fatality rate in the U.S.A. is more than three times the daytime rate.

Some broad statistics from the National Safety Council are quite revealing. From 1973 to 1983, U.S. highway fatalities declined remarkably, from 55,800 to 44,600. This reduction was generally distributed in both vehicle and pedestrian deaths, urban and rural, daytime and nighttime. But while all fatalities declined by 20 percent, and rural nighttime fatalities declined by over 18 percent, urban nighttime fatalities actually increased by 6 percent -- from 9,600 to 10,200. Urban nighttime non-pedestrian fatalities increased from 5,900 to 7,000, or by more than 18 percent. Apparently, the many successful measures contributing to the phenomenal record of reduced highway deaths in the last 10 years have not had the same dramatic effect on these categories of nighttime accidents as they have on daytime and rural accident experience.

A look at "Fatal Accident Reporting System 1982," a national summary of fatal accident data, is equally revealing. One table in this report shows fatalities by day of the week and three-hour time groups -- a total of 56 cells. The following seven time-blocks account for the highest numbers of fatalities:

Friday	Midnight to 3 am	1,093
"	6 pm to 9 pm	1,345
"	9 pm to Midnight	1,781
Saturday	Midnight to 3 am	2,390
"	6 pm to 9 pm	1,323
"	9 pm to Midnight	1,634
Sunday	Midnight to 3 am	2,091

These seven time periods, all involving hours of darkness, accounted for more than a quarter of the nation's 1982 highway fatalities (to be precise, 11,657 out of 43,271 or 26.7 percent). These time periods, those when the most-impaired drivers are operating in the most-impaired driving environment, clearly deserve attention.

It is obvious that the new federal initiatives to support improved delineation and to curb the drunken driver are correctly aimed at a major national problem. It is equally clear that the Symposium agenda squarely identifies the research and other visibility issues surrounding this significant national problem.

The program shows that some fundamental issues are being addressed -- how much visibility and guidance is needed, how should its quality be measured when it is provided, how does the driver use what he gets, what levels are appropriate for different aspects of the driving task. The reports on recent relevant research programs will help steer future research, not only in the Federal Highway Administration's projects on Night Visibility, for example, but also in other nations. So we welcome your interest in this Symposium and trust that the exchange of information that takes place will benefit you as well as those others in the transportation community who may be later informed as a result of this meeting.

TOWARD A COMPREHENSIVE TECHNOLOGY FOR APPLYING VISIBILITY DATA TO ROAD LIGHTING DESIGN

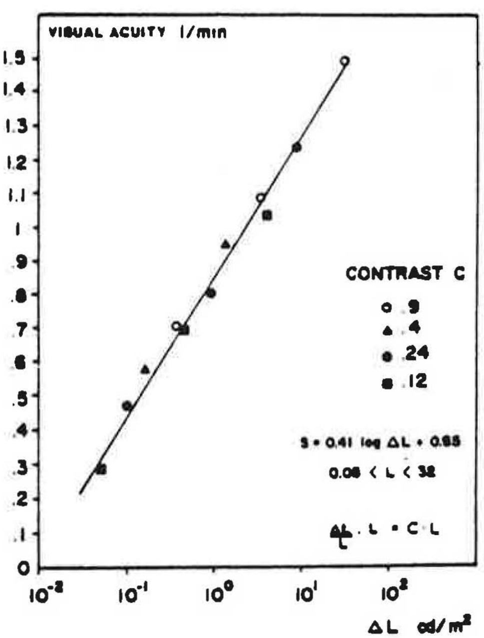
H. Richard Blackwell and O. Mortenson Blackwell, Columbus, Ohio

This Symposium seems a most timely opportunity to assess the state of current knowledge in many fields relating aspects of the road environment to driver performance at night. We would like to offer our assessment of the state of knowledge concerning the use of visibility data in the design of road lighting. Our assessment will draw upon CIE Report No. 19/2, and will include as well new material which has become available during the last three years. We consider that a comprehensive technology for use in applying visibility data to road lighting design is taking shape. This technology includes bases for development of visibility demand criteria for different traffic situations, the development of assessment methods to establish the visibility supplied by different road lighting installations, and the use of an overall index to describe the visual performance potential of different installations.

Visibility Demand Criteria for Differing Traffic Situations

We consider that the 1975 Gallagher-Meguire driver performance data provide the basis for establishment of visibility criteria for different traffic situations. Consider Figure 2, in which the Gallagher-Meguire data and 19/2 methods have been used to relate the driver performance index of time-to-obstacle to a measure of object visibility. Note that no single function suffices. Rather, there must be a family of curves relating the driver performance index to the visibility index, each curve describing a particular driver. The Gallagher-Meguire sample included 1,316 drivers and hence may be used confidently to describe overall driver populations.

Figure 1 - Visibility Demand Functions Derived from the Gallagher-Meguire Data (1975).



It can be shown that driver performance differences are directly relatable to differences in visibility demanded by different drivers, a key underlying variable being driver age. It is possible to calculate readily the distribution of levels of driver performance provided to different members of the driver population when any criterion value of time-to-obstacle is selected by traffic engineering. It is also possible to calculate readily the average visibility demand corresponding to any desired value of time-to-obstacle. (The visibility demand level may be expressed as in the figure in terms of equivalent visibility, $\tilde{V}$, or in terms of visibility index, VI, with values of VI = $\tilde{V}$/7.111.)

Visibility Supplied by Differing Road Lighting Installations

Current work is in progress in the U.S.A. by Keck and associates in which the visibility supplied by actual road lighting installations is being measured. Both psychophysical measurements with contrast-reducing visibility meters and physical measurements with suitable luminance photometers are being used. Reference visibility of sample targets (i.e., no account being taken of Disability Glare Factor (DGF) or Transient Adaptational Factor (TAF)) is being measured with both a conventional visibility meter involving an on-board light veil and a newly developed visibility meter which draws its light veil from existing road luminance. Allowance for the effects of DGF and TAF is to be made subsequently taking advantage of new developments in the technologies of defining and measuring these factors which modify reference visibility. It is now possible to allow for the effects of luminance non-uniformities in the area of road near the target by means of a model of the transient adaptational factor. This is based upon the effective contrast compression created when visual adaptation fails to track the changes in target background luminance that result when eye movements change ocular fixation from point to point in the non-uniform road environment.

Keck and associates are also working to develop practical predetermination programs for computing target visibility under different lighting installations, taking account of variations in target reflectance and placement.

The New Visual Performance Index, VPI

Once values of target visibility are available, either from field measurements or from predetermination calculations, it is a simple matter to assess the overall visual performance potential of a given lighting installation by means of the new Visual Performance Index, VPI. (This index is intended to supersede the similar concept described in CIE Report No. 19/2. The differences between new and old VPI involve only the means of calculation, the new VPI being distinctly easier to calculate.) Considering a broad distribution of target reflectances and locations along and across the road, VPI gives its overall assessment of an installation in terms of the percentage of instances in which one or another target reflectance to be found in one or another location supplies at least as much visibility as the criterion visibility corresponding to the criterion value of time-to-obstacle. The visibility supply data may be described in terms of either equivalent visibility, V, or visibility index, VI. Use of VI implies that the cone target of Gallagher and Meguire is accepted as the assessment target in all future measurements and predetermination calculations. Use of V allows selection of any desired target, the V/VI ratio being determined by measurement or calculation. We favor the use of V to allow such flexibility of choice with respect to assessment target. Incidentally, our simulator data show clearly that visibility of either two- or three-dimensional targets of differing size is most accurately assessed using a fairly large target, such as our original 12 x 32 inch two-dimensional target.

VISUAL PERFORMANCE UNDER NIGHT DRIVING CONDITIONS

Dr. Werner K. Adrian, University of Waterloo, Canada

Traffic safety is closely linked with the amount of visual information the driver can obtain on the road and its environment. The ability of perception can be described by the basic visual functions such as luminance contrast sensitivity and form perception and the influence that age has in these functions due to changes in the optical properties of the eye media.

The luminance difference threshold as obtained in the laboratory can serve only as a basis to reveal the perceptibility of objects because the observation conditions are different from those given in practice. Roper and Howard found a factor of four to account for that difference. This threshold elevation facilitates perception of the form of the object. Consequently, the criterion of form perception, measured in terms of visual acuity, was used to investigate the visual behaviors in road lighting luminance levels. It occurred that for the perception of certain details the product of the contrast of the object ($C = \Delta L/L$) and the level of the surrounding luminance L remains constant. This reveals the fact that in the range of road lighting levels form perception is dependent only on the luminance difference L of the objects to their background (see Figure 1). The influence of age will be briefly discussed.

Figure 1 -- Visual acuity as obtained with Landolt rings of different contrast $C = \Delta L/L$ on a background luminance L ranging from 0.05 to 32 cd/m., 8 observers, p = 80% detectability, age 20-30 years.