Adapting the Highway to the Human Element

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ABRIDGMENT

•ONE MAIN direction of recent research on the driving task has been the examination of the characteristics of the environment relative to the visual requirements essential to accurate and reliable vehicle control. This work has provided an insight into certain of the basic mechanisms employed by drivers to locate themselves in time and space, and the results indicate that the driver is faced less with the problem of simple detection than with the scaling of speed and projection of position, his own and others. Research has also indicated that immediate control is determined by conditions existing with a driver's visual field whose longitudinal extent is fairly short, varies as a function of speed, and laterally extends beyond the road borders. However, elements outside these limits are important because they provide coherence and structure to the visual world. This orientation is essential for accurate interpretation of what enters the driver's field. Further, they serve as advanced cues by which the driver may sort and order events or changes with which he must deal in the near future. Finally, there are indications that because of his limited information-processing capabilities, the driver must do considerable time sharing among the many sources in the environment. This appears to degrade accuracy and reliability of any one operation.

Results of this research indicate that visual velocity information is the most significant perceptual dimension for the safe performance of the functions of driving. This information must be available relative to the roadway itself and other objects, fixed or moving, with which the driver must deal. Thus, the basic conditions for safety are that the roadway environment be structured to provide this visual velocity information without discontinuities or distortion. Further, the environment must be adapted to these requirements and organized to be within the driver's information processing limitations.

Some examples may clarify these principles. A driver's speed and lateral position on a roadway will be adjusted to the availability of visual velocity information and to its magnitude. The driver will adapt his control to insure having the needed information in appropriate time and space sequence. This is a significant reason for having not only geometric design criteria, but also high contrast demarcation of the roadway. Fixed objects entering the drivers visual field will cause a lateral displacement whenever they enter without a detectable component of lateral velocity. If a driver cannot displace, he will reduce speed to minimize the probability or magnitude of displacement. Other vehicles are picked up as they enter the driver's visual field and are scaled on the basis of relative visual velocity. Thus, when and where they become of active concern to a driver depends on the extent of his visual field. Only in the case of car following, however, does there appear to be a direct way to translate the perceived motion into control responses. Gap acceptance and passing appear to reduce to a go, no-go decision process.

It is evident that there is a range of conditions in which a driver uses a common perceptual process for controlling his speed and position. Implicit is the principle that whenever and for whatever reason the accuracy or reliability of these perceptual and judgmental processes are reduced, safety is compromised. This human factors principle can be applied in safety engineering. Although it does not define what should be done, it does provide criteria for specifying conditions which compromise safety and when changes should be instituted to improve safety.

At present, a location is specified as unsafe when it has an excessive accident record. Ironically, a significant number of accidents must accumulate before safety measures

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aimed at preventing them are initiated. There is something very wrong, and I think unnecessary, with such a logic, because from what is now known about the driving task we can begin to see an alternative. What we are looking for are the locations or situations in which the environment is so complex or so ambiguous that the driver is forced to compensate in speed or position to maintain or minimize loss of accuracy of his control. We are in a position to specify some of the most significant environmental conditions which cause degrading of safety. They may be stated as follows:

1. Where the geometrics of the highway restrict a driver's view ahead so that there is insufficient visual information for him to control reliably for changes in gradient or curvature;
2. Where the continuity or differentiation of referents within the driver's field of view are so inadequate that there occurs high variability in lateral placement or high frequency of speed reduction;
3. Where there occur constraints within the driver's visual field that cause significant lateral displacements or speed reductions to avoid displacement;
4. Where the frequency of large speed differences occur from any cause;
5. Where the accurate judgment and/or frequency of occurrence of adequate gaps for turning, crossing, or passing is compromised regardless of cause; and
6. Where the number, complexity, and uncertainty of information sources with which the driver must deal becomes so great that speed reductions are frequent.

Each of these restrictions may be determined by direct measurement, which, including volume, becomes the real criterion for instituting any physical changes. The crux of that program is the appropriate measurement of changes in speed or placement. Further, the detection of many potentially unsafe locations may be determined by subjective driving experiences. All that is required is a sensitivity to the ease or difficulty experienced in driving.

This approach to safety engineering is predicated on the assumption that highway safety is a problem of adapting a machine-environment system to the requirements of human control. Using our growing understanding of driving behavior in this fashion can provide an objective basis for establishing priorities for safety improvements, and thereby avoid the dilemma of the accident criterion.