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These papers have made me appreciate how far we have all come since the first night driving symposium in 1968. We are now using a common basis for evaluation of the driver's nighttime visual needs. Whether we are concerned with vehicular or fixed illumination requirements, driver vision testing, or driver guidance, the evaluative metrics we are using are now based on visibility and required contrast levels for seeing. We are no longer talking solely in terms of the physical illumination output of a particular lighting system.

Such changes in research emphasis will undoubtedly bring a big change in our approach to highway illumination design problems. Eventually we will rewrite design standards toward a performance-based specification aimed at ensuring the driver at least a minimum level of visibility under all common roadway conditions rather than a hardware-based specification. Each highway illumination system will be designed according to the visibility requirements of the driver for the particular driving environment. This is independent of whether the light sources are mounted on the vehicle or along the roadside. It can no longer be blanketly stated that freeway fixed lighting systems should provide 0.6 ft-c to the pavement surface. It will become more of a design job in which, for each roadway situation, the designer will need to define the driver's requirements based on the specific driving situation. The illumination design can then be tailored to meet these requirements.

Walton's paper has started to develop the foundation for such a design approach. He has developed a framework for analyzing the driving task to determine driver visual requirements under different driving conditions. We must now see what parts of these tasks may be affected by changes in the visibility level and the utility for making these changes. At that point it becomes a question of the cost effectiveness of providing the type of illumination system that will alter the visibility to satisfy a given percentage of drivers in the specific driving situation.

The Blackwells and Gallagher and Meguire have started to provide us with the tools to measure driver visual requirements and to design the illumination systems to provide the required visibility. For at least one task, the relationship between driver behavior and visibility is being established. The next step is to expand this relationship to other parts of the night driving task and to relate this to control needs other than the visual complexity of the highway environment that must share the driver's attention. From that point, it should not be too difficult to develop the relationship between the ability of existing lighting systems to meet the visibility needs of drivers and the resulting effects on traffic and pedestrian accidents, traffic flow, crime, and energy consumption.

These factors could all then be related in an economic trade-off analysis to determine what specific aids to driver visibility should be provided for each roadway situation. With a management tool of this nature, administrators will be able to see what the explicit trade-offs are for a particular roadway situation. If we provide a fixed illumination system that gives a certain level of visibility, then we will satisfy the visual requirements of X percent of the night drivers on that facility and we can expect Y accident level, Z crimes, etc. If the level is increased, we can quantify the changes and see whether they are worth the added costs.

Several pieces of the picture are still missing, and work is still required on them. One of the most important questions is the effect of changes on the complexity of the roadside environment. Most of the research to date has been accomplished in very structured situations where the driver does not have much to distract him. As the driver moves into more complex situations where there are pedestrians, visual clutter, and lighted businesses along the street, what happens to his basic requirement for visibility? Can this informational loading be handled as a multiplication factor, or is this too simple a model?

Research on vehicle lighting discussed in the papers appears to be heading toward the same types of visibility measures. Perhaps someday soon we will have the ability to explicitly analyze the trade-offs between vehicular and fixed sources.

The paper on transient adaptation was particularly interesting in what it says about

the need for providing transition illumination levels in and out of areas with fixed illumination. It does not appear that this is as major a problem at night driving levels as earlier studies done at higher luminance levels had indicated. There is still a visibility loss, but it is not so large as anticipated.

The paper of Irving and Yerrel demonstrated that the British are facing many of the same problems, and we can learn much from such interchanges. The Transport and Road Research Laboratory study to measure the physical characteristics of large portions of the existing lighting system on British highways and relate this information to accident statistics will be extremely useful. I hope that they will use some of the measures of visibility we have been discussing here.

The paper on driver visual screening gives insight on what the design driver's vision is really like and what can be expected in terms of visual testing in the near future. There are some serious problems in implementing a new vision test that have not yet been addressed by the research. One is the time requirements for any test that obviously must be supported from the taxes or license fees we all pay. Therefore, vision screening should only be going on where it will prove sensitive in the driver licensing process. It, therefore, should not be something that is periodic for all classes of the population, but is probably desirable for certain subclasses of the population, such as older drivers and those with certain types of violation patterns, at regular intervals.

Improved visibility is not going to solve all of the night driving problems. If the problem is the result of a mistake in the geometric design of the roadway, improving the visibility may help alleviate the problem but it will not solve it. There are other techniques that may also help in these cases and we must learn how to determine what is appropriate for each case. Rockwell and Rackoff's research points in this direction. It is hoped that they can demonstrate the explicit trade-offs at the rural intersections they are studying among improvements in delineation, illumination, and signing.

Well, how can all of this be implemented? The method is pretty well known. The first step is to come up with suggested design procedures and warranting conditions. The next step is to develop a procedure for assigning priorities based on some type of economic utility model. Then these procedures should be tried out over some limited geographic area—perhaps a state or two. If the procedures work well and the benefits from using them are positive as compared to the current procedures, then a formal standard can be adopted by IES, AASHTO, AMVA, or SAE as the case may be. The TRB Committee on Visibility can help in this process mainly by seeing that, when research has been completed and it is ready to be tried out, it is brought to the attention of the administrators who have the authority to test and evaluate these results in the real world.