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HIGHWAY VISIBILITY RESEARCH NEEDS

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OPERATION AND MAINTENANCE OF TRANSPORTATION FACILITIES

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FOREWORD

It is an important function of the Transportation Research Board to point out problems that need research. At various times in the past, the TRB Visibility Committee (and its predecessor, the Night Visibility Committee of the Highway Research Board) compiled lists of needed research and developed research problem statements (for example, see TRB Special Report 158, 1975, pages 18-21). This is being done again at the beginning of the 1980's decade.

As we look forward to the 1980's we are fortunate in having a large body of pragmatic visibility research results on which to build. There are some important gaps in our knowledge which should be filled, and extension of practical knowledge is needed in other areas, as already noted. But on balance, we have a good structure of reliable knowledge to work with in increasing the quality of highway transportation.

In the files of the Transportation Research Board Visibility Committee there is a working paper dated July 27, 1964 which is entitled, "Subjects Needing Research, Study or Development Relating to Night Visibility in Highway Use." It posed twenty-four questions such as, "What are the relative advantages and disadvantages of various highway delineators and roadway edge markings?" In order to assess the growth in knowledge of night visibility on the highway since this document was prepared, several committee members recently rated each topic according to the progress they thought had been made. The results showed "substantial progress" for 17% of the questions, "some progress" in another 50% and "little progress" for only 33% of them. In effect, significant and worthwhile progress has been made toward solutions of two-thirds of those 1964 research problem statements.

Fifteen years later, during 1979, members of the TRB Visibility Committee drafted seventeen new research problem statements in the format currently employed by the Transportation Research Board. The original submissions were edited by the Research Problem Statement Subcommittee chairman, Dr. Albert Burg, who then circulated them to all members and affiliates of the Visibility Committee for comments. A revised set of statements was then re-circulated for approval and prioritizing, and the results analyzed. The statements are listed here in order of descending priority, with the first research problem considered to have top priority in relation to the others. In addition, an indication of the research problem's urgency (high, medium or low) is given. This refers to the importance of the proposed research to transportation safety, and for each research problem statement independent of the others. What follows, therefore, fairly represents the viewpoints of the Visibility Committee, together with consensus opinions of priority and urgency.

RESEARCH PROBLEM STATEMENTS

PROBLEM NO. 1

1.1 TITLE: NIGHT VISION OF OLDER DRIVERS

1.2 PROBLEM: A degenerative process is known to absorb and scatter light as human eyes age. The resulting degradation of vision affects older drivers at night and can cause discomfort glare, reduced legibility distance for traffic signs and possibly other, unidentified vision-related problems. The nature of these problems, and the extent of this degradation with age, are not well understood. A reliable and valid testing procedure for identifying drivers with severely degraded night vision is not currently available.

1.3 OBJECTIVES: a. Conduct research to identify and quantify nighttime vision problems associated strictly with age; b. Develop a reliable means for identification of such particularly impaired drivers; and c. Make recommendations for ameliorating the problem, at least social cost, by specifying countermeasures that may be taken to reduce the hazards associated with having drivers with this visual handicap in the traffic stream.

1.4 KEY WORDS: Aging Drivers, Night Vision, Degenerative Vision, Glare Resistance, Acuity Loss, Driver Vision, Threshold Illumination, Discomfort Brightness Levels, Disabling Glare Levels

1.5 RELATED WORK: Research by Blackwell, Burg, Olson and Richards, among others, has quantified certain aspects of this problem.

1.6 URGENCY/PRIORITY: The highway system is not designed to accommodate drivers with grossly deficient night vision; yet, proportionately more older drivers enter the system each year, and many of these are such worst case users. The need to identify such drivers is urgent now, and can only become worse.
URGENCY: HIGH

1.7 COST: $250,000 to $500,000

1.8 USER COMMUNITY: NHTSA, AAMVA, FHWA, AAAM, AMA

1.9 IMPLEMENTATION: Once the nature and extent of this problem are known, study recommendations for ameliorating the problem can be implemented. These might include such things as more effective visual screening of driver license applicants, remedial perceptual training, in-vehicle aids, better headlighting, and improved highway hardware (luminaires, traffic control devices, glare screening, etc.).

1.10 EFFECTIVENESS: Implementation of the study recommendations can not only reduce the hazards of night driving for all highway users, but also may make it possible to avoid serious impairment and disruption of the lives of older drivers. There is evidence that older drivers are underrepresented in the population of night drivers - that there is a self-selection process at work whereby older drivers eliminate or reduce their night driving activity because of a realization of their night vision shortcomings. This has a societal impact, both from a psychological (self-esteem) standpoint and also because older drivers are often, then, forced to rely on inadequate (or nonexistent) public transportation to meet their essential needs, often causing considerable physical inconvenience. Increasing the proportion of elderly drivers who can safely use the highways at night would minimize these societal costs.

PROBLEM NO. 2

2.1 TITLE: MINIMUM INTERCHANGE LIGHTING NECESSARY FOR SAFETY

2.2 PROBLEM: Because of the increasing seriousness of the energy situation, from the standpoint of both cost and availability, interest is growing among Departments of Transportation in the reduction of highway lighting to a level that will minimize energy usage but still provide adequate driver guidance in the interchange areas (where such lighting currently is concentrated). At present, however, there are not enough data available to provide a basis for needed decision-making.

2.3 OBJECTIVES: Develop standards that specify the levels of illumination necessary to provide driver guidance through different interchanges. Several illumination levels should be specified, including recommended pole locations and type, number and lumen output of luminaires for different types of interchanges. Factors that should be considered in arriving at these standards include interchange geometry, night traffic volume, number of through and exiting lanes, environmental setting (urban, suburban, rural) and climatic conditions (e.g., fog-prone area). Also to be considered in developing and standards are the experiences (including accidents) of the various Departments of Transportation currently using different interchange lighting levels and configurations, as well as all relevant research findings in driver visibility.

2.4 KEY WORDS: Highway Lighting, Interchanges, Visibility, Geometrics, Driver Guidance, Illumination Levels

2.5 RELATED WORK: Previous studies of interchange illumination on the Interstate System have provided data comparing illumination level with driver responses, accidents and the transient adaptability of driver vision. Other research involving vehicle and road lighting systems has related illumination level to visibility distance. Work in the area of driver visual performance under various levels of illumination (e.g., Gallagher) and the effects of contrast (e.g., Forbes) is also relevant.

Related work is currently underway under NCHRP Project 5-9, "Partial Lighting of Interchanges".

2.6 URGENCY/PRIORITY: As the energy crisis worsens, there will be increasing pressure to reduce lighting levels - with or without sufficient data. To avert such precipitous actions, which could create a serious safety

problem, it is important that activity be undertaken quickly to provide proper bases for such actions.
URGENCY: HIGH

2.7 COST: $50,000 to $75,000, based on the assumption that the study would consist essentially of insightful integration of already-available research findings with state-of-the-art information in highway lighting and the experiences gained by various agencies who have experimented with different interchange lighting configurations and levels.

2.8 USER COMMUNITY: State DOT's, FHWA, AASHTO, IES, DOE, NHTSA

2.9 IMPLEMENTATION: Assuming they support reduced levels of interchange illumination, the results of the study will find ready implementation by the various agencies responsible for highway lighting through modifications of luminaire spacing, intensity, height, etc.

2.10 EFFECTIVENESS: If the study produces more precise measure of interchange illumination effectiveness than are currently available, and the findings suggest the feasibility of lower illumination levels, then the societal impact will be significant, in terms of energy conservation and cost reduction with, at the same time, maintenance or improvement of present levels of driver guidance. Such data would also clarify the direction for future interchange design, geometrics and illumination parameters.

PROBLEM NO. 3

3.1 TITLE: REDUCED FIXED ROADWAY LIGHTING DURING PERIODS OF REDUCED TRAFFIC DENSITY

3.2 PROBLEM: A major effort is being put forth by various governmental agencies to reduce energy consumption and related costs while still providing maximum safety for the motoring public. An area of great concern to some governmental officials is the uninterrupted provision of lighting during the late night and early morning hours when traffic density is extremely low. The use of energy and its added cost to provide lighting for an entire interchange, as opposed to the illumination of a few critical locations under reduced traffic flow, requires professional research to provide factual information upon which to base a decision. The problem also involves the reversion of continuous freeway lighting back to interchange-only lighting during times of low traffic density.

A number of factors must be investigated. The safety of an individual motorist versus the economic justification of cost provided by large numbers of motorists; the legal responsibilities of the agency to provide equal facilities for all motorists; and the psycho-physiological needs of the late night-early morning driver must all be considered in the analysis of this problem. Electric utilities generally are in need of late night-early morning loads to balance out system requirements. Reductions in these time periods may have a negative effect on total energy consumption.

3.3 OBJECTIVES: a. Conduct research to determine the safety, economic and legal aspects of reduced fixed roadway lighting coverage during periods of low traffic density, taking into account all of the factors outlined above; and b. Recommend courses of action that may be used by agency administrators to decide on whether or not to reduce fixed roadway light coverage during these periods.

3.4 KEY WORDS: Highway Lighting, Energy Conservation, Night Accidents, Partial Lighting, Utility Load Balancing, Visibility, Legal Liability, Illumination

3.5 RELATED WORK: Several studies relating fixed roadway lighting to night accidents have been completed. A recent before-after study on I-95 by the Virginia Highway and Transportation Research Council indicates that continuous freeway lighting is better, both economically and from a safety standpoint, than interchange-only lighting. A Texas Transportation Institute study shows the same results. Both studies, however, involved turning lights off all night, rather than only during late night-early morning hours. The proposed work would further expand these studies to cover reduction of the coverage of roadway lighting during periods of low traffic density.

3.6 URGENCY/PRIORITY: The national effort to conserve energy and the even greater impact of reduced operating budgets have made it necessary for some agencies to seek methods for reducing the extent of facilities provided with lighting for motorists' use. Full-time night illumination of interchanges and continuous sections of freeways have been suggested as possible methods for reducing energy and expenses.
URGENCY: HIGH

3.7 COST: $200,000

3.8 USER COMMUNITY: FHWA, IES, AASHTO, DOE, NHTSA

3.9 IMPLEMENTATION: The findings of this research will permit administrators to make proper decisions as to lighting coverage during specific nighttime hours, to minimize energy consumption without increasing other costs unacceptably. The research may result in a change in the AASHTO Guide for Lighting.

3.10 EFFECTIVENESS: Depending on the results, this research could result in annual savings of 265 megawatts of electricity, or $9,000,000 in energy costs, without adversely affecting driver visibility wherever fixed lighting is proposed or now exists.

PROBLEM NO. 4

4.1 TITLE: REFINEMENT OF THE VISIBILITY INDEX

4.2 PROBLEM: Recent development of the concept of the Visibility Index (VI) has substantially advanced the understanding of driver visual needs in night driving. Field studies have shown a strong relationship between VI and one aspect of driver performance, i.e., object detection. To make the VI concept more broadly useful, there is a need to relate it to other factors which have a bear-

ing on it, such as highway geometry and driver conflicts.

4.3 OBJECTIVES: Further study of the visual parameters that influence the motorist's performance will make possible development of a classification system for different types of roadways in different areas based on the VI. For example, to achieve a desired speed on a downtown section of urban freeway, a certain VI will be specified that will provide the necessary parameters for a complete lighting design.

4.4 KEY WORDS: Highway Lighting, Night Visibility, Accidents, Visibility, Driver Vision

4.5 RELATED WORK: This is a continuation of the FHWA-funded research previously conducted by the Franklin Institute.

4.6 URGENCY/PRIORITY: It is most urgent that research in this area be furthered so that new standards may be developed resulting in superior lighting installations. This will be of substantial benefit to the public since improvement of lighting quality should result in better night visibility and, thus, greater safety for the motorist (and pedestrian). Also, development of more valid standards should result in more effective utilization of available highway lighting funds.
URGENCY: MEDIUM-HIGH

4.7 COST: $400,000

4.8 USER COMMUNITY: FHWA, IES, NCHRP, State DOT's, NHTSA

4.9 IMPLEMENTATION: Development of a more refined VI will provide a more comprehensive and sophisticated basis for actual field installations of roadway lighting. This, in turn, should lead to a national standard that will promote uniformity among all agencies responsible for highway lighting.

4.10 EFFECTIVENESS: The results of this research should lead to the Visibility Index being used as the primary criterion for roadway lighting design. This, in turn, should lead to a system that will maximize driver visual performance while minimizing initial costs, as well as energy consumption. In addition, since a direct correlation between accident reduction and visual performance has already been established, improved safety is expected to be a major end-product.

PROBLEM NO. 5

5.1 TITLE: DETERMINE THE OPTIMUM EFFECTIVENESS OF VEHICLE AND FIXED LIGHTING FOR URBAN ROADWAYS

5.2 PROBLEM: The nighttime visual environment produced by current fixed lighting and vehicle headlights lacks effectiveness for safety, is unnecessarily expensive and wastes energy. Present vehicle headlights are designed for lighting roads without fixed lighting. In urban areas, however, where fixed lighting is present and is utilized to meet many needs other than for vehicular traffic, the role of vehicle lighting need only be that of providing adequate delineation to the vehicle itself. Present headlights are generally not compatible with good fixed lighting. Limited research in this area has shown that fixed lighting in combination with vehicular parking lights produces greater visibility distances than fixed lighting with low or high beam headlights. The glare from oncoming headlights reduces visibility and provides unnecessary discomfort, as well as adversely affecting safety.

The cost of operating headlights is very significant, and should be taken into account when determining the cost of producing the safest and most economical night driving environment, especially in view of the fact that over 75 percent of the population lives in urban areas containing 10 percent of the national roadway mileage.

5.3 OBJECTIVES: The proposed research is very broad in scope, and has a number of objectives, including determination of the following: a. The optimum combination of fixed lighting and vehicle marker lighting for different classes of urban roadways; b. The mileage of different roadway classifications for typical towns; c. Night traffic volumes and average speeds for the different roadway classifications; d. Costs of present fixed lighting; e. Costs of present vehicle headlight operations; f. Costs of the combination of adequate fixed lighting with adequate vehicle marker lighting; g. Accident records on urban roadways, both with fixed lighting (adequate-fair-poor) and without fixed lighting; and h. Potential accident reductions and economic savings with appropriate fixed lighting and vehicle marker lighting for urban areas.

5.4 KEY WORDS: Night Visibility, Fixed Lighting, Vehicle Headlighting

5.5 RELATED WORK: There is no related research currently in progress in either the U.S. or Canada; however, the British Transport and Road Research Laboratory is currently studying the accident involvement of 400-500 postal vans equipped with the dipped-dim headlight system, a study which may provide some relevant data. Very limited experiments that have been conducted in the past in Europe support the need for a better combination of fixed and vehicle lighting.

5.6 URGENCY/PRIORITY: This type of research is long overdue, and as the energy crisis becomes worse, the need for this research becomes more and more urgent.
URGENCY: MEDIUM-HIGH

5.7 COST: $200,000 to $500,000

5.8 USER COMMUNITY: NHTSA, FHWA, NCHRP, IES, SAE, DOE, ITE

5.9 IMPLEMENTATION: The results of the proposed research would be implemented by modifying existing systems of urban fixed lighting and vehicle head- and marker lighting. The cost of implementation and the time required for full realization of a program based on usage of parking lights on urban roadways and headlamps on rural roads would be extensive. To be convenient and "fool-proof", motor vehicles would need to be equipped with a

device that would automatically turn on the headlamps when leaving an urban area, and turn off the headlamps when entering well-illuminated roadways. In addition, the present parking (position) lamps on motor vehicles would probably need to be upgraded in terms of size and light output. It would probably take 10 or more years before the majority of vehicles in use have the improved marker lights and automatic devices.

5.10 EFFECTIVENESS: The public is entitled to a safer, more economical and comfortable night driving environment. The results of this research should result in increased highway safety, and adequate fixed lighting should provide additional benefits, such as reduced crime and more effective fire and police protection. In addition, air pollution would be reduced and scarce fuel oil conserved.

PROBLEM NO. 6

6.1 TITLE: PEDESTRIAN VISIBILITY

6.2 PROBLEM: Each year many pedestrians are killed or injured in accidents with motor vehicles. In 1975, 8700 were killed and over 300,000 were injured. Over 54% of the fatalities occurred at night, despite the fact that the probability of vehicle-pedestrian conflict is much lower at night than during the day. Almost 40% of the fatalities occurred in urban areas at night. Recent studies have shown that added street lighting is effective in reducing urban night pedestrian accidents, suggesting one way in which the visibility of pedestrians at night can be improved.

Another study brought out that 80% of the drivers who struck pedestrians reported that they "did not see" the pedestrian. While light-colored clothing improves a pedestrian's visibility, it is not adequate for many commonly-encountered situations, and we cannot rely on the majority of pedestrians to wear light-colored clothing. It has been shown that the 15th percentile pedestrian's clothing has a reflectance of only 13%.

Retroreflective materials now exist in many forms that are effective in varying levels of brightness. An increase in their use as a means to improve pedestrian conspicuity at night represents an objective that clearly would aid in reducing the magnitude of this problem.

6.3 OBJECTIVES: a. Study the effectiveness of available retroreflective materials for pedestrians under various conditions of brightness, pattern, shape, area, color and motion; b. Develop a "visibility index" for comparing various retroreflective treatments with each other and with other materials commonly used for wearing apparel; c. Test retroreflective systems under field conditions to determine motorist response; and d. Recommend a procedure for implementing a visual protection program for occupational pedestrians, identifiable pedestrian groups (such as the stranded freeway motorist) and for the general public.

6.4 KEY WORDS: Pedestrian, Clothing, Reflectance, Visibility

6.5 RELATED WORK: Pedestrian visibility indexes and visibility assessments are reported in numerous studies by 3M, FHWA and NHTSA-(Report FHWA-RD-76-8, for example). Accident data gathered since 1966 are similar to those cited above for drivers allegedly not seeing pedestrians they hit. Allen, in Vision and Highway Safety (1970), relates numerous studies related to this problem. Current activities of the recently-formed ASTM Committee F-22, "High Visibility Materials for Individual Safety", are largely directed toward attaining the same objectives, but with additional target groups. A NHTSA study of pedestrian (and bicycle) conspicuity is currently underway.

6.6 URGENCY/PRIORITY: As the proportion of elderly people in our population continues to increase, so does the number of aging drivers and pedestrians. Recognizing that a failure of vision is the predominant problem in night pedestrian accidents, an increase in such accidents is inevitable, unless effective countermeasures are implemented. An increase in the night visibility of pedestrians is required, and methods for accomplishing this can be utilized to enhance the night visibility of other classes of highway users as well, such as highway construction workers, and operators of bicycles, mopeds and motorcycles. URGENCY: HIGH

6.7 COST: An estimated $35,000 will be required to carry out the research required to reach objectives a, b and c, listed above. The cost of attaining objective d cannot be estimated at this time.

6.8 USER COMMUNITY: NHTSA, FHWA, AASHTO, AAAM

6.9 IMPLEMENTATION: Programs motivating pedestrians to purchase and wear special apparel at night will require not only prodding by government but also the support of citizen groups, such as the PTA (for school age children), high school athletic groups, and for the elderly, the AARP. Proof that such apparel is effective will be required, through the use of such measures as personal testimonials, speakers bureaus, and organizational support.

6.10 EFFECTIVENESS: The effectiveness of the program will, of course, depend on the degree of compliance by the pedestrian population. Based on past experience with voluntary use of another "active" safety device, namely safety belts, a reduction in night pedestrian accidents of 10-20 percent may be possible.

PROBLEM NO. 7

7.1 TITLE: DEVELOPMENT OF A VISUAL COMFORT INDEX

7.2 PROBLEM: Current research has isolated and quantified most of the night visibility requirements to be fulfilled by fixed highway illumination. However, the manner in which driver visibility at night is affected by discomfort glare, a subjective quantity, has not been similarly defined in a manner suitable for predicting quantifiable results. A European method of quantifying "visual comfort" as a function of glare, known as the Glaremark system, has so far not been vali-

dated in the U.S. The ability to predict discomfort glare will provide lighting designers with the final tool in engineering the most efficient roadway lighting systems.

7.3 OBJECTIVES: a. Conduct research to develop and validate equations or computer programs that define and quantify discomfort glare for use by practising engineers in designing lighting systems; b. Implement these designs to provide night motorists with a substantially reduced level of discomfort and, therefore, a higher level of concentration on the driving task.

7.4 KEY WORDS: Glare, Night Visibility, Fixed Illumination, Discomfort Glare, Comfort Index

7.5 RELATED WORK: The Glaremark system has been developed in Europe. Higher level interior lighting systems use a Visual Comfort Probability system. Current work on lower illumination levels as found in roadway lighting is being conducted at Kansas State University. This work, known as the BCD (Borderline-Comfort-Discomfort) system, is in its early stages and will need further research to refine the system.

7.6 URGENCY/PRIORITY: This work should have the highest priority in that new national standards for highway lighting are now being formulated and will be forthcoming by 1982. The proposed study, along with other research on night driving visual needs, will lead to a complete and comprehensive description of the requirements for fixed illumination on U.S. roadways.
URGENCY: MEDIUM

7.7 COST: $170,000

7.8 USER COMMUNITY: FHWA, IES, NHTSA, AASHTO, FAA

7.9 IMPLEMENTATION: The research results will allow designers to incorporate discomfort glare formulations into highway lighting designs. These formulations will become part of national standards used by most engineers nationwide.

7.10 EFFECTIVENESS: Numerous fixed roadway lighting systems have been constructed and operated with little or no consideration for the night driver's visual comfort. Older drivers, especially, suffer from this problem of discomfort glare. New systems based on the proposed research and existing systems which may be modified to correct deficiencies will provide improved night driving performance. The effectiveness of this feature will be in a reduction of night driving problems and an improved night driving attitude.

PROBLEM NO. 8

8.1 TITLE: DEVELOPMENT OF NEW PAVEMENT MARKING CONCEPTS

8.2 PROBLEM: Conventional reflectorized pavement marking systems lose much of their effectiveness during periods of darkness in rainy weather. In addition, in snow belt states, raised markers are not practical, and the anti-skid material spread on the road surface often removes the painted markings (almost completely), so that little guidance is provided during winter months.

8.3 OBJECTIVES: Develop innovative retroreflective pavement marking systems that are practical, economical and effective on a year-round basis under nighttime wet-pavement conditions and that also are compatible with snow plowing.

8.4 KEY WORDS: Roadway Delineation, Night Visibility, Raised Pavement Markings

8.5 RELATED WORK: This problem has long been recognized, and several major research efforts have been completed in the past, the most recent being NCHRP Project 5-5 B. The December 1977 issue of Public Roads contains a review of this topic. Several developmental programs are underway to produce raised pavement markers that will be effective and compatible with snowplowing (e.g., the Stimsonite 96 for areas with snowfall ranging from 15 to 25 inches, and the NYSDOT grooved marker for greater snowfall depths). Also, prefabricated marking blocks are promising, as are epoxy thermoplastics. However, past research has first developed a raised marker device, and then subjected it to snowplow conditions. It is felt that a more productive approach would deal with the problem by beginning with basic studies of the forces produced by snowplows at or near the roadway surface, using high-speed motion picture techniques to evaluate impact failure.

8.6 URGENCY/PRIORITY: Because of the importance of adequate path delineation, especially at night and in adverse weather, this is a high priority research task.
URGENCY: MEDIUM

8.7 COST: $500,000

8.8 USER COMMUNITY: FHWA, NCHRP, AASHTO, State DOT's

8.9 IMPLEMENTATION: If new pavement marking concepts can be developed that satisfy the requirements set forth above, they will quickly be adopted as a new national standard and replace current pavement marking techniques.

8.10 EFFECTIVENESS: Use of such new pavement markings would be expected to reduce the incidence of accidents tracable to driver confusion about path, especially at night or in adverse weather. Any such improvement in safety would be expected to be most evident among the growing population of older drivers, for whom reduced visual performance capabilities is a common handicap.

PROBLEM NO. 9

9.1 TITLE: VISION TESTING TO PREDICT DRIVER PERFORMANCE UNDER ADVERSE VISIBILITY CONDITIONS

9.2 PROBLEM: It is well known that accident rates at night far exceed those during day-

time hours; it is also apparent that a disproportionate number of multiple-vehicle accidents occur under reduced visibility conditions caused by rain, dust storms, fog, smoke, blowing snow and ground blizzards. What is not known, however, is whether there are significant differences in individual abilities to see under such adverse visibility conditions that are measurable, and that also are related to accidents occurring under such conditions. The lack of such information makes it more difficult for driver licensing officials to do an effective job of weeding out those applicants who are likely to be unsafe drivers under adverse visibility conditions; also, lack of this information on driver visual capabilities makes research into countermeasures for reduced visibility conditions less likely to be productive, and the results of such research are less likely to be understood.

9.3 OBJECTIVES: a. Analyze the visual requirements of driving under adverse visibility conditions; b. Relate these requirements to visual functions for which tests (standard or prototype) are available (e.g., acuity, contrast sensitivity, glare sensitivity); and c. Develop standards of visual performance on these tests, if possible, for use by driver licensing officials and procedures for informing drivers whose performance on these tests is sufficiently below standard as to limit their ability to drive safely under adverse visibility conditions.

9.4 KEY WORDS: Vision, Visibility, Contrast Sensitivity, Reduced Visibility Conditions, Night Vision

9.5 RELATED WORK: Considerable research has been done in the area of countermeasures for reduced visibility conditions (see Transportation Research Circular, No. 193, 1978). Extensive information has already been generated with regard to highway illumination standards, drivers' night vision performance under mesopic and photopic levels of illumination, and contrast sensitivity as a function of age. Numerous scientific and research reports also are available that identify what is possible today by way of measuring drivers' visual functions, and NHTSA currently is sponsoring research to develop a more effective driver licensing vision test battery. In addition, a number of studies have already generated considerable data on driver vision (but have not related these data to accidents occurring under adverse visibility conditions).

9.6 URGENCY/PRIORITY: Night accidents continue to be a major and unsolved problem on our highways. While much effort is underway to improve the highway (illumination) and the vehicle (headlighting), no significant changes have yet occurred with regard to the third element of the system, that is, the driver. Training, licensing and re-training (driver improvement) continue much as in the past, with little (if any) consideration given to night vision limitations or problems in performance under adverse visibility conditions. It is important to improve the effectiveness of the driver education - driver licensing - driver improvement aspects of traffic safety.
URGENCY: MEDIUM-LOW

9.7 COST: $75,000-100,000, exclusive of test equipment.

9.8 USER COMMUNITY: State Driver Licensing Officials, AAMVA, State DOT's, AASHTO, FHWA, NHTSA, Driver Education Associations

9.9 IMPLEMENTATION: Field testing of the vision-testing hardware and development of information for distribution to driver licensing officials and drivers requires a joint effort. Specific testing procedures, standards development, materials and media development would be useful not only in the area of driver licensing, but in driver education and driver improvement as well. After initial developmental and testing procedures have been tested and finalized, demonstrations could be undertaken in each of these three fields, and the results ultimately made available to licensing officials, traffic engineers, driver education specialists and the research community. Drivers will have to be convinced of the usefulness of any new testing procedures and standards developed, in order for these ultimately to be effective.

9.10 EFFECTIVENESS: Development of the information desired should provide driver licensing officials, traffic engineers and driver education specialists with another tool to permit them to do their jobs more effectively. Also, if drivers are made aware of their visual limitations (of any type), an increase in their "safety consciousness" should result, as well as an increase in their appreciation of the hazards involved in driving under conditions of reduced visibility.

PROBLEM NO. 10

10.1 TITLE: LUMINANCE AND CONTRAST REQUIRED FOR HIGHWAY SIGN LEGIBILITY: COMPARISON OF RESEARCH RESULTS OBTAINED BY DIFFERENT METHODS

10.2 PROBLEM: Research on highway sign daytime legibility distances has shown fairly comparable results using actual reading tasks. However, some luminance and contrast studies of legibility under simulated and actual night viewing conditions on the highway have shown results which appear rather different. These results should be described in common terminology to allow comparison and to show which results are most valid for use by traffic engineers, i.e., which give the most valid distances for reading of signs on the highway by 85 to 90 percent of drivers.

10.3 OBJECTIVES: The objectives of this research program are to; a. Review highway sign legibility studies; b. Put the results of these studies in common terminology; and c. Compare these results and relate them to full-scale legibility on the highway at night under different viewing conditions.

10.4 KEY WORDS: Sign Legibility, Highway Signs, Sign Research Methodology, Luminance, Contrast

10.5 RELATED WORK: Early research by Forbes involved legibility measurements based on reading of actual letters and signs, either in the laboratory or full-scale, and compared laboratory results with those obtained in the field. For daylight conditions, this method has proved reliable, and has produced results which can be compared for different study conditions and target sign characteristics. This method uses fairly large groups of subjects and is, therefore, tedious and time-consuming, but it does give an index of what the majority of drivers can see on the highway.

Blackwell and Blackwell have developed a highly accurate method of determining thresholds of contrast detection and relative contrast sensitivity. This has proved of great value in evaluating the visual performance aspects of lighting, but Blackwell has pointed out the need for "field factors" to adapt and apply these results to various practical work problems. It is, therefore, very important to determine factors or procedures which will show what relationships and corrections are required for real-world reading of highway signs under various night lighting conditions.

Richards, among others, has pointed out that a wide range of methods is used in determining visual acuity, depending on the purpose of the measurement (see, e.g., studies by Allen, Burg, Forbes, Olsen, Richards and others). At one extreme, the maximum visual ability (minimum acuity threshold) for selected subjects may be measured under ideal conditions in a laboratory. At the other extreme is the determination of what a representative sample of drivers can actually read while driving under a variety of real-life conditions. It is important that minimum threshold values obtained using methods that maximize accuracy and reliability should <u>not</u> be used for the purpose of determining the practical legibility of highway signs unless properly corrected so that they apply to the average driving population "at work". Uncritical use of such idealized data would probably lead to underestimation of the true design requirements for effective highway signing.

Additional references of interest include:

a. <u>Richards, Visual Needs and Possibilities for Night Automobile Driving</u>

b. Forbes, et al., <u>Traffic Sign Requirements - Annotated Bibliography</u>

c. CIE Publication #19, <u>Methods for Evaluating Visual Performance Aspects of Lighting</u>

d. TRB Special Report 156, <u>Driver Visual Needs in Night Driving</u>

Related work is currently underway at the Institute for Research under FHWA Contract FH-11-96-46, "Performance Standards for Determining Luminous Requirements for Traffic Control Devices".

10.6 URGENCY/PRIORITY: It is important to avoid basing highway design standards on data that overestimate the level of driver visual performance that can realistically be expected in actual driving situations. At present, there is a high probability of this occurring, due to misinterpretation and/or misunderstanding of research results as a consequence of failure to be aware of the relationship between research results and research methodology and objectives.
URGENCY: MEDIUM

10.7 COST: The cost of the proposed research can vary widely, depending on the method chosen to approach the problem. A relatively inexpensive approach would entail TRB cooperation, and would take advantage of the diversity of talent and experience available within TRB. This could be done by developing a conference session at the Annual Meeting, or a separate workshop or symposium, or by forming a Task Force (or some combination of these). In any case, researchers on this topic whose reports are already available would develop methods of making their results compatible and explaining similarities or differences which may be attributable to the methods and objectives of each of the particular studies.

10.8 USER COMMUNITY: FHWA, IES, AASHTO, ITE

10.9 IMPLEMENTATION: The results of this research would find immediate implementation in the revision of highway signing standards, where called for.

10.10 EFFECTIVENESS: Presuming the results of this research would call for revision of existing highway standards, and in the direction of providing greater sight distance for highway signs, then a reduction in driver indecision and confusion would be anticipated, resulting in a more efficient and safe flow of traffic. Measures of effectiveness would include traffic conflicts, traffic volume and, possibly, accident reduction that could be directly attributable to the revised signing practices.

<u>PROBLEM NO. 11</u>

11.1 TITLE: COMMUNICATIONS VALUE AND UNIFORMITY OF EMERGENCY VEHICLE SIGNAL LIGHTS

11.2 PROBLEM: Emergency vehicle signal lights vary widely in type, style, color and combination, even in the same locale. This lack of uniformity logically would be expected to affect adversely the effectiveness (communications value) of these lights. In addition, non-standardization precludes lower cost, higher reliability devices, and public funds may be spent inefficiently for ineffective equipment.

11.3 OBJECTIVES: Study the communications value of various systems of emergency vehicle lights, and determine whether uniformity would increase their effectiveness. If warranted by the results of this study, develop a set of standards for signal lights to maximize their effectiveness in communicating to the motorist (or pedestrian) the specific type of emergency message intended, e.g., "Stop", "Clear the road", "Road Obstruction Ahead", and so on. These stan-

dards should specify the relevant parameters for effective signals, including color, size, intensity, placement, flash rate, and so on, and they should be developed with the cooperation of relevant agencies (See "Implementation" section, below.).

11.4 KEY WORDS: Emergency Vehicle Lights, Emergency Vehicles, Flashing Lights

11.5 RELATED WORK: a. NHTSA contracts DOT-HS-601468 and DOT-HS-5-01121; b. SAE Lighting Committee - Current Evaluations of Signal Effectiveness; c. California Highway Patrol - Blue Light Study (1972); d. European studies - ECE TRANS/SC1/WP29/R.16/Rev.1, 7-28-78; e. Muhler & Berkout, Journal of Safety Research, 8(2), 1976; and f. FHWA contract DOT-FH-11-8846.

11.6 URGENCY/PRIORITY: This study is complex, and it may require two years, or more, to complete a set of standards. Once they are developed, implementation of the new standards may take five years. In view of this, it would be advisable to embark on this research as soon as possible.
URGENCY: MEDIUM

11.7 COST: $250,000

11.8 USER COMMUNITY: NHTSA, Law Enforcement Agencies, Fire & Rescue Units, National Committee on Uniform Traffic Laws and Ordinances, State DOT's (Maintenance), Hospitals, etc.

11.9 IMPLEMENTATION: Implementation of the findings would be promoted through the cooperation of organizations such as the American Association of Motor Vehicle Administrators, Uniform Vehicle Code Committee, associations of police and fire chiefs, NHTSA, and SAE. NHTSA does not have any Federal Motor Vehicle Safety Standards covering emergency vehicles, but FMVSS 108 does include school bus lamps; therefore, uniformity of signals on emergency vehicles must be accomplished by the cooperative efforts of the states. The cost of implementation will have to be considered in relation to potential benefits to the motoring public (as well as pedestrians, bicyclists, etc.).

11.10 EFFECTIVENESS: Once implementation of the new standards is accomplished, it should be possible to evaluate their impact on safety by before/after comparisons of both accidents and traffic conflicts involving emergency vehicles. Average speed maintained during an emergency run can also be studied as a possible measure of effectiveness. The magnitude of this safety impact cannot be estimated at the present time; however, in view of the substantial number of accidents involving emergency vehicles at the present time, there is obviously considerable room for improvement.

PROBLEM NO. 12

12.1 TITLE: PROCEDURES FOR EVALUATING HIGHWAY MEDIAN GLARE SCREEN SYSTEMS

12.2 PROBLEM: Discomfort and disability glare are night hazards that confront all drivers on high-density, narrow-median highways. In recent years, glare screen systems have been developed and installed on many miles of highway in an attempt to minimize or eliminate this problem. Unfortunately, however, there have not yet emerged clear warrants for the use of such glare screens due, primarily, to the lack of adequate procedures for evaluating their effectiveness.

Four distinct types of median-mounted glare screen systems are currently available, i.e., metal screen, fabric screen, plastic louvers and raised concrete (or other opaque) barriers. Previous attempts to evaluate the effectiveness of these systems have been limited in scope, and the performance of only one system (metal screen) has been extensively studied. Further, since most glare screen installations have come about as part of major roadway redesign and renovation, before-and-after accident statistics have not proven particularly revealing, as the effects of glare screening cannot be isolated from the effects of the other roadway modifications.

What is needed is a valid and reliable procedure for evaluating the effectiveness of available glare screen systems. In order for this to be accomplished, it will be desirable to standardize definitions for "discomfort glare" and "disability glare", and to arrive at a more reliable way to assess the degree to which glare-induced driver vision impairment is involved in accident causation.

12.3 OBJECTIVES: The objectives of the proposed study are as follows: a. Develop a rational, practical and consistent procedure for field-testing and evaluating glare screen systems. Such a procedure would include a controlled before-and-after study of sufficient size, geographical scope and duration that collection of statistically significant data on any cause-and-effect relationship between headlight glare and traffic accidents could be accomplished; b. Define methods for establishing the relationship between the height of the glare screen and roadway geometry, establishing permissible cut-off angles for given intensities of light; c. Assess the present knowledge concerning the relationship between headlight glare and accidents; d. Study the cost-effectiveness of glare screen use; and e. Determine which particular systems are best suited to particular demands of road usage and accessability, median barrier treatment, geography, geometry and climate.

12.4 KEY WORDS: Glare, Glare Screens, Headlight Glare, Night Vision, Discomfort Glare, Disability Glare

12.5 RELATED WORK: a. Published discussions of glare screening favor the concept; highway authorities from Sweden to California have evaluated test installations of various glare screen systems and reported their findings. AASHTO and the NCHRP are currently undertaking surveys and synthesis studies to consolidate the practical experience of glare screen users nationwide; and b. Responsibility for conducting a survey of glare screen use by state highway agencies was assigned to the ad hoc committee on median barriers by

the Design Section of AASHTO. Waverly Brittle of the Virginia DOT heads this committee. An independent synthesis study of glare screen usage has been performed for the NCHRP by Edward Ricker of Harrisburg, PA (FY '77 Program Topic No. 9-11, "Design and Cost Guidelines for Median Glare Screen").

12.6 URGENCY/PRIORITY: Clearly defined or not, the glare hazard is real, and increasing with the increasing volume of night vehicle travel on high-denisty, narrow-median highways. Any success in quantifying glare as a hazard, combined with formulation of warrants for the use of glare screens, will be of value to traffic and safety officials, and to the motoring public.
URGENCY: MEDIUM

12.7 COST: No cost estimate is possible at the present time, until the results of current activity (see Item 5) are known.

12.8 USER COMMUNITY: FHWA, NCHRP, AASHTO, State DOT's

12.9 IMPLEMENTATION: The results of the research will find implementation through the establishment of glare screen standards for use by highway agencies. These standards will be promulgated through AASHTO and the U.S. Department of Transportation.

12.10 EFFECTIVENESS: The results of the study should prove their effectiveness in the long run by a reduction in glare-induced night accidents on high-density, narrow-median highways. This, of course, is contingent on development of a reliable means for relating glare to accident causation.

PROBLEM NO. 13

13.1 TITLE: DRIVER SPEEDS UNDER REDUCED VISIBILITY

13.2 PROBLEM: Under various reduced visibility conditions, such as fog, rain, snow and dust, there presently are no data that clearly indicate what expected speed profiles might be for varying degrees of visibility. As a consequence, transportation and law enforcement agencies are not in a position to provide the motorist with accurate information and guidance (e.g., suggested speed) in advance of limited-visibility areas, nor can they make proper decisions with regard to closing of facilities to traffic due to restricted visibility conditions.

13.3 OBJECTIVES: Provide guidelines for the use of transportation and law enforcement agencies in advising motorists of restricted visibility areas, determining advisory speeds (based on such factors as wind velocity and pavement slipperiness, as well as visibility) and in deciding upon facility closure. This should be done by: a. Bringing together all the information that currently is available, including state-of-the-art technology for measuring visibility in rain, fog, snow and dust, as well as current technology for communicating visibility conditions, advisory speeds, etc., to motorists (e.g., via radio or changeable message signs); b. Integrating the above information with the experiences of highway officials in the various states (and foreign countries) in dealing with this problem to develop a preliminary set of guidelines; c. Enlisting the cooperation of transportation and law enforcement officials plus motorists to utilize the proposed guidelines in a formalized guidance and communications system for reporting accurate visibility distances and speeds when adverse driving conditions occur and, finally; d. Revising the preliminary guidelines as required based on the information gained in c., above.

13.4 KEY WORDS: Visibility, Fog, Rain, Snow, Dust, Driver Guidance

13.5 RELATED WORK: State-of-the-art in this area was reported in August 1977 at the TRB Visibility Committee's Symposium on Driver Visibility Under Varying Adverse Weather Conditions. The proceedings of this Symposium appear in Transportation Research Circular, No. 193, 1978. Information on speed profiles was contained in both NCHRP Reports 95 and 171. A recent paper by Shepard (Virginia Highway and Transportation Research Council) used before-after comparisons of speed data to evaluate pavement insert lighting for use in fog. A major study by Wagner and Hofstetter (Oregon DOT) has been conducted for FHWA on "Speed Advisory Information for Reduced Visibility Conditions".

13.6 URGENCY/PRIORITY: This, for the most part, is an ongoing seasonal and geographical problem, and one against which few significant inroads have been made. A small but significant portion of the accident problem can be traced to excessive speed in poor visibility conditions, and this situation can be expected to worsen as the proportion of older drivers on our highways increases, with their reduced visual capabilities. Hence, developing appropriate guidelines and an effective communication system should minimize the occurrence of such accidents, and because the proposed study would be quite lengthy (involving a longitudinal study of accident experience), it would be advisable to begin as soon as possible.
URGENCY: MEDIUM

13.7 COST: $100,000 (excluding labor and hardware costs for the sensing and communications systems that might be installed or modified by the participating governmental agencies).

13.8 USER COMMUNITY: State DOT's, Law Enforcement agencies, AASHTO, FHWA, FAA

13.9 IMPLEMENTATION: Implementation of the study results would be carried out by the responsible highway and law enforcement officials for those states (or countries) for which these reduced visibility situations are a chronic problem. Implementation will take the form of improved driver guidance through the affected areas, including closure of the facility, if warranted. Models for this implementation - on a pilot basis - are currently available in several states and foreign countries.

13.10 EFFECTIVENESS: In certain geographical areas, adverse driving conditions frequently prevail. During such times, pilot efforts have shown that specialized information systems and controls on driving can reduce the probability of unsafe driver behavior. This indicates that the motoring public as a whole will respond favorably, if given convincing evidence of the reliability and effectiveness of such systems, resulting in a measurable reduction in unsafe driver behavior in reduced visibility conditions with a consequent reduction in accidents (especially multiple-vehicle).

PROBLEM NO. 14

14.1 TITLE: IMPROVING DRIVER UNDERSTANDING OF SYMBOL SIGNS

14.2 PROBLEM: Previous research on highway signs comprised of symbols, rather than words, has shown that such signs generally provide good legibility characteristics. However, various questionnaires, studies and comments from adult driver groups have revealed that many drivers are confused about the meanings of some of the new symbol signs.

14.3 OBJECTIVES: The objectives of the proposed research are to: a. Investigate by questionnaire and other methods confusions in meaning generated in some drivers by certain symbol signs; b. Develop techniques for making these "problem" signs as self-explanatory as possible; and c. Conduct a follow-up evaluation to show whether or not understanding of these symbol signs has been improved through introduction of these techniques.

14.4 KEY WORDS: Highway Signing, Symbol Signs, Driver Information

14.5 RELATED WORK: a. The Proceedings of the International Conference on Highway Sign Symbology (Washington, D.C., June 1972) contains a number of relevant reports, including one by Forbes, Gervais & Allen which indicates a method of obtaining and evaluating a self-explanatory type of symbol; and b. A number of studies have been carried out on the perception of symbolic traffic signs (e.g., by Robert Dewar of the University of Calgary and Ellis King of the University of North Carolina at Charlotte). Other studies may be underway at present that bear on this topic.

14.6 URGENCY/PRIORITY: Since new symbol signs are being introduced on our highways with increasing frequency, it is increasingly important that "problem" signs be identified and counter-measures for driver confusion developed as soon as possible.
URGENCY: LOW

14.7 COST: The cost of such work is estimated to range from $50,000 to $75,000, depending on the organization, the research method used, and the extent to which the problem is attacked. It might be desirable to start with a limited number of symbols and test out a procedure before attempting to apply it "across the board", which would involve greater expense.

14.8 USER COMMUNITY: FHWA, NCHRP, ITE, State DOT's, AARP, Driver Educators

14.9 IMPLEMENTATION: The findings of the research could be implemented through both driver licensing and driver education channels. In addition, the use of supplementary message plates below the symbol sign (already experimented with) during the "training period" might be effective.

14.10 EFFECTIVENESS: It is impossible to predict the societal impact of this research. Any reduction in driver confusion generated by traffic control devices inevitably reduces traffic conflicts and improves traffic flow. These advantages would be demonstrable by traffic conflict analysis; accident reduction would probably be more difficult to show.

PROBLEM NO.15

15.1 TITLE: COMPARATIVE COST-EFFECTIVENESS OF MERCURY AND SODIUM STREET LIGHTING

15.2 PROBLEM: Increasing concern with the cost and availability of energy has brought into sharp focus the relative energy-efficiency of various light sources for street illumination. While mercury vapor has been most favored in recent years, high- and low-pressure sodium are increasingly being used to replace mercury because of their higher efficiency; that is, sodium provides more lumens per watt than mercury. Despite this, however, it is not clear whether this higher efficiency is an unqualified benefit, or whether it comes at the expense of reduced driver performance. For example, for a given lumen level how do mercury and sodium light sources compare on factors directly related to accident avoidance (e.g., psychological or physiological variables such as annoyance and fatigue, as well as visibility distance, contrast sensitivity, discomfort glare and the like)?

15.3 OBJECTIVES: a. Conduct onsite evaluations of the two alternative systems using comparable existing installations of both mercury and sodium light sources for equivalent streets. Such evaluations should be conducted by qualified traffic and law enforcement officials to provide definitive and standardized data on the illumination, visibility and driver performance variables of interest; b. Compare traffic incidents occurring in the comparable street and lighting systems to identify the frequency and characteristics of incidents (traffic conflicts or accidents) possibly related to the level and type of illumination; c. Measure visibility distances and other objective or subjective variables influencing driver performance under the two lighting systems; and d. Compare traffic incidents and driver performance variables under different levels of mercury and sodium lighting.

15.4 KEY WORDS: Highway Lighting, Energy Conservation, Visibility, Illumination

15.5 RELATED WORK: Work by the Franklin Institute provides a method for collecting some of the data proposed for collection in this study.

15.6 URGENCY/PRIORITY: As the energy crisis deepens, there will be increasing pressure

to switch to more energy-efficient light sources. It is important that any decision to effect this transition be made by officials having full knowledge of all the costs (social as well as monetary), as well as all of the benefits. Consequently, prompt conduct of this study would appear to be not only timely, but essential.
URGENCY: MEDIUM

15.7 COST: $100,000, assuming the use of existing lighting systems.

15.8 USER COMMUNITY: State and local DOT's, AASHTO, FHWA, IES

15.9 IMPLEMENTATION: The results of this study will be implemented primarily by municipal street lighting departments. As existing street lighting systems age, they can be converted to more effective illumination systems using the results of this study together with consideration of both installation and operating costs of the new system. To the extent that a reduction in both accident likelihood and energy costs is possible under a new lighting system, the cost of installing that system will be justified.

15.10 EFFECTIVENESS: The effectiveness of this study will be reflected in street lighting cost savings that can be effected with no change or an improvement in the safety provided to the motorist. Energy conservation will be the major social benefit; as a fringe benefit, the study should lead to more definitive standards for street lighting.

PROBLEM NO. 16

16.1 TITLE: LOW COST REDUCED VISIBILITY SENSORS

16.2 PROBLEM: The availability and accuracy of data on the location, duration and intensity of reduced visibility conditions are limited. This inhibits the design and implementation of systems for the aid of motorists during reduced visibility. The primary reason for failure to obtain sufficient and accurate data is the lack of inexpensive and reliable automatic devices for sensing visibility level. This makes it necessary to rely on subjective observation, for the most part, to assess the degree of reduced visibility.

Most reduced visibility sensor designs to date reflect the aviation-oriented origins of the instruments (used at airports), rather than traffic-related needs. Gradually, this picture is changing. Cheaper, smaller and more flexible reduced visibility detectors have recently become available, partly as a result of the introduction of solid-state electronics techniques. However, even these instruments are far from being inexpensive enough to consider using for purposes of identifying reduced visibility problem areas.

16.3 OBJECTIVES: Conduct research to accelerate the development of inexpensive, flexible instruments for the detection of fog, snow, dust and other vision-obscuring agents.

16.4 KEY WORDS: Visibility, Fog Detection, Reduced Visibility Detection Instruments, Vision Obscuring Agents

16.5 RELATED WORK: State-of-the-art in reduced visibility detection was discussed in several papers presented in August 1977 at the TRB Visibility Committee's Symposium on Driver Visibility Under Varying Adverse Weather Conditions, the proceedings of which appear in Transportation Research Circular, No. 193, 1978. At the present time, there is no concerted effort being made to develop such instrumentation (although some manufacturers, perhaps sensing an expanding market, have made some moves in this direction).

16.6 URGENCY/PRIORITY: Development of such equipment is essential before any widespread and effective attempt can be made to develop a motorist guidance and communications system for use in areas prone to restricted visibility conditions.
URGENCY: MEDIUM

16.7 COST: $350,000-500,000 to develop a prototype instrument.

16.8 USER COMMUNITY: State DOT's, AASHTO, FHWA, FAA

16.9 IMPLEMENTATION: The results of this research would be utilized by equipment manufacturers (initially) and State Departments of Transportation (ultimately) in developing motorist guidance and communications systems for reduced visibility situations.

16.10 EFFECTIVENESS: The development of such instrumentation would have double benefits. First, it would simplify, shorten and improve the system design process. Second, it would make implementation less costly and more effective. The societal benefits of an effective guidance and communications system for motorists would, of course, be a reduction in reduced-visibility-related accidents.

PROBLEM NO. 17

17.1 TITLE: VISION BLOCKAGE BY LARGE VEHICLES

17.2 PROBLEM: Large vehicles ahead of passenger cars can block the view of such things as other vehicles, pedestrians, road hazards, highway geometry and traffic control devices. Such blockage of the driver's vision can result in missed turns, improper lane choice, simple delay or worse, insufficient time to maneuver or stop for hazards. The increasing numbers of trucks and recreational vehicles on our highways, together with emphasis on fuel-efficient smaller cars, may further aggravate the problem by creating a greater and more frequent disparity in vehicle size.

17.3 OBJECTIVE: Research has identified vision blockage by trucks and vans and has provided a means of determining the time of blockage relative to size of truck and following vehicle, headway and speed. What is needed is an inventory of current vehicle sizes and vehicle mix to determine the scope of the problem, and suggested and tested solutions.

The research should sample the vehicle

mix and re-evaluate vehicle sizes in light of the current emphasis on economy vehicles, increasing numbers of recreational vehicles, possible change in driver eye height, and so on. Vehicle populations, headways and speeds for a selected strata of highways should be considered. A percentage of time of vision impairment for passenger vehicles for both day and night should be developed. Following the identification of the scope of the problem, certain solutions, such as redundancy of traffic control devices, added lanes and greater effective sight distance, should be explored for effectiveness.

17.4 KEY WORDS: Vision Impairment, Traffic Mix, Traffic Control Devices

17.5 RELATED WORK: King, G.F. & Lunenfeld, H., Development of Information Requirements and Transmission Techniques for Highway Users, NCHRP Report 123, 1971.

17.6 URGENCY/PRIORITY: The change in vehicle mix with increasing usage of small cars and recreational vehicles is increasing the problem, as is a continual increase in traffic volume and density.
URGENCY: LOW

17.7 COST: $35,000 to $70,000

17.8 USER COMMUNITY: NHTSA, FHWA, ITE

17.9 IMPLEMENTATION: Implementation should identify the most effective supplementary vision aids and rank order the most cost-effective approaches to improve the percentage of unblocked vision time. Quantification for both day and night and by road type should be attempted.

17.10 EFFECTIVENESS: Increased time for maneuvering or avoiding last-minute lane changing, reduction of erratic maneuvers and improvement of decision time should reduce accidents, traffic interruptions and motorist delay. Reduction of time lost and accidents eliminated may easily justify the necessary improvements.