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1984 RESEARCH PROBLEM STATEMENTS—OPERATIONAL EFFECTS OF GEOMETRICS

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OPERATION AND MAINTENANCE OF TRANSPORTATION FACILITIES

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INTRODUCTION

Committee A3A08, Operational Effects of Geometrics, regards identifying research needs and communicating them to the transportation research community as one of its major functions. The committee has regularly evaluated and published research problem statements in the past; publication of this circular is a continuation of that activity.

EVALUATION METHOD

The committee received nine research problem statements for evaluation during 1983. These research problem statements were circulated to the committee membership, who were asked to evaluate each of them for perceived importance, for allocation of a hypothetical research budget, and for probability of success. The members were also asked to provide a brief rationale for each evaluation. Twenty-three committee members responded to this request. The results were summarized in such a manner that the anonymity of the respondents was maintained, and the summary was distributed to the entire committee.

EVALUATION RESULTS

The evaluation results showed a great diversity among the committee members in their assessment of the individual problem statements. On a scale from 1 to 9, every problem statement received the highest possible ranking (1) from at least one evaluator and a low ranking (8 or 9) from at least one evaluator. The average probability of success anticipated from the problem statements ranged from 55 percent to 80 percent.

The evaluation results were discussed at the committee's meeting during the TRB Annual Meeting in January 1984. A decision was reached to publish all nine problem statements that had been evaluated. The author of each problem statement was then asked to make appropriate revisions, taking into consideration the reviewer's comments on the problem statements. The nine research problem statements considered by the committee are presented below.

RESEARCH PROBLEM STATEMENTS

Problem No. 1

1. TITLE: Warrants for Left-Turn Lanes.

2. STATEMENT OF PROBLEM: A number of technical references (1) extol the virtues of channelized left-turn lanes at intersections because they favorably affect traffic flow, capacity and safety. Although the installation of some left-turn lanes is obviously beneficial, the engineer is often faced with situations where the relative merits of such an installation are less clear. In addition, there are problems in establishing the priorities for installing these lanes at various locations. A set of quantifiable warrants for left-turn lane installation and prioritization would facilitate the decision-making process.

3. OBJECTIVE: The objective of this project is to establish a set of warrants for the installation of left-turn lanes at signalized and unsignalized intersections on existing highways in both urban and rural areas. It is anticipated that the warrants would be similar in structure to those recommended for highway lighting in NCHRP Report 152.

4. KEY WORDS: Intersections; Left-turn Lanes; Warrants.

5. RELATED WORK: In NCHRP Project 3-30, Jack Leisch Associates are studying intersection channelization, with the objective of updating HRB Special Report 74. This research, which is concentrating on the design aspects of channelization, has already surveyed a broad cross-section of state and local agencies and found few that utilized warrants for the installation or prioritization of left-turn lanes. In the 1960's, California (2) used a before and after study approach to evaluate 53 left-turn channelization improvements at unsignalized intersections and to develop warrants. More recently, Kentucky (3) has proposed warrants based on accident experience, volume and traffic conflicts. A recent project in Texas (4) examined this problem at intersections with actuated controllers. Two studies (5, 6) used simulation models to develop left-turn lane warrants for unsignalized intersections. These previous efforts, while certainly worthwhile, suffer from small sample sizes, limited geographical coverage and constraints on the characteristics of the study sites. Therefore, the warrants developed by these studies are not presented in standard traffic engineering references.

6. URGENCY/PRIORITY: While there is no reason to believe that the problem will worsen if this project is not undertaken, there is some obvious merit in having a rational, justifiable procedure for the identification and prioritization of sites for left-turn lane installation. Based on data (1) which suggest that left-turn lanes are cost-effective countermeasures, the development of a warranting scheme encouraging their efficient deployment should receive at least moderate priority.

7. COST: Since the project will rely principally on secondary data, a budget of $125,000 and an 18 month performance period should be adequate.

8. USER COMMUNITY: The principal users of the research findings will be practicing highway and traffic engineers.

9. IMPLEMENTATION: Because of the diversity of the user community, effective implementation of the study results requires wide dissemination. It would be appropriate to incorporate the study findings into existing highway standards. In addition to publication in the standard technical journals, the results could be incorporated in short courses and academic programs. Feedback from practitioners who have utilized the warrants would obviously be beneficial.

10. EFFECTIVENESS: The application of the study results will lead to a more effective expenditure of limited funds for highway improvement. It will establish a basis for project justification and will reduce the likelihood of installing left-turn lanes at locations where they are not really needed.

REFERENCES

1. Synthesis of Safety Research Related to Traffic Control and Roadway Elements, FHWA-TS-82-232, Chapter 5.

2. "Evaluation of Minor Improvements, Part 5: Left Turn Channelization," California Dept. of Public Works, 1968.

3. "Warrants for Left-Turn Lanes," Agent, K.R., Transportation Quarterly, January 1983.

4. "Warrants for Left-Turn Lanes and Signal Phases," Machemehl, R.B., University of Texas at Austin, 1982.

5. "Volume Warrants for Left-Turn Lanes at Unsignalized Grade Intersections," Harmelink, M.D., Ontario Dept. of Highways, 1968.

6. "Design of Left-Turn Lanes for Priority Intersections," Lee, J. and Mulinazzi, T., TRB Record 757, 1980.

Problem No. 2

1. TITLE: Warrants and Guidelines for Continuous Exclusive Right-Turn Lanes.

2. STATEMENT OF PROBLEM: Roadways built at the time of no or rare land use activities often develop into commercial strips. Right-turn traffic moving into and out of these commercial developments and unsignalized intersections creates a serious operational and safety obstacle to approaching traffic.

3. OBJECTIVE: The study objectives are: (1) to identify operational and safety problems at sites with/without continuous exclusive right-turn lane with varying width and length, (2) to evaluate the benefit/cost of such lane, and (3) to develop warrants and design guidelines for continuous exclusive right-turn lanes under various roadway traffic, geometric, and land use characteristics.

4. KEY WORDS: Intersections; Right-turn Lanes; Warrants.

5. RELATED WORK: Design guidelines for exclusive right-turn lanes at intersections to expedite and store right-turning traffic are available (1,2). However, no warrants and design guidelines are available for the continuous exclusive right-turn lanes between signalized intersections to accommodate right-turn traffic into and out of frequent commercial driveways and unsignalized intersections.

6. URGENCY/PRIORITY: Increased concern over right-turn on red and angle/rear-end collisions by right-turn traffic makes the study high priority.

7. COST: $180,000 over an 18-month period.

8. USER COMMUNITY: Agencies and personnel responsible for highway design and operational and safety improvements.

9. IMPLEMENTATION: The results of this research will be immediately usable by governmental agencies in managing pavement width and improving traffic operations and safety.

10. EFFECTIVENESS: The study will be most effective in managing current and future pavement width under various right-of-way and roadway traffic, geometric and land use characteristics.

REFERENCES

1. A Policy on Design of Urban Highways and Arterial Streets, AASHTO, 1973.

2. Alexander, M.H., Development of an Economic Warrant for the Construction of Right-Turn Deceleration Lanes, Joint Highway Research Project No. 12, Purdue University, May 1970.

Problem No. 3

1. TITLE: Relationship of Stopping Sight Distance to Clearance Times at Stop Sign Controlled Intersections.

2. STATEMENT OF PROBLEM: An increased accident rate is occurring at Stop sign controlled multilane facilities. This may be due to underpowered small vehicles or longer truck combinations crossing multilane facilities. Design stopping sight distance for vehicles on the principal roadway, including diamond interchanges, may not

be adequate because of these varying types of vehicles now making up much of the traffic stream.

3. OBJECTIVE: A study would indicate the optimum sight distance or geometric changes required to provide crossing traffic with sufficient time to clear the intersection before approaching vehicle arrives.

4. KEY WORDS: Clearance Times; Intersections; Large Trucks; Multi-lane Facilities; Small Cars; Stopping Sight Distance.

5. RELATED WORK: Recent research has been done in the area of driver-reaction time (1), acceleration and deceleration times of vehicles (2) and advance warning signs for intersections (3).

6. URGENCY/PRIORITY: The Surface Transportation Act of 1982 provided for longer vehicles. With an increased volume of such truck traffic and the increased volume of smaller vehicles, both of which may have slower acceleration rates, the problem is rapidly developing. There are no criteria at this time to aid the designer or operations engineer in establishing adequate stopping sight distances or speed zones. Guidance should be given as soon as possible.

7. COST: $75,000

8. USER COMMUNITY: All highway and street agencies responsible for design or operations of a roadway system.

9. IMPLEMENTATION : New designs can incorporate the information immediately. Operations Engineers can revise speed limits, etc. immediately. Reconstruction will take longer.

10. EFFECTIVENESS: Cost-effective analyses can be made as soon as adequate "after" data is available for comparison with "before" data. Trends may be noted earlier.

REFERENCES

1. Hooper, K.G. and McGee, H.W., "Are Revisions to Current Specification Values in Order?," TRB Record 904, 1983, pp. 21-30.

2. Olson, P.L., "Parameters Affecting Stopping Sight Distance and Vehicle Acceleration/Deceleration Characteristics," NCHRP Project 15-8, Highway Safety Research Institute, University of Michigan.

3. Lyle, R.W., "Evaluation of Signs for Hazardous Rural Intersections," TRB Record 782, 1980, pp. 22-30.

Problem No. 4

1. TITLE: Coordinating Design, Operating, and Posted Speeds.

2. STATEMENT OF PROBLEM: There is often a discrepancy between the design speed selected and used by the designer of a highway improvement and the actual operating (running) speeds or the speed limit eventually posted. Such discrepancies may violate driver expectancies and result in accidents as well as create liability potential.

3. OBJECTIVE: The study objectives would be to identify the causes of differences in the design, operating, and posted speeds and make recommendations regarding the degree to which differences may be acceptable and/or the manner in which they may be made compatible.

4. KEY WORDS: Design Speed; Driver Expectancy; Geometric Design; Operating Speed; Posted Speed.

5. RELATED WORK:

   a. Highway Geometric Design Consistency Related to Driver Expectancy; FHWA-RD-81-036, April 1981.

   b. A User's Guide to Positive Guidance ; FHWA, January 1977.

   c. Driver Expectancy: Definition for Design; Texas Transportation Institute Research Report 606-5, 1972.

   d. Speeds and Service on Multilane Upgrades; St. John & Glauz, Midwest Research Institute.

6. URGENCY/PRIORITY: The increase in 3R type work where reduced standards (and therefore lower design speeds) are sometimes utilized tends to result in more situations where the stated discrepancy exists. Also, the existence of clear zone requirements for improvements on high speed highways makes it attractive, in terms of minimizing project costs, to use a lower design speed than can reasonably be expected as an operating speed.

7. COST: $100,000

8. USER COMMUNITY: Agencies and personnel responsible for highway design and operation.

9. IMPLEMENTATION: The results of this research will be useful in the form of guidelines to aid design and operations personnel in jointly determining at the predesign stage the proper design and eventual posted speeds.

10. EFFECTIVENESS: Reduction in accidents and liability caused by discrepancies between design and posted speeds would be the measure of effectiveness of this research.

Problem No. 5

1. TITLE: Increasing Roadway Geometric Delineation When Reducing Highway Illumination

2. STATEMENT OF PROBLEM: Highway illumination has been recognized as a primary device to provide the motorist an increased nighttime awareness of complex geometric design elements of the roadway. Over the past few years, however, due to concerns of energy conservation, increases in utility rates and reduced availability of funds, many highway agencies have opted to reduce their highway illumination programs drastically. This reduction of illumination has alleviated the problems associated with the expressed concerns, however, the overall change in travel characteristics (speed, capacity, accident experiences, etc.) and alternate roadway delineation methods (signs, pavement marking, delineators, partial highway illumination and various combinations) have not been reviewed extensively.

3. OBJECTIVE: The objective of this research is to obtain a synopsis of highway agency practices on improving roadway geometric delineation while reducing, or eliminating, highway illumination in areas of complex geometric design. Among the specific activities for this project are (1) development of a questionnaire relating to the extent of reduced highway illumination, alternate roadway delineation methods used and observed or researched overall change in travel characteristics; (2) dissemination of the questionnaire to appropriate city and state highway agencies; and (3) synopsize questionnaire responses and disseminate to respondees.

4. KEY WORDS: Energy Conservation; Geometric Delineation; Partial Highway Illumination; Reduced Illumination, Safety.

5. RELATED WORK:

a. Yates, J.G. and Beatty, R.L., "Relationship Between Lighting and Accident Experience," HRB Record 312, pp. 85-92.

b. Mullowney, W.L., The Effect of Raised Pavement Markers on Traffic Performance, Report No. FHWA/NJ-83/001.

c. Ketvirtis, A., "Programmable Roadway Lighting System as An Integral Traffic Management Component (Abridgment)," TRB Record 855, pp. 24-26.

d. Finch, D.M., Roadway Visibility Using Minimum Energy," TRB Record 855, pp. 7-16.

e. Olsen, R.A., Quantifying the Night Driver's Visual Environment, Report No. FHWA-RD-80-096.

f. Lundy, R.A., "The Effect of Ramp Type and Geometry on Accidents," HRB Record 163, pp. 80-119.

6. URGENCY/PRIORITY: This project has a high priority because many highway agencies are faced with drastically reduced budgets while at the same time being mandated to provide the motorist with increased nighttime delineation of complex geometric design elements of the roadway.

7. COST: Relative based upon extent of inquiry. Estimated to be $50,000.

8. USER COMMUNITY: AASHTO, FHWA and NHTSA

9. IMPLEMENTATION: Findings of this research can provide the practicing operational traffic engineer with an array of differing schemes to attack the problem of delineating the complex geometric elements of the roadway.

10. EFFECTIVENESS: The primary benefit of this research is to provide a less costly means of geometric delineation which will effectively alert the motorist to the geometric conditions.

Problem No. 6

1. TITLE: Operational or Geometric Countermeasures for Reducing Run-Off-Road Accidents on Rural Horizontal Curves

2. STATEMENT OF PROBLEM: Several recent studies have indicated that a predominance of single vehicle run-off-the-road accidents along rural highways occur at horizontal curve locations. The accident potential at horizontal curves arises from the same conditions that occur along a roadway but are more accentuated by the effect of the horizontal curvature on the driver-vehicle interactions. These include geometric inconsistencies, driver expectancy, road surface conditions and the impaired driver.

3. OBJECTIVE: To develop guidelines for selecting roadway improvements at rural highway horizontal curve problem locations. Guidelines could be both operational and geometric. The research would consist of two phases:

PHASE 1 - Study of accident records and existing locations to identify potential countermeasures.

PHASE 2 - Study of (any) existing countermeasure locations and/or field evaluation of potential countermeasures for comparative analysis.

4. KEY WORDS: Driver Expectancy; Geometric Inconsistencies; Horizontal Curvature; Operational Measures; Run-Off-Road Accidents.

5. RELATED WORK: Previous studies have shown driver concern with horizontal curvature and indications of higher accident occurrences. With the complex driver-vehicle-roadway interactions involved and the number of geometric combinations, there have been no definitive results obtained that isolate the accident characteristics of potential countermeasures for easy identification. Several studies have suggested possible countermeasures but no categorical approaches have been developed.

Brinkman and Perchonok described the influence of highway factors and roadside objects on single vehicle accidents (1). Box (2) provided some general countermeasure suggestions. The effectiveness of clear recovery zones (3), the effect of lane-shoulder widths (4) and shoulder rumble strips (5) and other modifications (6) including post mounted delineators (7,8,9,10) on accident rates have been studied.

6. URGENCY/PRIORITY: With the existence of rural highways already geometrically and functionally deficient and the emphasis on the development of 3-R design procedures, the need to identify effective operational or geometric countermeasures that would be cost and safety effective for inclusion as guidelines for roadway upgrading would be addressed in a timely manner.

7. COST: Phase 1 - $90,000; Phase 2 - $120,000; Duration - 30 Months.

8. USER COMMUNITY: FHWA, NHTSA

9. IMPLEMENTATION: NCHRP Synthesis or Report, FHWA Training Course.

10. EFFECTIVENESS: The relevant measures of effectiveness of this research activity would be accident rate reductions or severity rate reductions. A secondary measure of effectiveness could be the amount of socioeconomic costs avoided by the use of the guidelines (countermeasures).

REFERENCES

1. Brinkman, Public Roads, V43, N1, 1979, pp. 8-14.

2. Box, Traffic Engineering, V46, N8, 1976, pp. 38-43.

3. Graham, NCHRP Report 247, 1982, 78 p.

4. Zegeer, TRB Record 806, 1981, pp. 33-43.

5. O'Hanlon, Caltrans, HPR, 1974, 115 p.

6. Cooper, AASHO Proc., 1971, 26 p.

7. Butzlatt, Mont Dept. Highways, 1978.

8. Reid, Kansas DOT, 1978.

9. Helman, WV Dept. Highways, 1977.

10. Morley, Illinois DOT, 1978.

Problem No. 7

1. TITLE: Analysis of Rural Highway Alignments Prone to Increased Accident Rates.

2. STATEMENT OF PROBLEM: Current geometric design for highways is based on different standards and policies. There is a certain amount of variance among these standards, which leads to inconsistency of design. Furthermore, some confusion emanates from the trade-off between minimum and desirable design. By adopting large, above-minimum design criteria, designers of rural roads would like to ensure high-speed, convenient and safe driving; on the other hand, economic and topographic constraints usually tend to mitigate these criteria. The necessity thus exists to establish a tool for evaluating a road in terms of its overall geometric features as related to its operational characteristics. A first phase toward this end is an analysis of highway alignments that are prone to increased accident rates.

3. OBJECTIVE: The general goals of this study are to develop a tool for improving the evaluation process of alternative highway schemes as well as to improve and enhance the overall design. The immediate objective is, by analyzing the relationship between the overall geometric features of rural two-lane highway sections and their accident rates, to identify those alignments which are prone to increased accident rates because they were not designed to fit either the nature of the terrain or the related operational characteristics of these sections.

4. KEY WORDS: Accidents; Consistency; Evaluation; Geometric Design; Rural Highways.

5. RELATED WORK: The state of the art of alternative roadway selection and geometric design evaluation has not been explored sufficiently and needs to be further advanced, particularly by using safety measures of effectiveness. Currently, evaluation of highway geometry for safety is based on discrete geometric measures, such as curvature or width, and is not sensitive to overall measures. Some recent studies are listed at the end of this problem statement.

6. URGENCY/PRIORITY: This research has a high priority since the results can assist decision-makers in allocating scarce resources among alternative rural highway upgrading projects.

7. COST: $180,000

8. USER COMMUNITY: AASHTO, FHWA, State Highway Agencies

9. IMPLEMENTATION: Results of this research may lead to improved overall design, provide a better evaluation framework, and serve as a basis for upgrading existing two-lane rural highways.

10. EFFECTIVENESS: Rural accident rates may be decreased if a tool for the proper, balanced design of new roads and the improvement of existing roads is provided.

REFERENCES

1. Perchonok, K., et al., Hazardous Effects of Highway Features and Roadside Objects, FHWA-RD-18-202, 1978.

2. Mullin, E.F., "Road Safety and Its Influence on Road Design," Report of Safety Symposium, Sydney, HS-013-379, 1972.

3. Dart, O.K., et al., "Relationship of Rural Highway Geometry to Accident Rates in Louisiana," HRB Record 312, 1970.

4. Polus, A., "Relationship of Overall Geometric Characteristics to the Safety Level of Rural Highways," Traffic Quarterly, Vol. 34, No. 4, 1980.

5. Kurimoto, N. "Analysis of Traffic Accidents - The Geometric Design of Highways and Traffic Conditions," Proceedings, International Road Federation, 1977.

Problem No. 8

1. TITLE: The Optimum Selection of Access Locations Along Major Arterials.

2. STATEMENT OF PROBLEM: In order to avoid closely spaced access locations along collectors or major arterials, the tendency is to attempt to align proposed accesses opposite an existing or planned access, this creating a 4-leg intersection. When considering a new access near an existing public "T" intersection, the tendency is to allow either a private access or a minor public access to be placed opposite the stem of the "T" and, thus again, develop a 4-leg intersection. It is generally accepted that, 4-leg intersections, with or without signalization, are more difficult to negotiate than are adequately spaced "T" intersections, especially when there is little demand for major street crossing movements. The end result of this practice is often the need for intersection signalization which, if not anticipated, can be poorly spaced with adjacent signalized intersections, or can result in undesirable delays and/or a proliferation of accidents at intersections where it is not desirable to signalize.

3. OBJECTIVE: To develop design criteria that would assist the practitioner in deciding whether to create a new "T" intersection or a 4-leg one. Criteria developed could be based on specific movement traffic volumes, major arterial signalization spacing, and "T" intersection offset distances. The following variables should be studied in order to measure the relative impacts of creating a new "T" intersection or expanding an existing "T" intersection into a 4-leg one:
   a. relative potential delay to accessing vehicles
   b. relative accident potential to entering motorists
   c. relative accident potential to existing arterial motorists (especially those involving left turns)
   d. relative adverse travel time and distance to major street crossing motorists when new "T" intersection is created
   e. relative potential need for traffic signal control and its impact on arterial flow characteristics
   f. relative operational impacts between a "T" and a 4-leg intersection if signalization is not a viable alternative

4. KEY WORDS: Access Points; Accidents; Delay; Intersections; Major Arterials; Signalization.

5. RELATED WORK:
   a. Brindle, R. E., Town Planning and Road Safety in Small Urban Areas, Australian Road Research Board, 1982.

   b. Cooper, D.F., Storr, P.A. and Wennell, J., "Traffic Studies at T-Junctions -- The Effect of Speed on Gap Acceptance and Conflict Rate," Traffic Engineering and Control, Vol. 18, No. 3, March 1977, pp. 110-112.

   c. Del Mistro, R. F., Safety of Urban Intersections, ITE, Washington, D.C., 1980.

   d. Dunne, M.C. and Buckley, D.J., "Delays and Capacities at Unsignalized Intersections," Australian Road Research Board Conference Proceedings, Vol. 6, Pt. 3, pp. 345-358, 1972

   e. Harasyn, H., Analysis of Road User Economy Before and After Traffic Signal Installation at a T-Intersection, Report Eep-8, Dept. of Civil Engineering, Stanford University, March 1964.

   f. Klar, H.J., "Designing Safe and Efficient High Volume Driveways and Intersections," Traffic Engineering, Vol. 43, No. 4, January 1973, pp. 32-37.

   g. Schafer, B.F., "Comparison of Alternative Traffic Control Strategies at a T-Intersection," Transportation Research Board Special Report 194, 1981.

6. URGENCY/PRIORITY: From a planning standpoint, this research can result in significant payback. As access control strip maps are being developed along major arterials traversing primarily undeveloped property, due consideration should be given to "T" intersections for private access, as well as any public access other than

planned intersections with continuous public streets.

7. COST: $50,000.

8. USER COMMUNITY: AASHTO, FHWA, ITE

9. IMPLEMENTATION: Distribution could be handled through abstracts published in professional magazines and publications, as well as reflected by federal policy and/or standard modifications.

10. EFFECTIVENESS: The minimizing of motorist delay and frustration, when attempting to access collector or major arterials, will be positively reflected through motorists' attitudes expressed by the affected business community, as well as individual motorists.

Problem No. 9

1. TITLE: Raised Medians - A Poor Substitute for Good Access Control

2. STATEMENT OF PROBLEM: Raised medians, once the "state of the art," continue to be used in new and reconstruction projects. One rational explanation for the continued use of raised medians is that they assist in overcoming problems resulting from poor access control. But, in doing so, they create operational problems that could equal or exceed that which they are preventing. There is a need to assess the effectiveness of raised medians versus flush medians.

3. OBJECTIVE: The following variables should be studied in order to measure the impact that raised medians have on traffic operations as compared with flush medians:
   a. accidents
   b. ability for the roadway and its "support devices" to communicate effectively to the motorist the existence of, and how to use, the median
   c. trip length - time (percent change)
   d. illegal maneuvers
   e. snow plowing and street cleaning
   f. median maintenance
   g. access delay/motorist frustration
   h. initial cost

4. KEY WORDS: Access Control; Accidents; Flush Medians; Raised Medians.

5. RELATED WORK:

   a. Garner, G.R., Median Design and Accident Histories, Kentucky Department of Highways, Lexington, KY, April 1970.

   b. Harwood, D.W. and Glennon, J.C., "Selection of Median Treatments for Existing Arterial Highways," TRB Record 681, 1978, pp. 70-77.

6. URGENCY/PRIORITY: Median type affects the total design of a roadway section and, as such, can be a high-cost item. Unnecessary right-of-way may be purchased and unreasonable restrictions placed on the private property owner which, along with the operational characteristics being studied, create a high priority for this project.

7. COST: $70,000

8. USER COMMUNITY: AASHTO, FHWA, ITE

9. IMPLEMENTATION: Distribution could be best handled through articles within professional magazines and other publications.

10. EFFECTIVENESS: Research results will be useful in enhancing safety and operations relative to highway medians while maximizing benefits from available funds.