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LANE MARKINGS IN NIGHT DRIVING: A REVIEW OF PAST RESEARCH AND OF THE PRESENT SITUATION

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EXECUTIVE SUMMARY

One of the basic driver tasks is to follow the road. In daytime driving, when the visibility of the road in clear weather is unobstructed, this is normally not a problem. However, when driving at night on dark roads with low beams, it is often quite difficult to see the direction the road is taking.

Indeed, drivers state that poor road guidance is their main problem in night driving. This view is supported by accident statistics showing single vehicle accidents (running off the road) to be overrepresented in night traffic.

To overcome this problem roads are fitted with retroreflective pavement markings, which are

visible in night driving. This study was designed to review the role, effects, and functioning of lane
markings in night driving. Section 1 further details the scope and the limitations of this report.
Drivers' needs for road guidance should be the basis for the design of pavement markings. Consequently, in Section 2 the road guidance needs are analyzed based on existing driver models and on basic driver characteristics. It is concluded that drivers need road guidance and give this need very high priority. An effective lane marking provides a preview time of at least 5 s, which corresponds to about 140 m at a speed of 100 km/h. In daytime, both long-range guidance (at least
5 s of preview time) as well as short-range guidance (less than 3 s of preview time) are provided. Long-range guidance is generally carried out with central vision and it is performed only intermittently. Short-range guidance is carried out primarily unconsciously, continuously, and by peripheral vision. In night driving, however, drivers are often forced by poor visibility to forgo long-range visual guidance, and drive with the use of short-range guidance only. In such conditions, this sometimes has to be done with central vision, consciously, rather frequently, and presumably with considerable mental effort.
In Section 3, previous studies on pavement markings are reviewed. Specific attention is given to the measurement of the photometric properties of pavement markings because the photometric properties are critical for visibility. Studies of the general impact of lane markings on road accidents are reviewed. The conclusion is that good lane markings improve road safety. However, the effects are smaller than expected, except for combinations of marking systems (e.g., edgelines with centerlines and side-post delineators), which have substantial accident-reduction effects.
The presence and nature of lane markings affect drivers' choice of speed and lateral position. However, the results concerning speed changes are inconsistent. While some studies report a reduction, most report a slight increase in speed as a consequence of improved lane markings. A limited number of well-controlled subjective and objective visibility measurements of lane markings have been carried out. The results are summarized in tables showing that the visibility distances in night driving are normally considerably shorter than the safety criterion iv chosen (140 m). The worst situation tested involved wet roads. The visibility distance of lane markings tends to be approximately proportional to the logarithm of the retroreflected luminance. The effects of other lane-marking characteristics (such as color and width) are also described.
The effects of various road, vehicle, and driver parameters are discussed. Concerning the road conditions, the main effects come from wear and weather. The effects of vehicle type and beam pattern on lane-marking visibility have not received much previous attention. There is

evidence that older drivers and impaired drivers would benefit more from improved lane markings than would the average driver. Finally, durability, maintenance, cost, and photometric requirements and standards are briefly discussed.
Section 4 summarizes the main issues that have emerged from this review and presents suggestions for future research. In Section 5, the general conclusions are made, and proposals for research topics and technical developments are listed.
The overall conclusion is that while drivers need both long-range and short-range road guidance, present pavement markings often offer only short-range road guidance at night, especially in wet-road conditions.

2.1 Driver models

The two major driver tasks according to Gibson and Crooks are:
 To create an area of safe driving in front of the vehicle.
 To decide upon a minimum stopping distance within this area of safe driving.

2.2 Driver characteristics

A more realistic preview time for long-range visual guidance appears to be 5 s, with 3 s as an absolute minimum preview time. At a speed
of 100 km/h, 5 s would yield a preview distance of 140 m and 3 s would yield 84 m.