offset the performance decrements associated with either uncertainty or background complexity. For example, a sign requiring a 2-foot lambert increase in luminance to attain some level of perceptual performance is considered twice as conspicuous as a sign requiring a 4-foot lambert increase in luminance.

Very few studies have examined the effects of the visual complexity of nighttime highway environments on driver requirements for sign size and luminance. In general, the literature suggests that sign detection can be considered as a function of the visual characteristics of the target and its surround. Size and contrast have been found to be more important determinants of conspicuity than luminance but both Mace and Jenkins have found that scene complexity has a significant effect also. In fact, when visual complexity is high, the earlier study of Mace suggested that complexity was more important than sign luminance or contrast, although increased luminance could offset performance decrements produced by scene complexity. A subsequent field study suggested that in low complexity areas, signs below federal luminance standards for Type 2 sheeting may be adequate and that in high complexity areas, even new Type 3 sheeting may not be adequate for conspicuity.

While it may not be possible to produce a continuous scale reliable throughout the range of visual complexity, it may, from a practical perspective, be adequate to trichotomize the complexity dimension. The low end of the scale would define locations where sign maintenance is less important and the high end would define locations where special attention may be necessary.

In an effort to simplify the scaling of complexity, we have recently reduced the large number of complexity measures from our earlier work into four orthogonal factors:

1) number of traffic signs
2) demand of driving task
3) ambient brightness of the background
4) number of distracting elements

Subjective ratings on these factors were obtained for the same scenes as used in an earlier study and their validity using a sign recognition criterion from that study was compared with several global scales. The results suggest that global ratings lack validity, but that the orthogonal factors show promise. More recently a field study was conducted with 21 new highway locations. Complexity ratings were obtained from both photographs and site visits. Sign recognition and legibility distances are being obtained in the field using 3 levels of sign luminance at the 21 sites, which vary from very low to high complexity. We are hopeful that we will identify a procedure which will allow us to identify sites which require signs of higher luminance than Type 3 sheeting and sites where even degraded Type 2 sheeting is adequate.

## DETERMINING MAINTENANCE NEEDS FOR TRAFFIC SIGNS

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The reconstruction of the nation's highways became a federal mandate with the recent approval by Congress of the motor fuel tax increase. With the availability of these funds, the highway community now has an obligation to produce results that go beyond the simple elimination of pot holes and the replacement of the most obsolete bridges. With the improvement in roadway surfaces, bridge widening and curve straightening will come increased traffic volumes and speeds. Increases in speeds and volumes are gauges of success. At the end of the first year of operation, however, another measure will be the accidents and fatalities. Will the increased speeds and volumes extract their price? There is clearly an obligation to take some strong measures to incorporate the optimum safety features at the time of restoration and rehabilitation.

Although some satisfaction may be taken from the gradual decrease in traffic fatalities for 1981 and 1982, these figures tend to conceal the fact that nighttime reductions are simply not there. Indeed, the nighttime fatality rate (fatalities per 100 million vehicle miles) was 2.7 times the day rate in 1971 and now, a decade later, stands at 4.3 times the day rate. While we have seen a reduction in daytime fatalities from 25,600 in 1971 to 19,400 for 1981, fatalities from nighttime accidents have risen from 29,100 to 31,400 for the same periods. These figures simply state that although driving is apparently safer in daytime, it is now more hazardous at night. What are we going to do about it?

There are numerous factors that have intervened which we can blame: 1) smaller vehicles with less crush space, with greater danger for object intrusion, 2) greater disparity with heavy trucks, 3) alcohol with, perhaps, a more disastrous interaction with youthful drivers, 4) changing demographics which have resulted in more younger and older drivers on the road while the number of middle aged, those with the best safety record, has decreased. Visibility has changed. Highways become commercialized and a concentration of complex and confusing nighttime surrounds may now encroach and pollute roadways planned only a decade before. These alarming trends will likely continue and should stimulate action now rather than reaction later.

Retroreflection and roadway lighting can help in every instance: older drivers, alcohol-impaired drivers, poor roads, vehicle size disparity, driver inattention and preoccupation. Research conducted over the past decade has sufficiently quantified the improvements that can be achieved with measures such as wider pavement markings, oversize and brighter signs, and maintenance techniques and equipment to inspect and identify deficient signs and markings.

Most recently, Sivak and Olson[1] have identified nighttime sign performance in terms of required luminance for percentage of users served at design legibility thresholds, as shown in Table 1.

The values apply to white, yellow and orange backgrounds of signs with black legends and to legends of signs with reflectorized backgrounds of up to 0.4 $cd/m^2$. The values apply to ideal, that is dark, conditions.

The translation of luminance values to coefficient of retroreflection ($R^1$, $cd/lx/m^2$) employs the model derived by Olson, Sivak and Egan[2].

Interpretation indicates that for 75th percentile performance retroreflectivities equal to or in excess of values obtainable from Type III

Table 1

OPTIMUM AND REPLACEMENT RETROREFLECTANCE (Cd/lx/$m^2$)

U.S. Lower Beams

| | Sign Luminance | Sign Location: Left Shoulder | Overhead | Right Shoulder | Shoulder Guide |
|---|---|---|---|---|---|
| Optimum | 75 Cd/$m^2$ | 2806 (Cd/lx/$m^2$) | 3547 | 736 | 856 |
| 85th Percentile | 16.8 Cd/$m^2$ | 630 | 798 | 168 | 189 |
| 75th Percentile | 7.2 Cd/$m^2$ | 270 | 342 | 72 | 81 |
| 50th Percentile | 2.4 Cd/$m^2$ | 90 | 114 | 24 | 27 |

European Lower Beams

| | Sign Luminance | Sign Location: Left Shoulder | Overhead | Right Shoulder | Shoulder Guide |
|---|---|---|---|---|---|
| Optimum | 75 Cd/$m^2$ | 4644 (Cd/lx/$m^2$) | 7252 | 2436 | 1113 |
| 85th Percentile | 16.8 Cd/$m^2$ | 1043 | 1624 | 546 | 252 |
| 75th Percentile | 7.2 Cd/$m^2$ | 447 | 696 | 234 | 108 |
| 50th Percentile | 2.4 Cd/$m^2$ | 149 | 232 | 78 | 36 |

For white, yellow, and orange signs and white legends of reflectorized background signs.

For dark rural conditions.

Sivak and Olson
UMTRI-83-43
University of Michigan, 1983

Table 2

MINIMUM VISIBILITY FACTORS FOR MARKINGS

| | | |
|---|---|---|
| Line: Road Luminance Ratio | Minimum | 3:1 |
| Stripe length | Minimum | 15 feet |
| Gap length | Minimum | 15 to 20 ft |
| Visibility distance | Minimum | 125 feet |
| Luminance-Millecandelas/$m^2$ | Minimum | 100 mcd/$m^2$ |

For dark rural conditions

Allen and O'Hanlon. Report No. 229, Systems Technology, Inc. 1979

Figure 1

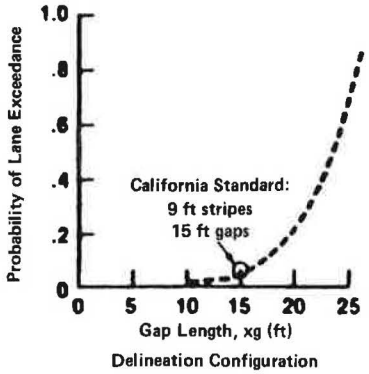



Figure 2

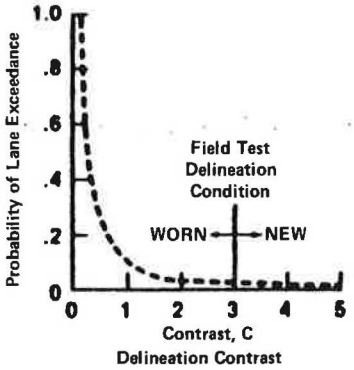
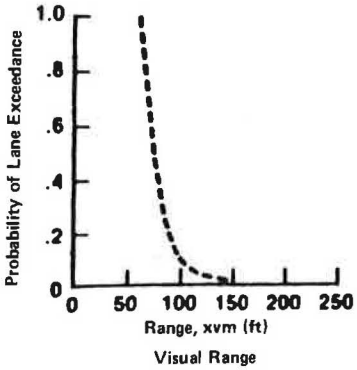



Figure 3



(FP-79)[3] or Class II (CIE 39-2, 1983)[4] sheetings will be required for U.S. lower beams, for yellow, orange, green and blue signs on the right shoulder and for all colors (including white) for signs in any other position, or for a higher percentage of performance, or for European type headlighting. Safety factors are not included in their table to offset decrements from nominally dirty signs or headlamps, the effects of weathering or for signs located in complex nighttime surroundings.

In a similar manner, Allen and O'Hanlon[5], and Serres[6] have quantified markings for pavements, as Figures 1, 2, 3 and Table 2 show.

A retroreflectometer for highway signs[7] can provide information that a device is below reflectivity requirements or specifications. In a similar manner, pavement markings may be evaluated with a marking retroreflectometer[8] so that objective, quantifiable information can be obtained in the field. Infrequent use is made of such instruments, and regular nighttime inspections using such instruments are frequently lower in priority than is appropriate, particularly considering that these inactions are hardly defensible in tort liability suits. A serious need has existed for more convenient instruments for both brightness assessment and record keeping. Today the means are nearly at hand. Portable microcomputers can be used by maintenance personnel in the field to record inspection results, location, and sign identification, much of the information required for a computer sign maintenance file. Programs[9] are available for such use. Bar coding is a technique which can simplify and speed the input of information in the field.

An intermediate step is the use of a sticker placed on the back of the sign to date the installation. The sign sticker should have three elements: a date code, a warning to vandals of unlawful defacement or theft, and a telephone number to call in the event of a knockdown. The date code is easily readable from a maintenance truck when the sticker is printed in color. A key element in a tort action remains regular day and night inspection which can be substantiated with record keeping, indicating that effective remedial action is taken in a timely manner.

Industrial research has made simultaneous progress in providing improved life expectancies for both marking and signing. Pavement markings are now available having an order of magnitude improvement in service life, reducing the need of continual restriping with seasonal periods of poor visibility. Signing materials are now in use with double the effective service life offering a greater degree of optimal nighttime performance.

We have an opportunity and an obligation to optimize the nighttime efficiency and permanence of signs, delineators and pavement markings. It is not enough to just conform to the provisions of the MUTCD[10]. These are minimum standards. It is the optimization of night vision aids which will produce a safety improvement, followed and augmented with a determined maintenance effort to avoid subsequent decay.

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## TRENDS IN ROAD SIGNING IN EUROPE

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### Introduction

Europe is a mixture of cultures, political and social societies with many linguistic barriers. Taken as a whole with both the Western and Eastern countries, Europe forms a very strong economic body which depends on its road infrastructure for its economic development. In other words, the road network of Europe must have the equipment in road signing and markings allowing drivers from any country to feel safe and comfortable when using the roads within and outside of their own country.

### International and National Legislation

It is necessary that European roads show similar if not the same characteristics in their construction and equipment. To this effect several international and world Conventions and Agreements have been drawn up since the last world war by the United Nations' Economic Commission for Europe (UNECE) based in Geneva. They include the following: