION

CMV DRIVING TASK	SELECTED VISUAL FUNCTIONS		
	1	2	3
MAINTAINING SAFE SPEED FOR CONDITIONS (HIGHWAY GEOMETRY/WEATHER/VISIBILITY)	Visual Fields	Motion Perception	Contrast Sensitivity
MAINTAINING SAFE FOLLOWING DISTANCE	Depth Perception/Stereopsis	Motion Perception	Visual Fields
STAYING IN LANE/STEERING CONTROL	Visual Fields	Static Visual Acuity	Contrast Sensitivity
MERGING/YIELDING IN TRAFFIC CONFLICT SITUATIONS (LANE DROP, RAMP CORE, INTERSECTION OR DRIVEWAY)	Visual Fields	Visual Search/Attention	Motion Perception
CHANGING LANES AND PASSING	Visual Fields	Depth Perception/Stereopsis	Motion Perception
COMPLYING WITH TRAFFIC CONTROL DEVICES (SIGNS, SIGNALS AND PAVEMENT MARKINGS)	Static Visual Acuity	Visual Fields	Contrast Sensitivity
BACKING UP/PARKING OPERATIONS	Depth Perception/Stereopsis	Visual Fields	Contrast Sensitivity

291b/56/Form 3

NAME: _____

2. **RELATIVE SAFETY RATINGS FOR MATCHED MONOCULAR AND BINOCULAR DRIVERS**
AND "B" ON EACH SCALE) (MARK "M")

CMV DRIVING TASK

LIKELIHOOD OF SAFE PERFORMANCE UNDER
"REASONABLE WORST-CASE" OPERATING CONDITIONS

EXAMPLE:

unlikely (M or B) (M or B) extremely
 1 2 3 4 5 6 7 likely

Maintaining safe speed
 for conditions

extremely unlikely 1 2 3 4 5 6 7 extremely likely

Maintaining safe fol-
 lowing distance

extremely unlikely 1 2 3 4 5 6 7 extremely likely

Staying in lane/
 steering control

extremely unlikely 1 2 3 4 5 6 7 extremely likely

Merging/yielding in
 traffic conflict sit-
 uations (e.g., ramps,
 intersections)

extremely unlikely 1 2 3 4 5 6 7 extremely likely

Changing lanes and
 passing

extremely unlikely 1 2 3 4 5 6 7 extremely likely

Complying with traffic
 control devices

extremely unlikely 1 2 3 4 5 6 7 extremely likely

Backing up/parking
 operations

extremely unlikely 1 2 3 4 5 6 7 extremely likely

RETURN TO: KETRON, INC.
 600 Louis Dr., Suite 203
 Warminster, PA 18974
 ATTN: L. Decina

Phone: 215-957-8013
 FAX: 215-957-8099

NAME: _____

PLEASE RETURN BOTH PAGES AT THE SAME TIME

APPENDIX E

PANELIST DIRECTORY

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