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CIRCULAR

Research Problem Statements on Traffic Control Devices

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FOREWORD

In recent years, increasing tort liability and rapidly advancing technology have joined with economic advantage as the principal motivating factors influencing research and development of traffic control devices (TCD's). Understandably, those considerations emphasize exploration of fundamental concepts and testing of new theories, techniques and products. Relatively little effort is devoted to research and evaluation of existing devices and prevailing application standards.

In order to increase the practical use of research findings in the standards adoption and revision process, the Traffic Control Devices Committee relied heavily on input from the user-community--practicing traffic engineers--to identify needed TCD research and evaluation. The following eleven problem statements developed by a joint subcommittee of operators and researchers were reviewed, revised and approved by the full committee for recommendation to the Group 3 Council for publication and appropriate distribution to the research community.

Members of the RPS Subcommittee were:

Paul Fowler	Richard W. Lyles, Chairman
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Zoltan A. Nemeth	Clinton A. Venable
Peter S. Parsonson	W. Scott Wainwright

PROBLEM NO. 1

1. TITLE: Evaluation of Warrant 6, Accident Experience, MUTCD

2. PROBLEM: The present warrant for accident experience is met if five or more correctable accidents occur within a 12-month period. Neither accident severity nor exposure (i.e., vehicles per year) are considered in this warrant. Also, "correctable" remains largely undefined.

3. OBJECTIVE: This study should be addressed to refining the accident experience warrant for signalized intersections. It should include a thorough review of the literature to define the relationship between signalization and changes in accident patterns. The potential advantages to be derived from considering accident severity and exposure in addition to the total number of accidents should be evaluated. Further, a more explicit definition of correctable should be developed. If appropriate, the existing warrant should be revised accordingly.

4. KEYWORDS: signal warrants, accident experience, traffic signal safety.

5. RELATED WORK: Limited efforts in Utah and Arizona; FHWA: "Evaluation of MUTCD Selected Standards" (COMSIS, 1986); NCHRP 3-20 Traffic Signal Warrants; University of California project: "Accident Prediction Models for Signalized Intersections."

6. URGENCY/PRIORITY: Liability cases against governmental agencies indicate a high priority as well as the fundamental need to evaluate and improve highway safety at signalized intersections.

7. COST: $250,000.

8. IMPLEMENTATION: The study may result in modification of Warrant 6, MUTCD.

9. EFFECTIVENESS: More appropriate use of signalization will result in improved highway safety.

PROBLEM NO. 2

1. TITLE: Symbol Signing Comprehension

2. PROBLEM: Present acceptance of symbol signing by the MUTCD allows supplemental signs for educational purposes; however, expected level of driver comprehension is largely estimated by individual traffic engineers.

3. OBJECTIVE: The study should be addressed to a systematic evaluation of the level of comprehension of symbol signing (perhaps with demographic dimensions--e.g., age, sex). Different methods for satisfying motorist information needs through use of symbols, combinations of symbols, and/or words and symbols should be evaluated. A first phase consisting of an extensive literature search directed to synthesizing existing work should be completed prior to execution of new studies.

4. KEYWORDS: symbol signing, symbols, signs, logo(s), glyphs.

5. RELATED WORK: Limited study by FHWA of symbol signing for highway safety and reduced user costs; AASHTO; TRRL and Australian Road Research Board; glance legibility (West Virginia University); 1972 FHWA/International Road Federation conference; Maine Facility work on work zones; Ministry of Transport, Canada (Dewar); others.

6. URGENCY/PRIORITY: Essential to further evaluation of satisfying motorist needs.

7. COST: $50,000 first phase; $250,000 total.

8. IMPLEMENTATION: Identification of deficiencies and alternatives for solution, together with demonstrated consequences for uncorrected problems, would significantly assist traffic engineers in addressing motorist information needs, thereby providing for better traffic control devices. Revision of one or more parts of the MUTCD.

9. EFFECTIVENESS: Improved operational efficiency as a result of better problem identification and solution would increase highway safety and reduce user costs.

PROBLEM NO. 3

1. TITLE: Safety Effectiveness of Enlarged, Illuminated and Advance Street Name Signs

2. PROBLEM: There has been a significant (nationwide) increase in the use of enlarged, illuminated, and advance name signs for major highways and streets. To date, there is little or no quantifiable evidence of safety or other user benefits. However, the ambiguity of application may increase susceptibility to tort actions.

3. OBJECTIVE: The benefits of various applications of enlarged, illuminated, and advance street/highway name signs should be quantified, providing an objective basis for installation and improving traffic control management. There appear to be three areas where benefits (and costs) need to be estimated:
    1. safety benefits on specific intersection approaches where such signs are installed;
    2. safety benefits accruing from reductions in excess travel and directional uncertainty; and
    3. user benefits accruing from travel time savings from reductions in travel and directional uncertainty.

4. KEYWORDS: guide signs, street name signs, route signing.

5. RELATED WORK: None known.

6. URGENCY/PRIORITY: If usage provides greater safety, more extensive use provides greater safety; if not, there is only moderate probability of other user benefits. Should be considered as moderate priority.

7. COST: $150,000.

8. IMPLEMENTATION: The study will provide guidelines (and perhaps warrants) for the use of enlarged, illuminated, and advance street name signs. Revisions to the MUTCD and/or TCD handbook are possible.

9. EFFECTIVENESS: Better understanding of the safety impacts and other user benefits will lead to more rational decisions regarding use.

PROBLEM NO. 4

1. TITLE: Roadway Delineation Selection

2. PROBLEM: The MUTCD provides numerous alternative roadside delineation treatments (e.g., shoulder striping, standard delineators, raised pavement markers, chevrons). Little or no guidance has been provided regarding the comparative effects of each or the benefits of various combinations.

3. OBJECTIVE: The first phase should consist of the preparation of a synthesis of practice regarding the use of individual treatments and combinations and their relative effectiveness in terms of safety. Implications of use/non-use of, for example, chevrons with regard to

liability should also be included. A systematic study directed to assessing the marginal (safety) improvements for the various treatments and combinations should then be undertaken. Direct comparisons of pavement markings with other options should be included (especially for "snow" states).

4. KEYWORDS: delineation, roadside safety, accident countermeasures, chevrons, roadway markings.

5. RELATED WORK: Numerous local and national studies. The most comprehensive attempt to review/evaluate delineation usage to date were reported in NCHRP Report No. 130 and FHWA-RD-78-50.

6. URGENCY/PRIORITY: As a potential source of improved roadside safety--high priority. As a means of ambiguity reduction for tort litigation, also a high priority. As a means of reduced user cost (other than safety)--moderate priority.

7. COST: First phase--$50,000; complete study--$250,000.

8. IMPLEMENTATION: The study provides quantifiable comparative data for individual delineation system selection and expected benefits for various combinations. MUTCD revisions are possible.

9. EFFECTIVENESS: Improved implementation criteria will permit more effective and uniform application of delineation treatments. The number of tort actions may be reduced.

PROBLEM NO. 5

1. TITLE: Safety Warrants for Left-turn Signalization

2. PROBLEM: Present traffic signal warrants include consideration for accident reduction. There are, however, several approaches in use for defining when left-turn phasing should be used (e.g., Kentucky's accident warrant; critical movement analysis and delay). There should be clear accident warrants for left-turn phasing and for different types of left-turn movements (i.e., protected, protected/permissive).

3. OBJECTIVE: Establish accident warrants for different types of left-turn signal phasing; also, determine peripheral safety benefits and/or hazards associated with left-turn phasing (e.g., capacity impacts).

4. KEYWORDS: traffic signals, traffic-signal warrants, left-turn phasing, traffic signal safety.

5. RELATED WORK: TRR 737; states of Kentucky (Agent and Deen) [also in TRR 737] and Virginia; FHWA work by JHK; FHWA-IP-81-4; Florida Section of ITE; considerable work from capacity perspective; current (1987-88) study in Michigan on "flashing red."

6. URGENCY/PRIORITY: Moderate--appropriate for revision of MUTCD.

7. COST: $150,000 with state's assistance; $350,000 without.

8. IMPLEMENTATION: New warrants would be incorporated in the MUTCD.

9. EFFECTIVENESS: Improved highway safety, reduced user costs, and uniform usage of left-turn phasing will result from new warrants.

PROBLEM NO. 6

1. TITLE: Safety-Related Guidelines for Two-Way Left-Turn Lanes (TWLTL) vs. Raised Medians

2. PROBLEM: The MUTCD provides for the use of painted two-way left-turn lanes without guidelines for application and/or anticipated benefits. Relative safety and operational benefits of permissive painted medians versus prohibitive raised medians should be determined. Also, advantages and disadvantages of three and five-lane installations should be identified and evaluated.

3. OBJECTIVE: A rationale for using painted two-way left-turn lanes and raised medians in both three and five-lane situations should be developed. The following should be included in the research:
    1. consideration of trade-offs between volume-capacity and safety considerations;
    2. determination of the efficacy of retrofitting high-ADT, high-driveway-density TWLTLs with raised medians or median barriers; and
    3. evaluation of the impacts of the frequency of breaks in raised medians.

4. KEYWORDS: two-way left-turn lanes, medians, access, median barriers.

5. RELATED WORK: Numerous local studies; Midwest Research Institute (NCHRP Report 282); Ohio State University; University of Texas; Highway Research Records 31 and 257; Compendium of Technical Papers of the 49th ITE Meeting (1979).

6. URGENCY/PRIORITY: High priority.

7. COST: $200,000 if local data available; $350,000 if data collection necessary.

8. IMPLEMENTATION: The study would result in the development of warrants and a rational decision process for selection and use of two-way left-turn lanes and raised medians.

9. EFFECTIVENESS: Increased understanding of the proper function and potential benefits of TWLTL and raised medians should lead to more widespread, uniform, and safer applications.

PROBLEM NO. 7

1. TITLE: Use of "Left-Turn Yield on Green" Sign for Protective/Permissive Left-Turn Phasing

2. PROBLEM: Use of MUTCD-approved sign is a MAY condition for protective/permissive left-turn phasing. Varying applications or non-use may affect safety significantly and should be tested under various conditions. Significant variations in use lead to driver confusion.

3. OBJECTIVE: The proposed study should be addressed to the following objectives:
    1. determine whether universal application of the "left-turn yield on green" sign, for all types of left-turn phasing (e.g., protective/permissive) is justified or constitutes overuse;
    2. determine the effect of signal-head placement in regard to LT and through traffic lanes;
    3. evaluate the use of "flashing yellow" to convey the absence of protected movement vs. the "yield on green" sign;
    4. test driver comprehension of various configurations;
    5. determine relative quantifiable safety benefits of various applications; and
    6. develop objective criteria/warrants for use.

4. KEYWORDS: left-turn phasing, protective/permissive phasing, traffic signals, flashing signals.

5. RELATED WORK: Virginia Highway Research Council--limited; experimental work on "flashing yellow" in Northwest; JHK; current (1987-88) study on "flashing red" in Michigan.

6. URGENCY/PRIORITY: With the expanding use of different types of left-turn phasing, the information from this study is important and would be widely applicable.

7. COST: $300,000.

8. IMPLEMENTATION: The study should result in the development of standards and/or warrant conditions for application of appropriate warning that left-turn is, or is not, protected.

9. EFFECTIVENESS: Standards and/or warrants for use of appropriate signing will lead to uniformity of use, better motorist comprehension, and increased safety.

PROBLEM NO. 8

1. TITLE: Intersection Flashing Beacon Warrants

2. PROBLEM: Flashing beacons represent a substantial investment for installation and maintenance and may be frequently used as the alternative to an unwarranted traffic signal. More precise information should be available to the practitioner to determine when and where such devices should be used.

3. OBJECTIVE: The study should result in explicit standards or warrants for the use of flashing beacons at intersections. The "cut-offs" between the use of stop signs only, flashing beacons, and signals must be clear and the benefits, costs, and risks (in terms of potential liability) must be defined. The fairly large body of literature on the use of flashing beacons at different types of intersections must be synthesized.

4. KEYWORDS: beacons, flashing beacons, intersection safety.

5. RELATED WORK: A considerable amount of work has established the relative effectiveness of flashing beacons. There appears to be less in regard to developing warrants for their use. FHWA-RD-79-190, "Guidelines for Flashing Traffic Control Devices;" Indiana warrants (Rust, Purdue University); Netherlands; Caltrans; others concerned with signals which switch to flashing operation during low-volume hours.

6. URGENCY/PRIORITY: Moderate to significant.

7. COST: $100,000 if supported with existing data; $500,000 if field data are to be collected.

8. IMPLEMENTATION: Explicit guidelines and/or warrants will result from this project.

9. EFFECTIVENESS: Rational decisions for selection and use of alternative traffic control devices will result from this study. Standards and/or warrants for use of appropriate signing will lead to uniformity of use and increased safety at non-signalized intersections.

PROBLEM NO. 9

1. TITLE: Traffic Signal Warrants for High-Speed Approaches to Intersections

2. PROBLEM: The MUTCD provides for 70% warrant requirements when the approach speed exceeds 40 mph (85th percentile). Presumably this exception is provided in the interest of safety, although little or no supporting research has been provided. If the high-speed approach is more hazardous for non-signalized locations, what are the comparable effects of these conditions for existing signalized locations?

3. OBJECTIVE: Determine the relative effects of high-speed approaches to both signalized and non-signalized locations. Effective parameters of safety for various approach speeds should be determined. Validate or reject current warrant reduction for higher speed locations.

4. KEYWORDS: traffic signals, traffic signal safety, traffic signal warrants, high-speed approaches.

5. RELATED WORK: Project was included in a previous FHWA (FY 86) research work program. Committee recommends this research problem statement as a follow-up or addition to that study. Considerable work with dilemma zones; HRR 286; TRR 681.

6. URGENCY/PRIORITY: Priority moderate to high and increasing.

7. COST: $250,000.

8. IMPLEMENTATION: Modification and/or amplification of traffic signal warrants in the MUTCD would result from this project.

9. EFFECTIVENESS: Increased safety through additional information in making traffic signal installation and modification decisions. Uniformity in application should have significant safety benefits and result in more uniform driver expectancy when such intersections are encountered.

PROBLEM NO. 10

1. TITLE: Evaluation of Traffic-Actuated Signals

2. PROBLEM: Equipment deficiencies and inadequacies in maintenance programs/procedures have rendered many existing actuated traffic signals inoperative or functioning no better than pre-timed units.

3. OBJECTIVE: The study should be addressed to the following:
    1. status of current state-of-the-art actuated traffic signal maintenance;
    2. extraordinary user cost resulting from increased accidents, delay, fuel consumption, pollution, etc.;
    3. principal problem areas for actuated traffic signal maintenance; and
    4. magnitude of national problem in the context of energy conservation.

    Once the above are addressed, a model maintenance program (actuated traffic signal management system [ATSMS]) should be developed.

4. KEYWORDS: traffic-actuated signal maintenance, energy conservation, delay, traffic signal timing optimization.

5. RELATED WORK: Almost all related research is associated with successful or in-process maintenance operations. There is no evidence of a comprehensive study estimating non-maintenance activity or identifying deficient areas (e.g., geographical, jurisdictional).

6. URGENCY/PRIORITY: Moderate to high.

7. COST: $200,000 with state or local data; $500,000 if data must be collected.

8. IMPLEMENTATION: Identification of maintenance deficiencies with alternatives for solution, together with demonstrated consequences for uncorrected problems, would assist traffic engineers in obtaining necessary resources for improvement. Determination of needs should also motivate responsible supervisory agencies to improve management of the maintenance function.

9. EFFECTIVENESS: Increased efficiency of traffic control management and substantial savings in user and provider costs would result.

PROBLEM NO. 11

1. TITLE: Testing Motorist Understanding of Traffic Control Devices (TCDs)

2. PROBLEM: Based on a limited number of widely variable studies, it is clear that many drivers have difficulty understanding some TCDs currently in use. Further, it is evident that some agencies have developed and used "non-standard, non-uniform" TCDs which have not been properly evaluated. Some of these TCDs are in actual conflict with adopted standards, increasing driver confusion and possibly degrading the benefits from uniformity of TCD design and application. Without objectively determining how drivers will react, new and revised national standards for TCDs have been proposed and adopted on the basis of subjective opinion and "engineering judgement" or political pressure. The lack of general knowledge of driver response to some TCDs and of adequate (uniform) procedures for evaluating TCDs indicates the need for an objective method or method(s) for evaluating motorist understanding of, and response to TCDs.

   Development of a standardized testing procedure (or set of procedures) would permit comparative evaluation of TCDs to determine their effectiveness over time by region, age group, and other parameters, ultimately leading to threshold requirements for motorist understanding as a prerequisite to the adoption or revisions of national standards.

3. OBJECTIVE: The objective of this project is to develop, validate, and codify a method (or methods) for the evaluation of driver understanding of, and response to TCDs, including signs, signals, pavement markings, and delineators, both individually and in various combinations. More specifically, this objective should be achieved in three phases.

   Phase 1--Feasibility. Based on the literature on TCD understanding and knowledge of state-of-the-art technology available to study TCD comprehension, determine the feasibility of developing a standardized method (or methods) for testing driver understanding.

   Task A. Review available evaluation methods and techniques with emphasis on those which are relatively inexpensive (e.g., not involving a driving simulator) and determine the appropriate scope of the evaluation method(s) (e.g., whether TCDs are understood must be determined as well as whether the driver response is appropriate) including statistical methods.

   Task B. Review available hardware required for testing and/or evaluation of TCDs with emphasis on portability and ease of operation (so that "local" traffic engineering personnel can use).

   Task C. Determine the appropriate characteristics of drivers that should be considered (e.g., age, sex, driving experience, linguistic ability, and geographical regions).

Task D. Determine the context in which TCDs should be evaluated (e.g., driving scenario) and how driver responses should be measured (e.g., non-verbal).

Phase 2--Development of devices and procedures. Based on the review in phase 1, detailed specifications of the testing method(s), equipment, and so forth must be developed.

Task A. Develop and/or specify the hardware and software necessary for measuring driver understanding of, and response to TCDs.

Task B. Develop a general evaluation (experiment) design including a driver population sampling procedure consistent with phase 1.

Phase 3--Demonstration of the equipment and method(s).

Task A. As required, manufacture testing devices and conduct small-scale validation studies using local traffic engineering department personnel.

Task B. As specified by the sponsor (e.g., FHWA), conduct a nationwide pilot program, using the recommended devices and procedures to determine the level of understanding and response to a sample of TCDs--both in current use and proposed new devices.

Task C. Recommend steps to improve (or eliminate) TCDs which are not well understood (as determined in task B in phase 3).

4. KEYWORDS: traffic control devices, driver testing, highway signs, signals, and markings.

5. RELATED WORK: While considerable work has been done, the effectiveness of many TCDs remains unknown and no method(s) is (are) generally agreed upon as being most appropriate. BioTechnology Inc. has summarized literature through 1984. Comsis Corp. is assessing all standard devices from their inception or introduction into the current MUTCD.

6. URGENCY/PRIORITY: High (especially in light of increasing numbers of tort actions regarding the appropriateness of TCDs).

7. COST: $300,000 (an unknown is the cost of development of new equipment if it is required).

8. IMPLEMENTATION: Correction/modification of existing TCDs and standards; adoption of threshold measures of effectiveness for TCDs in new standards; and development of improved driver training programs.

9. EFFECTIVENESS: A standardized evaluation procedure for motorist understanding of TCDs will lead to development and use of more effective TCDs based on uniform standards of driver recognition and response. This will also result in response-oriented driver education programs. Equally important is the effect on the (traffic) engineering decision-making process.