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RESEARCH INITIATIVES FOR TRAFFIC SIGNAL CONTROL SYSTEMS

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FOREWORD

Significant improvements in traffic flow can be obtained from modern vehicle and pedestrian responsive traffic control systems. This includes improved operations which can be achieved from the integration of traffic signal and freeway traffic management systems. The availability of more powerful microcomputers makes the development of improved systems a reality. It is also possible to obtain large amounts of information on traffic flow through advanced detection systems and to use this information to improve traffic control systems. Likewise, fiber optic cables provide a means for transmitting large amounts of traffic information to and from control system elements at a reasonable cost.

To take advantage of these improved traffic control systems and communication technology, there is a need now to research algorithms and approaches for improved traffic signal system operation; to make these systems more responsive to traffic demands; and provide improved equipment diagnostics and fail-safe operation. There is also a need to look at methods of integrating traffic signal, freeway management, and non-transportation control systems within cities and metropolitan areas.

New computer models for analyzing traffic movement have been developed and are now available for personal computers. Although the analysis routines are of value, there is still a need to correlate the output from these computer models. These models should also be made more user friendly.

There is also a need to look to the future--to determine through research how to make the best use of existing street and freeway networks. This can be accomplished through development of advanced traffic control systems and improved motorist information systems. Research is needed on driver behavior as it relates to motorist acceptance and use of new traffic control and motorist information and guidance systems.

The Traffic Signal Systems Committee of the Transportation Research Board has developed this circular of research problem statements which list and discuss specific research needs for the present and the future. Chapter I discusses the areas that need research in advanced technology. This is followed by a list of problem statements in Chapter II which describes the research needed now.

This Circular of Research Statements is provided as a guide for governmental and research agencies in developing programs of research in traffic signal control systems. It is also intended to provide information and education on research needs to legislators, administrators, and engineers involved in the area of traffic and transportation.

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CHAPTER I RESEARCH INITIATIVES FOR ADVANCED TECHNOLOGY TRAFFIC SIGNAL CONTROL SYSTEMS

INTRODUCTION

This Circular presents recommended initiatives for research into advanced technology applications for traffic signal and traffic control systems. These research needs were developed by the Committee on Traffic Signal Systems of the Transportation Research Board.

The ideas outlined in this Circular were proposed at a workshop organized by the Traffic Signal Systems Committee, and hosted by the Connecticut Department of Transportation at Hartford on June 15, 1989. The workshop was attended by thirty professionals in traffic control technology and included representatives of the Federal Highway Administration, state departments of transportation, municipalities, engineering consultants, traffic signal equipment suppliers, and universities.

Background

The steady increase in traffic congestion in the United States is being experienced by all. In many areas, congestion is already reaching crisis proportions. The probability that congestion will continue to increase for the next two decades has been widely documented along with the associated environmental, economic and social costs that accompany the congestion.

A variety of programs can contribute to reducing the impact of traffic congestion. New highway construction, although limited, and the more efficient and widespread application of existing traffic management techniques will help to alleviate the problem in the near term.

However, none of the current programs provide a solution to the problem. Rather the development and implementation of advanced technology systems for traffic management must be the major mechanisms for handling growing traffic congestion.

The "Discussion Paper on Intelligent Vehicle-Highway Systems" issued in May, 1989 by the U.S. Department of Transportation provides a framework for the application of advanced technology for alleviating traffic congestion. Within this framework, the area of traffic signals and control is a major component.

The Workshop described above used the USDOT Discussion Paper as a starting point to identify and develop the recommendations for research in traffic control that are presented in this Circular. It is becoming clear that research thrusts in this area are essential for the United States and that they will have direct and indirect benefits to the nation. Beyond the domestic concerns, however, are the beneficial spinoffs involving the improved competitiveness of U.S. firms in the international markets. Traffic congestion is a worldwide phenomenon.

Overview of the Initiatives

Any productive research developments in the area of traffic control will be necessarily diverse and complex. The broad sub-areas covered here are:

1. Traffic surveillance
2. Communications
3. Software for traffic control systems
4. Support areas
5. Local signal hardware
6. Driver behavior

These sub-areas are described in more detail below.

1. TRAFFIC SURVEILLANCE

Problem: Traffic surveillance is the sensory core of any effective traffic control system. The accurate and reliable collection of traffic data is an absolute necessity for advanced technology systems. Unfortunately the existing surveillance technology has many deficiencies. The most critical of these are that it cannot collect at reasonable cost many kinds of the needed information and it has severe problems with reliability.

Proposal: Improve the accuracy, capability, reliability and cost-effectiveness of traffic surveillance technology.

It is suggested that the research approach emphasize the evaluation of existing technologies available in other fields. These technologies might include:

(a) Image processing
(b) Use of satellites
(c) Heat-seeking missile technology
(d) In-vehicle detection
(e) Stand alone in-pavement detectors subject to occasional interrogation
(f) Improvements in existing detection hardware related to reliability, cost, capabilities, etc. Review all detector technologies such as loops, infrared, magnetic, radar, etc.

Discussion: The surveillance data available from current traffic detector technology is inadequate for much of today's control systems--let alone future advanced technology developments. These deficiencies are compounded by the uncertain reliability of existing equipment.

Surveillance and data acquisition are widely used in other fields and there have been many advanced technology applications. A concentrated effort is needed to modernize traffic surveillance technology. Without this surveillance capability, other advanced technology developments in traffic management will be severely handicapped.

2. COMMUNICATIONS

Problem: Communication is a major factor in any traffic control system. The transmission of surveillance data, signal operating conditions and control instructions requires reliable, cost-effective communication capabilities. As new technology in traffic management brings the driver in as an active participant, communication with the driver also becomes an essential need.

Proposals: (a) Develop the functional description of communication needs for traffic control systems particularly as they relate to emerging technologies. This functional description should cover both the basic communication requirements to operate an area-wide traffic surveillance and control system and the anticipated communications needs for in-vehicle navigation and control systems. (b) Evaluate and develop the appropriate communications for area-wide traffic surveillance and control. Review all current technologies including various cable alternatives, fiber optics, and radio. New technologies including satellites and lasers should also be reviewed and evaluated.

Discussion: Effective traffic management requires cost-effective and reliable communications. This communication technology must be made less costly, more reliable and more weather resistant.

New technological advances will place additional demands on the communications capabilities. These advances will require information to flow to the driver and from the vehicle. The overall design and execution of these communication systems will be an important component of the advanced technology research program.

3. SOFTWARE FOR TRAFFIC CONTROL SYSTEMS

Problem: The development of the software for traffic control systems in the United States has lagged behind developments in Great Britain and Australia. The growing needs for control systems that are more responsive to unexpected shocks to the traffic system and accommodate the emerging technologies for in-vehicle driver information, will require software developments well beyond the current state of the art.

Proposal: Develop an advanced software traffic control platform that will replace UTCS. This platform should provide control that is closer to real-time than what is available now. It should be demand-responsive rather than traffic-responsive and should fully accommodate new developments in surveillance, communications and in-vehicle navigation.

Discussion: Software development for traffic control presents some conflicting issues. On the one hand maintainability, minimum performance levels, and uniform traffic rules and procedures imply some standardization. On the other hand, innovation, creativity and maximum use of new technologies generally follow from competitive developments. The proposal for a software platform attempts to seek the middle ground.

The benefits of new advanced software systems will be real-time responsive control that will not only respond to traffic demands and driver behavior but will direct traffic demands to maximize the inherent network capacity and modify driver behavior to maximize efficiency and safety. The software will allow immediate response to system shocks such as incidents and weather. It will integrate streets and freeways. The prediction capabilities will limit the propagation of negative conditions and be an important data source for motorists choosing travel times, routes and destinations.

4. SUPPORT AREAS

There are many areas of traffic related research that require considerable development to provide support for the overall program in advanced technology research. Some of these areas are listed below.

(a) Improved traffic modeling software.

(b) User friendly software that uses 'expert system' methods.

(c) Data and analysis software. The traffic management system is driven by data. Much of the data collected is of doubtful value, inaccurate, and later discarded. The new proposals for advanced technology will increase the need for data and will increase the flow of data. Information management is a critical need both for the control system and its managers. A wide range of hardware and software needs exist in managing traffic information and monitoring its reliability and accuracy.

(d) The costs and benefits of traffic control with particular attention to environmental, energy and economic benefits.

Traffic congestion is very costly to society. A uniform methodology should be developed for cost-benefit estimates of traffic management proposals.

These cost-benefit methods should utilize the data from the traffic control system.

(e) Education and training needs: As shortages of skilled personnel already affect our traffic management capabilities; the question of education and training is going to be a major issue.

(f) National traffic test bed: There is a need for one or more traffic test beds and/or test cities where new research in traffic control technologies is tested.

Discussion: The successful operation of the proposed advanced technology systems hinges on the availability of accurate, on-line traffic data and traffic analysis and control "tools" (primarily in the form of computer models). These tools will use the data to "advise" system operators how and when to implement various congestion reduction strategies.

The availability of these tools is of utmost importance. Current traffic engineering practice does not treat the congestion problem on a network-wide basis. Rather, it is problem/site oriented and does not consider the impacts of actions taken to alleviate congestion at specific locations on the rest of the network. As a result, the congestion is relocated within the network.

Computerized traffic tools, both for analysis and control, are the backbone of any future system and must be developed, tested, and calibrated into an integrated system where analysis results feed into control and vice versa.

5. DRIVER BEHAVIOR

Problem: Vehicle performance within a traffic control system has a considerable impact on the operational efficiency of that system. Driver behavior is the key to vehicle performance and current signal design assumes a certain level of driver behavior. Important questions arise as to how the efficiency of a system is affected by driver behavior, to what extent our assumptions on driver behavior are correct, and whether we can modify driver behavior either off-line or in real-time to improve the system performance.

Proposal: Develop a research program focussing on aspects of driver behavior related to traffic control and the adoption of advanced technologies. The research should include an assessment of the impact of driver behavior on system performance, the current knowledge of the critical components of driver behavior and the quantification of these components, and the possible mechanisms for the positive alteration of driver behavior.

Discussion: There is a lack of knowledge of many aspects of driver behavior. For example, how well do current design practices consider the responses of elderly drivers? Can they respond to advanced technology developments? Is it possible to monitor vehicle and driver capabilities and allow the control system to include this information in its decision process? Most important is there a possibility of real time modification of driver responses to improve system performance?

6. LOCAL SIGNAL HARDWARE

Problem: The local signal controller is the fundamental unit of any traffic control system. There are number of important issues that need to be addressed to maximize the benefits of advanced control developments. The future local controller should be capable of interfacing with the new surveillance and communications technologies. It should have improved maintainability, on-board failure diagnostics, and an internal performance evaluation capability. The local controller could become a link in system advisories to motorists in the local area. It may also have more responsibility for decentralized data processing for both control and surveillance. The local controller must also have a stand alone capability, both for emergency control when the system fails and for the isolated intersection. In the case of the isolated intersection, advanced control methods such as OPAC may be necessary.

Proposal: Develop the function specifications for an "intelligent" local controller. It should be able to stand alone or be part of a system. It should be able to accommodate advanced technology in communications, surveillance and data processing. It should have on-board diagnostics and performance evaluation. It should also contain redundant circuitry to assure adequate operation when one or more detector and control functions fail. The basic controller specification should allow the signal controller industry to develop enhancements and customized capabilities.

Discussion: The role of the local controller needs to be more clearly identified. The potential for an "intelligent" local controller carrying out a variety of duties, beyond just switching lights and transmitting data, is great. Many control, surveillance, and communication functions will have to be delegated if truly cost effective real-time systems are to be implemented.

CHAPTER II RESEARCH PROBLEM STATEMENTS FOR CURRENT RESEARCH NEEDS IN TRAFFIC SIGNAL SYSTEM OPERATIONS

RESEARCH PROBLEM STATEMENT NO. 1: TEST BED FOR TRAFFIC CONTROL STRATEGY RESEARCH*

Problem: Traffic control strategy research has been hampered by the lack of effective field testing of new strategies. Great strides were made in the field in the early 1970s when the FHWA sponsored the UTCS research project and the Washington, D.C. test facility. Most recently, the British have established themselves as leaders in the field of traffic control strategy research--in part because of their effective use of their test facility in Glasgow.

One or more test facilities are needed within the United States to test new algorithms and concepts. This would permit testing various designs under different conditions.

Objective: To select one or more sites and provide the administrative and legal mechanisms that will enable an agency or agencies with a computerized signal system(s) to act as a continuing test bed(s) for traffic control strategy research.

Under this study, candidate sites would be surveyed and one or more would be selected to serve for testing of traffic control strategies. Technical, institutional and administrative factors would be considered in the selection. Recommendations would then be made and agreements drafted and signed to establish a continuing source of funding for, and administration of, investigations conducted at each test facility.

No hardware or software development or control strategy research would be conducted under this particular study. It is envisioned that additional hardware/software would be developed as needed, and each test would be conducted at a test center facility.

Such facilities are needed to ensure that the most effective use is made of the research money committed to these studies and to improve the probability that the new control strategies developed will be thoroughly tested, will work, and will be accepted and implemented by practicing engineers.

Key Words: Testing, Traffic Signal Systems, Test Facilities.

Related Work: The experience gained about the requirements from the facilities in Glasgow and Washington, D.C. can be used to develop U.S. test facilities.

Urgency/Priority: Because of advances in traffic control hardware, quantum improvements in traffic control can be achieved. Research will begin soon on the development of new algorithms for traffic responsive control and control during saturated traffic conditions. There is a need to test the new concepts as they develop. There are also new computer models used for simulation and optimization which need to be tested. Satisfactory results cannot be achieved without adequate field testing. One or more facilities which have the characteristics needed for broad testing of new traffic signal system concepts are urgently needed.

Cost: $100,000 - $150,000. This will be needed to study the system needs, locate the facilities, and develop agreements with the future test agencies. Actual funding for testing of new concepts could be included in the specific research projects.

User Community: The user community includes all those persons involved with traffic signal system design and operation. The problem statement should be considered by ITE, AASHTO and FHWA as well as TRB.

Implementation: The results of the testing will be implemented with confidence by agencies that are improving or installing traffic signal systems.

Effectiveness: The test facility or facilities will permit testing of new concepts, provide guidelines to future users, and stimulate future development.

*Problem Statement originally developed as part of NCHRP Project G3-38.

RESEARCH PROBLEM STATEMENT NO. 2: FIELD VALIDATION OF SIMULATION AND OPTIMIZATION MODELS*

Existing traffic models such as NETSIM, PASSER II-84, and TRANSYT-7F are being used successfully in practice. Their accuracy is considered minimally adequate when used with proper engineering judgment.

There is still a need to make their outputs comparable, or as close to each other as possible. The studies which validated the use of these models in the U.S. were limited in scope and were conducted several years ago (PASSER and NETSIM), or outside the U.S. (TRANSYT). Driver, and especially vehicle performance characteristics are considerably different from those exiting when these studies were conducted. Also, the TRAFLO and FRESIM simulation models are now being completed by FHWA. These models should be subjected to rigorous field validation studies to confirm their accuracy and relative agreement in predicting the impact of proposed traffic operations improvements.

Objective: The conduct of field validation studies for existing and new traffic simulation and optimization models. The project will cover a series of studies under which rigorous, statistically valid, field validation studies would be conducted for the models mentioned above. The study would help provide engineers and planners with the proper tools for determining the most effective solutions to urban congestion problems.

Key Words: Computer Simulation Models, Computer Optimization Models, Traffic Signal System Timing, Arterial Street Traffic Analysis.

Related Work: The TRAFLO and FRESIM computer models are being developed. The PASSER, TEXAS and MAXBAND models are being improved. These models need to be validated.

Urgency/Priority: The research results will have direct application to traffic signal systems and other traffic management applications. Because of increasing congestion along streets, there is an urgent need to assure that computer models do provide accurate results and answers. This is a highly urgent project.

*Problem Statement originally developed as part of NCHRP Project G3-38.

User Community: The problem statement should be made available to ITE, AASHTO, and FHWA, as well as TRB.

Implementation: The results of the research will be implemented by traffic operations personnel, managers, administrators, researchers, and planners.

Effectiveness: The results of the research project will be very beneficial in assuring that data are correct and can be relied upon in traffic engineering and planning applications. The measures of effectiveness will be reduced vehicular delays as well as reduced fuel consumption and vehicle emissions.

RESEARCH PROBLEM STATEMENT NO. 3: IMPROVED TRAFFIC CONTROL TO RELIEVE NON-RECURRING URBAN CONGESTION*

Problem: Congestion on both freeways and surface streets can be divided into categories of recurring and non-recurring congestion. Recurring congestion is defined as congested traffic conditions which are predictable because they occur at the same time of day during a period of many days. Examples of recurring congestion include commuter traffic, shopping traffic, or weekend holiday traffic. Non-recurring congestion is unpredictable. It could be caused by an accident, a special event, or construction activities.

It has been known for many years that non-recurring congestion on freeways is responsible for levels of vehicle delay and motorist operating cost equivalent to those caused by recurring congestion. The two types of congestion are equally important. It is also known that the measures required to relieve the impact of non-recurring congestion on freeways are significantly different from those required to relieve the impact of recurring congestion.

*Problem Statement originally developed as part of NCHRP Project G3-38.

Objective: The objective of the research will be to develop guidelines and strategies for improved traffic control during non-recurring activities such as accidents, special events, and construction activities. This will include development of measures of effectiveness of traffic signal system strategies for use in managing traffic, special signing for advising and routing of motorists, signing for traffic control around and/or through the event, incident management team organization, and police enforcement needs. The study should include the effect of non-recurring congestion on the street system as a result of freeway incidents as well as those special activities which occur along city streets. The study would include contact with cities that have successfully applied various techniques to relieve non-recurring congestion.

Key Words: Non-Recurring Incidents, Traffic Management, Incident Management, Special Traffic Signal System Strategies, Incident Management Teams.

Related Work: Minimum research work has been carried out in this area as it applies to corridor streets. Studies to date have applied primarily to freeway incidents with utilization of the corridor streets when necessary to improve conditions. Although cities have handled traffic congestion during special conditions, it has been relatively undocumented.

Urgency/Priority: The research results will help improve overall traffic operations along corridor streets. With congestion evident at present, and conditions worsening, the need for efficient operations makes this a high priority project.

Cost: $250,000 - $300,000.

User Community: The user community includes administrative, traffic engineering, maintenance and police enforcement personnel who are involved in street and freeway traffic management. The problem statement should be considered by TRB, ITE, AASHTO, FHWA, and public works and enforcement organizations.

Implementation: The results of the study will be implemented by city, county and state traffic engineering, enforcement and maintenance personnel.

Effectiveness: The results of the study will decrease congestion and accidents along city streets during non-recurring incident conditions on both the city streets and freeways.

RESEARCH PROBLEM STATEMENT NO. 4: TRAFFIC PERFORMANCE ANALYSIS PROCEDURE

Problem: There has been, with few exceptions, little change in the methods used for obtaining and processing data for traffic studies and inventories. Thus, efficient use of computer-based methods is not being achieved. More efficient, progressive methods, even when they have been developed, have not been incorporated in user manuals to facilitate their use by others.

Objective:

- Increase the number and quality of signal system and other traffic engineering studies by providing more effective and efficient methods for data collection and processing.
- Survey data collection and data reduction methods reflected in the literature or in practice.
- Develop, where there is an unmet need, automated methods. Maximum use should be made of the detector sub-systems of traffic signal systems.
- Evaluate the effectiveness of these methods.
- Develop a user manual.

Key Words: Traffic studies, data analysis, performance measures.

Related Work: UTCS 1.5 Generation Studies.

Urgency/Priority: Highest priority. Failure to develop more efficient methods restricts the evaluation of transportation measures.

Cost: $400,000.

User Community: Practicing transportation engineers and researchers.

Implementation: Via distribution of the manuals and training workshops.

Effectiveness: More and better evaluations and transportation inventories.

RESEARCH PROBLEM STATEMENT NO. 5: ESTIMATION OF NETWORK VOLUME DATA FROM SAMPLE MEASUREMENTS

Description: In England and Australia, the SCOOT and SCATS systems have been developed to provide traffic adaptive signal control. In the U.S., practice seems to be evolving towards the 1.5 generation form of control. In 1.5 generation control, a signal timing optimization computer program is integrated with the computerized signal system. The traffic volume data collected by the system detectors serve as a basis for synthesizing a complete traffic volume input data set for the signal timing optimization program. The optimization program is run at the discretion of the traffic engineer, perhaps in response to some measurement of current timing plan performance provided by the system. Timing plans so produced may then be reviewed by the traffic engineer before being implemented in the system. 1.5 generation control may be supplemented by traffic responsive (pattern matching) and critical intersection control, as in the Los Angeles ATSAC system.

Problem: There is no adequate method of synthesizing the traffic volume input data set at the present time. A recent FHWA research study recommends a series of rules for developing estimating equations at the time of system (software) installation. When the engineer decides to develop a new timing plan, the system detector data serve as input to these equations and a complete traffic volume input data set results (in the FHWA study, TRANSYT-7F was the signal timing optimization program used, see reference #1 below). Development of these estimating equations is complex and time consuming. Also, there is no way of verifying that the relationships represented by the equations are still valid when a new timing plan is being developed in the future (e.g., new generators may change traffic flow patterns).

Objective: Develop a better way of synthesizing a traffic volume input data set for 1.5 generation traffic control systems.

Scope: Investigate operations research and statistical techniques that may provide means of accomplishing the objective (see, for example, reference #2 below). Test these techniques. Data sets from Tallahassee and Los Angeles should be available from the FHWA study.

References

1. *Automatic Updating of Traffic Volume Data for Signal Timing Plan Development*, prepared by JHK & Associates for FHWA's Office of Safety and Traffic Operations Research and Development. Source: NTIS. FHWA Contract: Paul Ross 703-285-2093.

2. Chin, Shi-Miao, *Multi-Variate Network Traffic Monitoring Data Analyses*, paper presented at Engineering Foundation Conference on Control of Urban Traffic Systems (June 1983: New England College). New York, NY: Engineering Foundation, 1985.

RESEARCH PROBLEM STATEMENT NO. 6: DEMAND-RESPONSIVE DECENTRALIZED CONTROL SYSTEMS

Problem: State-of-the-art strategies for traffic signal control consist of fixed-time/fixed-cycle strategies superimposed by some form of actuated control at critical intersections (CIC). Demand-responsive control, such as OPAC, has been studied primarily at individual intersections. An overall demand-responsive decentralized strategy for a system (network) of intersections can provide substantial improvements in performance by being able to respond automatically to local as well as systemwide variations in traffic.

Objective:

1. Develop a demand-responsive decentralized strategy for signal systems based on the OPAC or a similar optimizer.
2. Test and refine strategy through simulation studies.
3. Implement the strategy in a test network and evaluate its effectiveness.

Related Work: The SCOOT method, which was developed in Great Britain, demonstrates the potential benefits of a quasi-demand-responsive strategy. However, this strategy, which was initially developed in 1973, does not take full advantage of existing computer technologies, and can be superseded with existing knowledge and technology. Field tests with OPAC have shown its capability to achieve optimal on-line conditions at individual intersection. It is to be expected that the integration of OPAC controllers into a systemwide operation can provide comparable benefits at the network/arterial level.

Urgency/Priority: Many cities are grappling with severe traffic problems and would like to replace their aging control systems with the most advanced technology that is available today.

Cost:

Phase 1: Strategy Development$150,000
Phase 2: Simulation Studies 100,000
Phase 3: Field Testing 250,000

Total$500,000

Effectiveness: Improved traffic performance and reduction of traffic engineering manpower requirements.

RESEARCH PROBLEM STATEMENT NO. 7: SIGNAL SYSTEM INTERCONNECTION GUIDELINES FOR ARTERIALS AND NETWORKS

Problem: There is a continuing need for traffic engineers to determine whether an isolated signal or a group of signals should be interconnected within an existing signal system. No nationally recognized guidelines exist that address this important issue.

Objective: Practical procedures and/or guidelines would be developed that identify when adjacent signals should be coordinated. Network, traffic, and control features would be analyzed to determine the appropriate guidelines.

Key Words: Signalization, traffic control, coordination, interconnection.

Related Work: Texas Transportation Institute developed some preliminary guidelines for FHWA in the early 1970's within the Dallas Corridor Project. This early effort was published in the Traffic Control Systems Handbook of 1976. These preliminary guidelines were also published in the 1985 Traffic Signal Systems Handbook. Comments from many traffic engineering consultants reflect the need for, and continued use of, the very preliminary guidelines. However, no synthesis of these experiences or recommended improvements have been collected.

Urgency/Priority: Increasing urban congestion will be addressed by proposed new signals. Should they be coordinated and/or interconnected with existing systems? This proposed research is very urgently needed to achieve more cost-effective signal systems.

Cost: This could be a low-cost HPR Type B project (Synthesis of practice) at $20,000 or less. Possible PhD dissertation topic.

User Community: Federal, state and local traffic operations agencies. Traffic consultants nationwide.

Implementation: Application guideline with probable implementation procedures and data requirements.

Effectiveness: Urban auto traffic will experience reduced traffic congestion, fuel consumption and delays.

RESEARCH PROBLEM STATEMENT NO. 8: BALANCING OPERATIONS ALONG FREEWAY AND CORRIDOR STREETS DURING DIVERSION

Problem: There is a need to develop algorithms which will permit means for balancing traffic conditions along a freeway corridor.

Objective: To develop corridor balancing algorithms which projects the results of vehicle diversion assignments so as to permit a determination of when to stop and restart the diversion instructions to motorists.

Key Words: Diversion, Freeway, Corridor.

Related Work: Studies have been conducted on the effects on diversion. Also computer models such as FREQ provide the results of "what-if" changes within a corridor.

Urgency/Priority: Freeway corridor surveillance and control systems are being developed. There is an urgent need for developing an algorithm which predicts the results of diversion on the corridor.

Cost: $50,000

User Community: AASHTO, FHWA

Implementation: The research results can be developed using off-line calculations for determining which strategy to implement.

Effectiveness: Reduced travel time and operating costs, reduced fuel consumption and air pollution.

RESEARCH PROBLEM STATEMENT NO. 9: USE OF MAXIMUM BANDWIDTH AND MINIMUM DELAY MODELS IN SIGNAL SYSTEMS TIMING

Problem: There are two basic methods of timing traffic signals along arterials and within grid networks. These are the maximum bandwidth and minimum delay methods. Although there is considerable debate as to which to use, there are no guidelines available to assist the traffic engineer to determining where and when to use these models. It may be that under some circumstances one model should be used while in others another model should be used.

Objective: To develop guidelines for properly timing interconnected traffic signals using the maximum bandwidths and minimum delay models under different traffic conditions along arterials and within grid networks.

Key Words: Traffic Signal System Timing, Maximum Bandwidth, Minimum Delay

Related Work: Before and After studies have been made which demonstrate the benefits of both techniques. Comparisons between the two timing models have also been made; and in some instances, both models have been run in determining the best operation. No dedicated research work has been carried out, however, to develop guidelines for use by traffic engineers.

Urgency/Priority: It has been shown that properly timed traffic signals increase throughput along arterials and efficiency of intersection control. At present, it is only possible to determine the best timing concept by utilizing a combination of NETSIM, and engineering analysis of both maximum bandwidth and minimum delay timing models for various traffic conditions. With the need to assure increased efficiency of operation with minimum utilization of engineering time, there is an urgency for developing guidelines. The priority for this research is high.

Cost: $200,000 - $300,000

User Community: The user community includes all those persons involved with traffic signal system operation. The problem statement should be considered by ITE, AASHTO, and FHWA as well as by TRB.

Implementation: The research will be implementable by all traffic engineers involved with traffic operations and management.

Effectiveness: The research results will be of considerable effectiveness and of benefit to the traveling public. The effectiveness will be able to be measured by increased throughput and reduced stops, delays, vehicle emissions and fuel usage.

RESEARCH PROBLEM STATEMENT NO. 10: EVALUATION OF THE HIGHWAY CAPACITY MANUAL SIGNAL TIMING ANALYSIS TECHNIQUE

Problem: The 1985 Highway Capacity Manual (HCM) contains significant improvements in its ability to model the operation of a signalized intersection. The manual suggests on page 9-5 that the methodology is appropriate for determining signal timing. An entire appendix to Chapter 9 is devoted to determining sequences, cycle lengths and splits.

The new Highway Capacity Software (HCS) creates a computerized technique for signal analysis which joins a long list of established computer-based methods including SOAP, PASSER, and TRANSYT. The large current user base suggests that this is the most widely distributed signal timing analysis tool for microcomputers.

The HCS offers significant improvements in determination of saturation flow rates of individual approaches. There are, however, several apparent shortcomings. For example:

1. There is no optimization capability for any of the design parameters. Nonetheless, the complete design must be specified before the analysis may proceed.
2. The method is limited to a single time period, which precludes grouping in similar time periods for control purposes.
3. There is no provision for progression design.

4. The aggregation of left, through, and right turning movements into a single lane group destroys important origin-destination information needed for offset optimization.

5. The definition of delay in the HCM precludes a cost-benefit comparison of alternatives, especially when the saturation levels are high.

The HCM is based on a large amount of objective research, combined with a nationwide base of expert consensus. This imparts a degree of credibility to the procedure which could suggest that the values for delay, etc. computed by the HCS are superior to those computed by the established signal timing programs. This is a recurring question which should be resolved.

Objectives:

1. Identify the strengths and weaknesses of the HCM methodology for signal design and analysis, compared to the established signal timing programs.

2. Provide guidelines for a comprehensive procedure which utilizes the HCM techniques with the established signal timing programs.

3. Where appropriate, modify the traffic analysis models in the established signal timing programs to reflect the HCM procedures.

Key Words: Highway Capacity, Signal Timing

Related Work:

1. Through FHWA and state level support, the established signal timing programs are supported, maintained and updated.

2. NCHRP Project 3-28C is concerned with improving the progression-delay model in the HCM technique.

Urgency/Priority: This work needs to be done as soon as possible to ensure that the new HCM techniques will be integrated as quickly and smoothly as possible into traffic engineering practice.

Cost: $100,000

User Community: A broad segment of the traffic engineering profession.

Implementation:

1. HCM updates.

2. Updates to the established signal timing programs.

Effectiveness: Motorist operating costs, fuel consumption and safety measures are all known to be sensitive to the quality of signal timing design. As the design techniques are improved, the motoring public will benefit in each of these areas.