



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

Visual Disorders and Commercial Drivers

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7. Author(s) Lawrence E. Decina, Michael E. Breton, Ph.D. * and Loren Staplin, Ph.D.				8. Performing Organization Report No.	
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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	0.765	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)

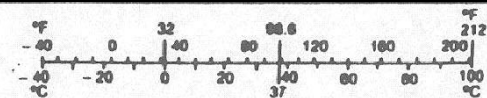
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T

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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Merrill J. Allen, O.D., Ph.D.
Indiana University, School of Optometry

Clifford Anderson
MRS Diagnostics, Inc.

Karlene Ball, Ph.D.
Department of Psychology
Western Kentucky University

Bernard R. Blais, M.D.
Knolls Atomic Power Laboratory
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Raymond P. Briggs, Ph.D.
Perceptual Safety and Systems Research

Neill Darmstadter
American Trucking Associations

Chris A. Johnson, Ph.D.
Department of Ophthalmology
School of Medicine
University of California

Arthur H. Keeney, M.D., S.Sc.
Kentucky Lions Eye Research Institute
University of Louisville

A. James McKnight Ph.D.
National Public Services Research Institute

Cynthia Owsley, Ph.D.
Department of Ophthalmology
School of Medicine
University of Alabama at Birmingham

Sandra Z. Salan, M.D.
Office of Medical Evaluation Branch Chief
Neurology and Special Senses
OD/OME SSA

Frank Schieber, Ph.D.
Oakland University

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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-10)

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 **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.

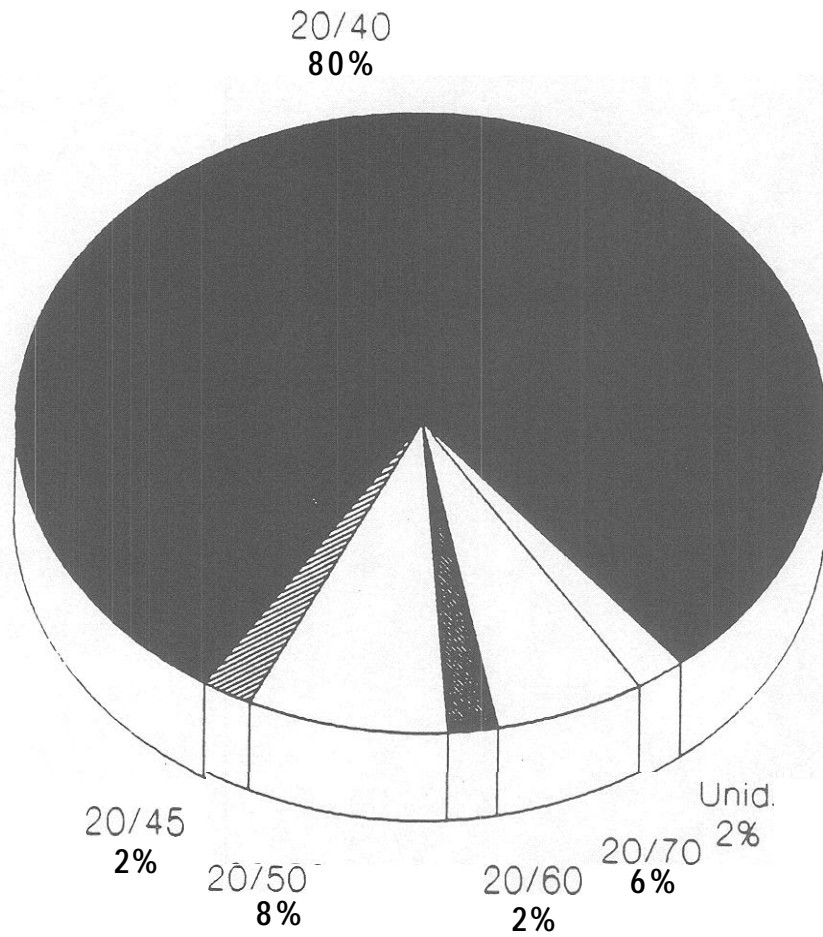


Figure 1. Binocular **Visual** Acuity Standard for **CMV** Operators

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.

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. Vii 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 simii 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 ¹ 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 **t** 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 Imuainments 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 available 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	visual fields
Staying in lane/steering control	Visual fields	Static acuity	Contrast sensitivity
Merging/Yielding in traffic conflict situations	visual fields	Visual search/Attention	Motion perception
Changing lanes and passing	visual fields	Depth perception/Stereopsis	Motion perception
Complying with traffic control device:	Static acuity	Visual fields	Contrast sensitivity
Backing up/Parking operations	Depth perception	visual 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 T. **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 wed 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)
