Figure 1 - Computational Steps for a Computerized Overhead Guidesign Conspicuity/Legibility Analysis

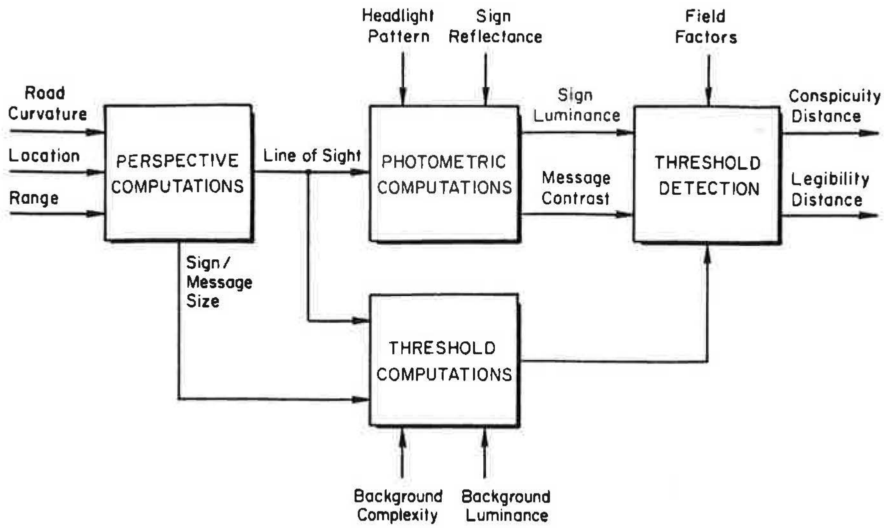
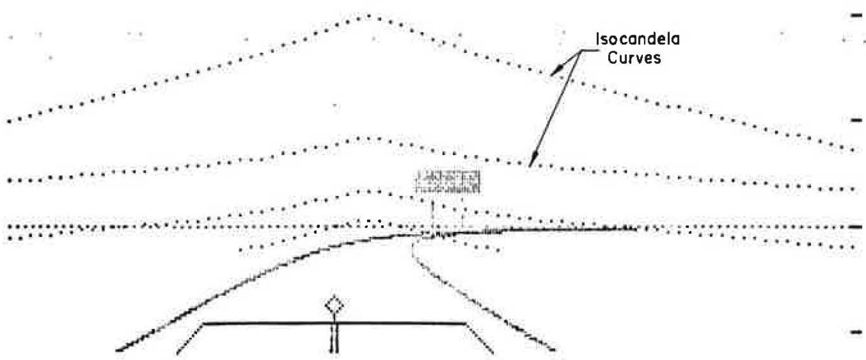


Figure 2 - Computer Graphics Plot Showing Overhead Guidesign Relative to Vehicle Heading Direction and Headlight Beam Pattern



LUMINANCE OF TRAFFIC SIGNS AT NIGHT

Prof. H. J. Schmidt-Clausen, Technische Hochschule, Darmstadt, West Germany

The luminance of traffic signs was investigated in a 1:10 scale model experiment and the ranges of the minimum, sufficient, and otimum luminance of traffic signs at night were determined. The measurements were done with the threshold, the visual acuity and a rating scale as criteria.

These results were compared with those in the real street situation. The following parameters were among others considered:

- European/American low beam light distribution
- Class I/Class II retroreflective materials
- Indirect illumination by luminous flux reflected on the pavement surface

These tests and observations show that sign luminance (white area) of between 3.5 cd/m^2 and 10 cd/m^2 is quite sufficient. The luminance range between 10 cd/m^2 and 35 cd/m^2 is rated as 8n optimum luminance. The upper limit increases up to$\approx$ 60 cd/m^2 with glare of opposing vehicles.

TRAFFIC SIGNAL BRIGHTNESS REQUIREMENTS FOR THE NIGHTTIME DRIVING ENVIRONMENT

Mark Freedman, KETRON, Inc., Philadelphia, Pennsylvania

The objective of this FHWA-sponsored research project is to determine the traffic signal brightness levels needed to satisfy the perceptual requirements of motorists for signal conspicuity, especially at night. The research techniques included analytical studies of the effects of driver age on the need for signal visibility, a laboratory study to determine the particular needs of color-vision-deficient drivers, a controlled field study to expand and validate the laboratory investigations, and a set of observational field experiments at six signalized intersections to determine the traffic operations and safety impacts of reduced brightness levels. Guidelines and criteria were developed to determine whether signal dimming is desirable at particular intersections. The economic impacts of a variety of dimming techniques were evaluated.

The analytical study of the brightness needs of the elderly driver (70-74 chosen as design age) indicated that while a traffic signal must be about two times brighter than presently recommended by the Institute of Transportation Engineers to enable the elderly driver to perform as well as a 20-29 year old driver, the associated difference in performance between the young and elderly drivers is not great enough to warrant increased signal luminance.

The laboratory study of the intensity needs of color-vision-deficient drivers, including protanopes (red deficient), deuteranopes (green deficient), and anomalous protanopes and anomalous deuteranopes (red-green confusers), utilized a signal simulator to present test subjects with all combinations of four signal intensity levels, three chromaticity variations of each signal plus one white stimuli, three levels of nighttime background complexity, and four positions of the stimulus within the field of view. The dependent variables were 1) the time required to indicate the color (either red, yellow, green or white) of the stimulus, and 2) the accuracy of the color identification. It was found that the protan class color-vision-deficient drivers required 40-70 percent more time than normal drivers to make a color choice while the deutan class and elderly drivers required 30-40 percent more time. The absolute magnitude of this difference was approximately one half second. Red color-vision-deficient drivers correctly identified the red stimulus color an average of 20-35 percent less often and the green stimulus color 15-75 percent less often than normal drivers. Green color-vision-deficient drivers failed to correctly identify the red signal color in fewer than 10 percent of trials and were incorrect in 15-25 percent of green stimulus trials. Elderly drivers correctly named the stimulus color about as often as normal drivers. Significantly, it was found that the performance of the protan class drivers improved as signal intensity was reduced.

A controlled field study that utilized full-scale 8 in. (200 mm) and 12 in. (300 mm) traffic signals was conducted to further evaluate the effects of reduced signal luminance. Response time and accuracy of color identification were again the dependent variables, while intensity (3 levels: 100%, 30% and 10%), signal size (2 levels) and background complexity (3 levels) were independently varied. Each subject was required to perform an auxiliary task (track a moving target with the steering wheel) while the signal trials were taking place. The findings indicated that reduced signal luminance had no significant effect on the accuracy of response for normal drivers of all ages and for deutan class drivers. For protan class drivers, response accuracy improved at the two lowest levels of signal intensity. Reaction time was found to increase as signal luminance decreased, but in general, there was not a significant difference in response time between the highest and medium intensity levels. It was suggested that signals could be dimmed at night to about 30 percent of the luminance recommended for daytime operation without negative impacts.

An additional controlled field study using observers who were experts in traffic signal systems or visibility research found that within urban settings, dimming of 12 in. (300 mm) signals can commence when the sky darkens to 50-80 ftL (170-270 cd/m^2), and may be dimmed to 30% of full luminance when the sky darkens to 20-30 ftL (70-100 cd/m^2). Urban 8 in. (200 mm) signals can begin to dim at 30-90 ftL (100-300 cd/m^2) until dimmed to 30% at 3-25 ftL (10-85 cd/m^2). Rural 12 in. signals may commence dimming at 170-370 ftL (580-1260 cd/m^2) until dimmed to 30% at 30-70 ftL (100-240 cd/m^2). Rural green and yellow 8 in. signals may commence dimming at 150-450 ftL (510-1530 cd/m^2) and be dimmed to 30% at 50-120 ftL (170-410 cd/m^2). The red rural 8 in. signal was deemed not sufficiently bright when dimmed to 30%.

In the observational field study, traffic operations were measured at six intersections that represented a range of site types at which signal dimming would be just marginally recommended. Three luminance levels (100%, 65% and 30% of the daytime recommendation) were tested. Measures of effectiveness were start-up delay and the frequencies of undesirable maneuvers including red interval violations, yellow interval entries, stop line encroachments, sudden rapid acceleration/ deceleration, accident avoidance maneuvers and others. Preliminary analysis of approximately 6,000 observed vehicles indicated that drivers are no more likely to execute undesirable maneuvers at dimmed signals than at undimmed signals, and that in some cases, there may be a slight (0.4 seconds) increase in initial vehicle start-up delay at the dimmest signal setting, although the finding was not highly significant statistically.

Economic analysis has indicated that the use of proper dimming equipment at night combined with good maintenance of signal equipment can reduce energy consumption from 20 to 30 percent while also extending lamp life, thus reducing the cost of relamping.

VISIBILITY THRESHOLDS IN NIGHT DRIVING CONDITIONS

M. Michaut, Organisme National de Securite Routiere, France, and Mme. Colomb and M. Bry, Laboratoire Central des Ponts et Chaussees, France

In night driving conditions, more than during daytime, road users have to detect and perceive a certain number of signaling devices which are supposed to help them in their choice of path and routing.

Physical properties of these signals in terms of luminance and contrast are evidently of prime importance. But these physical values make sense only when evaluated in relation with the various possible functions of the signal, taking into account the variability of real world conditions in which it is encountered by road users.

Basic data (Blackwell's curves, for example) can and must be used as a starting point but may have to be validated in specific experimental conditions when practical questions have to be answered.

Several experiments have been performed with groups of human observers, in which various practical requirements have been incorporated.

Experiment I

A study of Reflectorized Raised Pavement Markers (RRPM) has been made on a closed road circuit. Observers (48) moved in a vehicle starting from 500 meters from the RRPM. These were positioned at the end of a track and their number was varied. Observers had to report, as soon as possible, when they saw them.