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RESEARCH AND MANAGEMENT FOR ADVANCED TRAFFIC SIGNAL SYSTEMS

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FOREWORD

The new age of advanced technology in transportation is evolving to include all levels of transportation management systems. Faster and more powerful microcomputers permit the application of new concepts and algorithms in ways which have never before been possible. Such applications will be utilized by the traffic signal system computer located at a traffic management center (TMC) and at several subsystem control locations. Intersection controller and distinct detector systems will also become integrated. Furthermore, this new technology will allow a fusion of traffic signal, freeway, and public transportation systems (integrated traffic management systems) to allow free communication between these systems and the individual vehicle.

As technology is developing, it is vital that research keep current with these developments.The TRB Committee on Traffic Signal Systems has recently focused its attention on the developmental needs of advanced traffic signal systems and traffic management. They have examined the research needs related to the development of these systems and have drawn together several that apply directly to the improvement of traffic signal and traffic management systems.

Contained in this circular are:

- A report on "Planning Issues of Advanced Traffic Management Systems," which is a summary of committee discussions on the planning issues of traffic signal control systems;
- A white paper, "Definition of Functional Requirements and Identification of Potential Research Initiatives," in which (1) the functional requirements of Advanced Traffic Signal Control Systems are identified, (2) the ability of the existing "typical" traffic signal control systems to deliver each functional requirement is rated, and (3) the areas that need to be researched are also prioritized; and
- A set of Research Problem Statments grouped into various technology categories.

The answers to the issues and needs presented in this circular will significantly improve traffic management systems.

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PLANNING ISSUES OF ADVANCED TRAFFIC MANAGEMENT SYSTEMS

INTRODUCTION

The Intelligent Vehicle-Highway System (IVHS) program has grown rapidly in the United States since the passage of the Intermodal Surface Transportation Efficiency Act of 1992 (ISTEA). One major component of IVHS is the Advanced Traffic Management System (ATMS) which incorporates state-of-the-art technologies to monitor traffic conditions, adjust traffic operations, and respond to incidents. Clearly, traffic signal control systems (TSCS) will be major building blocks in the development of ATMS. The TRB Traffic Signal Systems Committee recognized the strong need to plan and design for TSCS and initiated a group discussion to address the planning issues during a mid-year meeting. The following summarizes the conclusions of the group discussion.

SYSTEM OBJECTIVES

Traditionally, a TSCS is designed to achieve the maximum progression and minimumize vehicle stops and delays. These objectives, while still legitimate, need to be broadened for application to ATMS. The following objectives are critical to ATMS:

To Improve Traffic Movement Efficiency

This objective is to allow maximum utilization of the existing roadway systems by people, goods, and services. ATMS addresses all modes of highway transportation including single occupancy vehicle, high occupancy vehicle, public transportation, and freight transportation. ATMS should serve all travellers and all modes of roadway transport, not just passenger car drivers. It is important to understand that the primary focus should be the maximum utilization of the roadway by people, not by vehicles.

To Enhance Safety

In Europe, systems are being designed with safety as a primary objective. There is great potential to enhance traffic safety through advanced technologies.

To Improve Highway Operating Performance

Through performance improvements on roadway systems and trip predictability in major urban traffic corridors economic benefits to individuals and society through a maximization of return from an investment in the roadway infrastructure will be realized.

To Improve Air Quality

The advanced traffic management systems will reduce exhaust emissions through the more efficient operation of the roadway. In metropolitan areas such as Los Angeles and Denver, improvement in air quality through advanced technologies is a primary objective of ATMS.

To Conserve Energy

With the use of real-time traffic data, traffic responsive control strategies, and integration with advanced information systems, total energy consumption on the roadway transport system can be reduced.

LEAD AGENCY FOR ATMS

It is expected that most IVHS programs will involve public agencies at multiple levels because of the large scope and technical complexity involved. Institutional aspects likely will be more complex with a freeway/ surface street corridor type of control system where multi-purpose integrated systems are implemented and additional governmental entities, such as police departments and transit authorities, are involved. Obviously, multi-agency coordination is a key factor for the successful achievement of any ATMS programs.

Facilitator's Role

It is debatable whether a so called "Lead Agency" should be designated for the entire project effort. Such a designation may give a single agency overriding powers, causing grievances and frictions that may become detrimental to the project. However, it is recognized that at least one agency needs to provide a facilitator's role for the project efforts. Such an agency will share the visions and provide directions for the entire project team to move forward with the process.

Policy Advisory Committee

A practical procedure is to form a "Policy Advisory Committee" which would involve all related agencies from the earliest planning stage through the implementation and operation of the systems. Periodic meetings should be held to discuss and resolve system issues and to acquaint participants with the overall project goals, schedule, and work plan. Each agency should be aware of its responsibilities and resource requirements. Financial, personnel, and other resource commitments should be described in formal written agreements. The Policy Advisory Committee can be a part of the Traffic Management Team, which brings all agencies involved in traffic operations together regularly to solve traffic management, congestion, safety, and enforcement problems.

Consensus Building Process

In summary, multi-agency coordination is a consensus building process to achieve common understandings of the project objectives and responsibilities among all participating agencies. Any dispute over conflicting priorities and policies needs to be resolved using a great deal of sensitivity and patience. All agencies must strive to work together on a team basis.

NON-ATMS SOLUTIONS

There are many non-ATMS solutions that can be applied to alleviate congestion problems. These solutions should not be overlooked when any intensive ATMS programs are planned, designed, and implemented. Congestion management plans, land use issues, and broader area overviews were identified as key non-ATMS solutions that should be considered.

EXISTING URBAN TRAFFIC SYSTEMS

There are various types of urban traffic systems in existence including closed-loop systems, UTCS, SCOOT, and many others. Each system has its unique functionalities and characteristics. The true issue is how these existing urban traffic signal control systems can adapt to the future IVHS implementations.

In a recent report prepared by the ATMS subcommittee of A3A18 chaired by Les Kelman, entitled *Advanced Traffic Signal Control Systems: Definition of Functional Requirements and Identification of Potential Research Initiatives* (included in this Circular), the functional requirements of Advanced Traffic Signal Control Systems are identified. The ability of the existing "typical" traffic signal control systems to deliver each functional requirement are also rated. In the end, the areas that need to be researched are prioritized into four major groups. The two highest priority groups are:

Group 1

- Provide online creation or modification of traffic plans.
- Provide selection by notification of congestion or near saturation conditions.
- Provide inter-system communication of both processed and raw data, control, and status information.

Group 2

- Provide arterial incident detection.
- Provide integration of available data from multiple sources into required traffic plans.
- Provide the processing of data from other data collection devices/techniques.
- Provide several control objectives.

It is noted that not all existing systems lack the above capabilities. For example, the SCOOT system is already capable of creating online timing plans on a real time basis. Research and development is also underway to develop fully adaptive control systems.

Another area that offers tremendous benefits is the application of expert systems to traffic control. Expert system software can greatly enhance the data collection, decision making, verification, and evaluation processes in a "typical" traffic control system.

The need to provide common communications protocol, integration of various data sources, and component interchangeability are the critical features to the adaption of the existing traffic control systems to the ATMS.

REGULATIONS AND STANDARDS

IVHS related regulations need to be reviewed, revised, or even established at various levels of government. The ATMS will effect certain display signs and equipment installed in the roadway. It is important for governing entities to ensure that all new devices meet the safety criteria when exposed to the public. For example, the introduction of new warning signs to advise motorists of road conditions need to be properly located and provide clear messages to the motorists.

Standards should not be established at the early stage of any research efforts when alternate solutions are not fully explored. At a later stage of research, however, it becomes inefficient to work along parallel paths without a standard. The need to develop certain standards for the advanced traffic management system can be summarized as the following:

- Traffic control systems have a cross-border function, standards can ensure consistency and compatibility.
- To achieve economics of scale for the production of the traffic management equipment, adequate standardization is required.

• Standards are needed in traffic information systems to avoid any language problems. This will become an important issue when international application is considered.

It is noted that some standards already exist, but they are not encompassing nor are they sufficient. A process for identifying necessary standards and then for developing, revising, approving, and implementing these comprehensive standards is needed. As an early step, studies should be undertaken to determine the need for standards in the communication system between various control centers, the display system of traffic messages, and the data collection system transmitted directly from/to vehicles. It is suggested that performance specifications be developed to clearly define the functional requirements of each subsystem.

FLEXIBILITY AND ADAPTABILITY OF ATMS DESIGN

To meet the functional requirements of IVHS, traffic management system design needs to incorporate future area-wide demand-responsive and route guidance systems into today's traffic responsive system. Maximum flexibility should be built-in to accommodate future expansion. This involves the development of long term plans at an early stage to ensure installation of efficient and cost-effective systems. Any advanced traffic management systems should also make provisions for public transportation and high-occupancy vehicle (HOV) lane operation.

Another aspect of the ATMS design is adaptability. Systems should be designed on a modular basis for application in both large and small cities for easy interface with future IVHS route guidance and advanced motorist information systems. The purpose is to set up a base structure for uniform IVHS application in the future.

OPERATION AND MAINTENANCE

The importance of operation and maintenance cannot be over-emphasized. The technological complexity of equipment and the increased flexibility of the software for the advanced traffic management systems can represent a significant increase in operation and maintenance activities. For example, the enhanced hardware monitoring capability requires a higher and more responsive degree of maintenance. Similarly, the increased flexibility of the advanced system demands additional operator involvement. A higher level of technical expertise and more technically competent staff is required to adequately operate and maintain the IVHS system. In addition, there is a strong need for enhanced tools such as test equipment and terminals.

It is crucial to budget sufficient resources and staff if the system is to be utilized to its full potential. When the total cost of an advanced system is budgeted, the operation and maintenance costs should be included up-front to ensure that adequate operation and maintenance activities can be performed. The Federal government is considering providing funding for up to three-years of operation and maintenance costs together with the capital cost of the federal-aid IVHS programs. Consideration should also be given to allowing state and local agencies to use a portion of their federal-aid allocation to fund IVHS operations and maintenance costs at their discretion.

ACCEPTABILITY OF ATMS SYSTEMS

To the Public

To achieve public acceptance, the advanced traffic management system must be reliable. All information given to the motorists such as speeds and delays must be reasonably accurate. Discrepancies between actual road conditions and the information provided to the public should be minimized. It is better to provide no information than wrong information. Public trust is a very sensitive issue and the support from the public can evaporate very easily if credibility cannot be maintained.

To All Agencies

The advanced traffic management systems have to be acceptable to all agencies involved. Several traffic control strategies such as ramp metering and route diversion can be expected to generate strong opposition from local agencies. These measures can be perceived to improve freeway travel at the expense of added congestions on local streets. Such conflicting priorities and policies among agencies in any advanced traffic management system projects can cause significant problems and have to be resolved with a great deal of sensitivity at the planning stage. Normally, a certain level of autonomous control over signal operation and the magnitude of diverted traffic is granted to individual agencies to allay local concerns.

CONCLUSIONS

The major issues of planning traffic signal control systems for ATMS identified in this Circular include System Objectives, Lead Agency, Non-ATMS Solutions, Existing Urban Traffic Systems, Regulations and Standards, Flexibility and Adaptability, Operation and Maintenance, and Acceptability.

It is recognized that the system objectives for the ATMS need to be broadened to include the improvements on overall traffic movement efficiency, highway safety, highway operating performance, air quality, and energy conservation.

Multi-agency coordination is a key factor for the successful implementation of any IVHS programs and at least one agency should provide a facilitator's role to lead the vision and direction. It is a consensus building process to achieve a common understanding of the project objectives and responsibilities among all participating agencies.

There are many non-ATMS program solutions that should not be overlooked when any intensive ATMS programs are planned, such as congestion management plans, land use issues and broader area overview.

For the existing urban traffic signal control systems, the issue is how they can adapt to the future IVHS implementations. The functional requirements of advanced traffic control systems identified by the ATMS subcommittee can serve as a base. Also, the need to provide common communication protocol, integration of the various data sources, and component interchangeability are critical features to the adaption.

ATMS related regulations need to be reviewed, revised or even established at various levels of government. A process for identifying necessary standards needs to be developed. It is suggested that performance specifications be prepared to clearly define functional requirements of each subsystem.

Maximum flexibility should be built into each system to accommodate future expansion. Also, systems should be designed on a modular basis for application in both large and small cites, and for easy interface with future IVHS across the country.

It is crucial to budget sufficient resources and staff for operation and maintenance. Funding from public sources is becoming available for the IVHS programs through ISTEA. Various privatization arrangements can be explored to encourage private participation in the IVHS programs.

The last, but perhaps the most important, issue is the acceptability of the ATMS programs to the public and to all agencies. To achieve public acceptance, the ATMS has to work well, reliably, and accurately. Any conflicting priorities and policies among agencies in any ATMS project has to be dealt with a great deal of sensitivity at the early planning stage.

REFERENCES

1. Herman E. Haenel and Alfred H. Kosik, "Texas's PEGASUS and Triad – Planning for Tomorrow's Transportation Needs," ITE Journal, April, 1991.

2. Edwin Rowe, "Public Agency Issues in the Implementation of IVHS," paper presented in the ASCE Second International Conference of Advanced Technologies Applications on Transportation, August, 1991.

3. U.S. Department of Transportation, "Report to Congress on Intelligent Vehicle-Highway Systems," March, 1990

4. Mark R. Norman, "Intelligent Vehicle-Highway Systems in the United States-The Next Steps," ITE Journal, November, 1990

5. Organization for Economic Cooperation and Development, "Dynamic Traffic Management in Urban and Suburban Road Systems," Paris, 1987

6. Organization for Economic Cooperation and Development, "Route Guidance and In-Car Communication Systems," Paris, 1988

DEFINITION OF FUNCTIONAL REQUIREMENTS AND IDENTIFICATION OF POTENTIAL RESEARCH INITIATIVES

INTRODUCTION

Development and implementation of Intelligent Vehicle/Highway Systems (IVHS) are proceeding at a rapid pace. The major components of IVHS include:

- Advanced Traffic Management Systems (ATMS);
- Advanced Traveller Information Systems (ATIS);
- Automated Vehicle Control Systems (AVCS);
- Commercial Vehicle Operations (CVO); and
- Others.

Within the component of Advanced Traffic Management Systems, it is recognized that existing traffic signal control systems (TSCS) will play a significant role.

An objective of the Transportation Research Board (TRB) Signal Systems Committee is to develop formal statements of research needs for Advanced Traffic Signal Control Systems (ATSCS) to ensure that these systems will not be the "weak link" in future IVHS implementations. Before preparing these formal research statements, it is necessary to define typical functional requirements and identify potential research initiatives. Therefore, the Signal Committee has conducted the following tasks:

- Identified Functional Requirements for ATSCS;
- Classified the Functional Requirements;
- Rated the ability of "typical" traffic signal control systems to deliver each Functional Requirement; and
- Prioritized the Functional Requirements not typically available in most TSCS into four groups based on a mail survey of the Traffic Signal Systems Committee members and friends.

These four tasks are discussed in the remaining sections of this report.

IDENTIFYING FUNCTIONAL REQUIREMENTS

Table 2.1 in Chapter 2 of the Federal Highway Administration (FHWA) Traffic Control Systems Handbook (FHWA-IP-85-11) provides a detailed list of functional requirements for Traffic Signal Control Systems. Using this as a base, the list of functional requirements for Advanced Traffic Signal Control Systems included in Appendix A was developed as:

- The FHWA list was edited and condensed where appropriate; and
- The list of functional requirements prrpared during a mid-year meeting of the Traffic Signal Systems Committee was cross-referenced to this base list and new items were added as appropriate.

The list of functional requirements in Appendix A has been restricted too true ATSCS features. It has been assumed that related functions (e.g. traveller information, in-vehicle navigation systems) will be handled by other IVHS subsystems. The requirements for inter-system communication (Appendix A, Item 14) have been included to allow ATSCS to send and receive data related to these external functions.

CLASSIFYING FUNCTIONAL REQUIREMENTS

For discussion purposes, it is advantageous to group the functional requirements into categories. The preliminary definitions set out by the committee were found to be a subset of those given in the FHWA Traffic Control Systems Handbook, Section 2.2 and Figure 2.1 shown below.

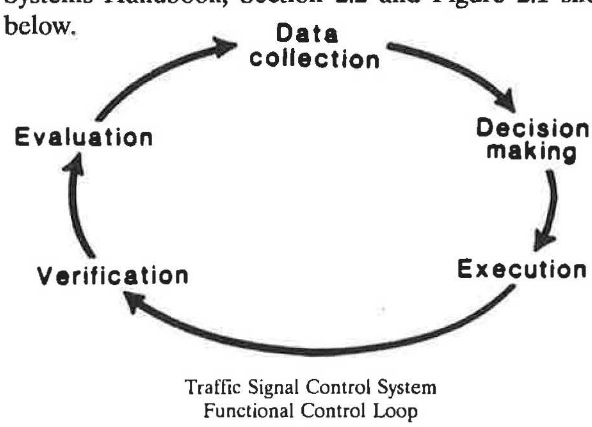

FIGURE 1 Traffic signal control system, functional control loop.

These categories form a closed control loop. Each pass through the loop is directly dependent upon the evaluation of the performance during previous circuits of the loop.

The functional requirements presented in Appendix A have been classified according to the five categories in the control loop and further subdivided according to nine types of features given by Table 2.1 of the FHWA Handbook. The classifications and subdivisions are:

Category	Features That Have to do With
Data Collection	(A) Data Collection
Decision Making	(B) Overall Traffic Plan Creation (C) Traffic Plan Selection
Execution	(D) Operational Capabilities (E) Safety, Backup, and Maintenance
Execution/Verification	(F) Operator Monitoring and Control of the System
Evaluation	(G) Assistance for Intersection or System Evaluation
Data Collection	(H) Storage of Ancillary Data
Execution/Verification/ Data Collection	(I) System Wide Communication

Groups A and H both relate to the category of Data Collection to emphasize the concept of a control loop. Group 1 deals with communication that is integral to the entire control loop. Ordering of the requirements within each group in Appendix A does not have any implications.

RATING TSCS PERFORMANCE

In order to define the extent to which present Traffic Signal Control Systems deliver the functions listed, a performance rating based on a scale of one to five was assigned. This is intended to reflect our present capabilities and not necessarily the extent to which we use these capabilities. A hypothetical "typical system" has been assumed. It must be recognized that many functions could be rated differently for different systems (e.g. UTCS versus SCOOT). The 16 functional requirements assigned a low rating number (i.e., 1) are those that we believe are most likely to benefit from new research initiatives. A further description of these requirements has been developed and included as Appendix B. These descriptions relate each requirement to its basis in technology (devices), techniques (initial processing of the device), or strategy (overall processing of the device).

PRIORITIZING RESEARCH INITIATIVES

All members and friends of the Traffic Signal Systems Committee to rank the relative importance of research related to the 16 high priority functional requirements.

Although a wide variety of opinion was apparent, the results were used to create four priority based groups of functional requirements as follows: (Appendix A identifier in parentheses).

Group 1 (highest priority for research)

- Provide online (real time) creation or modification of traffic plans. (B5)
- Provide selection by notification of congestion or near saturation conditions. (C5)
- Provide inter-system communication of both processed and raw data, control and status information. (I4)

Group 2

- Provide arterial incident detection. (A4)
- Provide integration of available data from multiple sources into required traffic plans (phasing, timing, related functions). (B1)
- Provide processing of data from other data collection devices/techniques. (A2)
- Provide several control objectives. (C8)

Group 3

- Provide techniques for short term traffic flow prediction. (B4)
- Provide selection of control objective by signal grouping, by time or by other conditions. (C9)
- Provide an online presentation of traffic demand, short term estimates, and available system responses. (F12)

Group 4

- Provide travel time estimation and verification. (A5)
- Provide variable system architecture (central and distributed). (D1)
- Provide online, expert system calculation of actual values for intersection/system measures of effectiveness specific to the control objective. (G2)

• Provide a variable transition timing strategy dependent on control objective and/or source of new selection. (C10)

• Provide offline, expert system calculation of desirable values for intersection/system measures of effectiveness specific to the control objective. (G1)

• Provide measures of long term traffic trends. (A6)

A further group of ten functional requirements at a priority level just below these are:

• Provide processing of preempt/priority vehicle request. (A3)

• Provide selection by external notification of special events or incidents. (C4)

• Provide operation of related non-signal devices. (D6)

• Provide implementation of adaptive control algorithms at the controller. (D7)

• Provide detection, classification, warning, and historical records of component failures. (E2)

• Provide a color graphic CRT display. (F9)

• Provide for operation by multiple jurisdictions. (F10)

• Provide operational status monitoring of other IVHS subsystems. (F11)

• Provide storage of signal operation details (actual phase timing, hardware performance). (H3)

• Encode/decode data for demand specific communications. (I2)

SUMMARY

This white paper has provided a background for the development of formal research statements related to Advanced Traffic Management System (ATMS).

In proceeding with the research statements, it should be noted that we have considered the present ability of most TSCS to deliver each functional requirement. We have not evaluated the benefit/cost ratio or the potential for success of research related to the functions.

It is also noted that several functional requirements are inter-related and could be combined in subsequent research statements.

APPENDIX A: FUNCTIONAL REQUIREMENTS AND PERFORMANCE RATING

TABLE 1 FEATURES THAT HAVE TO DO WITH DATA COLLECTION

Performance Rating ~ Range 1 To 5

5 ***Functional Capability Is Typically Available In Most TSCS***
3 ***Functional Capability Is Partially Developed In Most TSCS***
1 ***Functional Capability Is NOT Typically Available In Most TSCS***

Performance Rating	Identifier	Statement Of Functional Requirement
		Category: Data Collection
		Features that have to do with Data Collection
3	A 1	Provide processing of data from standard inductive loop detectors e.g. Volume, Occupancy, Speed(1 loop estimate, 2 loop actual), Vehicle Classification, Queue Length
1	A 2	Provide processing of data from other data collection devices/techniques ~ Above ground detectors, e.g. As per loops ~ Pedestrian detection, e.g. Volume and/or location in crosswalk ~ Video detection, e.g. Image processing for data similar to loops ~ Visual Surveillance, e.g. Operator detection of changing conditions ~ Environmental sensors, e.g. Air quality, Ice probability ~ Instrumented Vehicles, e.g. travel time, delay ~ Other IVHS subsystems, e.g. FTMS diversion imminent, Intelligent vehicle travel data, Centralized notification of Scheduled Events
2	A 3	Provide processing of preempt / priority vehicle requests e.g. Emergency service vehicles, Transit vehicles, Railroad crossings, HOV lanes, Other IVHS subsystems
1	A 4	Provide arterial incident detection
1	A 5	Provide travel time estimation and verification
1	A 6	Provide measures of long-term traffic trends

TABLE 2 FEATURES THAT HAVE TO DO WITH OVERALL TRAFFIC PLAN CREATION; FEATURES THAT HAVE TO DO WITH TRAFFIC PLAN SELECTION

Performance Rating ~ Range 1 To 5

5 Functional Capability Is Typically Available In Most TSCS

3 Functional Capability Is Partially Developed In Most TSCS

1 Functional Capability Is NOT Typically Available In Most TSCS

Performance Rating	Identifier	Statement Of Functional Requirement
		Category: Decision Making
		Features that have to do with overall traffic plan creation (Phasing, Timing, Related Functions)
[1]	B 1	Provide for integration of available data from multiple sources into required traffic plans
5	B 2	Provide storage for many unique traffic plans for each intersection
3	B 3	Provide offline (background) creation of traffic plans
[1]	B 4	Provide techniques for short-term traffic flow prediction
[1]	B 5	Provide ONLINE (real time) creation or modification of traffic plans
		Features that have to do with traffic plan selection
5	C 1	Provide selection by operator command
5	C 2	Provide selection by time of day
4	C 3	Provide selection by traffic responsive algorithm
[2]	C 4	Provide selection by external notification of special events or incidents
[1]	C 5	Provide selection by notification of congestion or near saturation condition
3	C 6	Provide techniques for determination and storage of selection parameters
3	C 7	Provide techniques for ensuring system stability (hysteresis)
[1]	C 8	Provide several control objectives e.g. Min Delay, Max Air Quality, Queue/Congestion Dissipation, Demand Control(Gating)
[1]	C 9	Provide selection of control objective by signal grouping, by time or by other conditions e.g. Jurisdiction, Subarea, TOD/DOW, Environment Conditions
[1]	C 10	Provide a variable transition timing strategy dependent on control objective and/or source of new selection

TABLE 3 FEATURES THAT HAVE TO DO WITH OPERATIONAL CAPABILITIES; FEATURES THAT HAVE TO DO WITH SAFETY, BACKUP, AND MAINTENANCE

Performance Rating ~ Range 1 To 5

5 Functional Capability Is Typically Available In Most TSCS

3 Functional Capability Is Partially Developed In Most TSCS

1 Functional Capability Is NOT Typically Available In Most TSCS

Performance Rating	*Identifier*	*Statement Of Functional Requirement*
		Category: Execution
		Features that have to do with operational capabilities
1	D 1	Provide variable system architecture (central or distributed)
5	D 2	Provide for operation of pretimed signal controllers
4	D 3	Provide for operation of actuated signal controllers
4	D 4	Provide coordinated or free signal controller operation
4	D 5	Provide for unattended system operation
2	D 6	Provide for operation of related non-signal devices e.g. Reverse lane systems, Lane control signals, Blank out signs, Speed Signs
2	D 7	Provide for implementation of adaptive control algorithms at the controller.
		Features that have to do with safety, backup, and maintenance
5	E 1	Provide detection and warning of unsafe signal displays
2	E 2	Provide detection, classification, warning and historical records of component failures
3	E 3	Provide backup signal control with coordination and TOD/DOW plan selection
5	E 4	Provide programmed flash operation
4	E 5	Provide safe, smooth pickup, dropoff and reversion to/from all operating modes e.g. Online, Standby, Backup, Free, Flash
4	E 6	Provide safe, smooth system restart capability
3	E 7	Provide for ease of system maintenance e.g. Appropriate diagnostic procedures, Upload / Download of all controller parameters, Confirmation of previously downloaded controller parameters,

TABLE 4 FEATURES THAT ALLOW OPERATOR MONITORING AND CONTROL OF THE SYSTEM

Performance Rating ~ Range 1 To 5	
5	***Functional Capability Is Typically Available In Most TSCS***
3	***Functional Capability Is Partially Developed In Most TSCS***
1	***Functional Capability Is NOT Typically Available In Most TSCS***

Performance Rating	*Identifier*	*Statement Of Functional Requirement*
		Category: Execution / Verification
		Features that allow operator monitoring and control of the system
3	F 1	Provide a menu driven operator instruction system using current computer techniques
3	F 2	Provide an override of the menu driven system for the experienced operator
3	F 3	Provide a context sensitive, online Help facility
3	F 4	Provide an operator supervised display subsystem
3	F 5	Provide numerous reports to selectable devices/destinations
4	F 6	Provide for a wall-type map display
3	F 7	Provide for a projection-TV map/graphics display
3	F 8	Provide a user-friendly database management system
2	F 9	Provide a colour-graphic CRT display
2	F 10	Provide for operation by multiple jurisdictions e.g. Variable priorities, passwords and/or terminal access linked to specific signal groupings
2	F 11	Provide for operational status monitoring of other IVHS subsystems e.g. FTMS subsystem online / offline status by subarea
1	F 12	Provide an Online presentation of traffic demand, short term estimates and available system reponses.

TABLE 5 FEATURES THAT PROVIDE ASSISTANCE FOR INTERSECTION OR SYSTEM EVALUATIONS; FEATURES THAT HAVE TO DO WITH STORAGE OF ANCILLARY DATA; AND FEATURES WHICH PROVIDE SYSTEM WIDE COMMUNICATIONS

Performance Rating ~ Range 1 To 5
5 Functional Capability Is Typically Available In Most TSCS
3 Functional Capability Is Partially Developed In Most TSCS
1 Functional Capability Is NOT Typically Available In Most TSCS

Performance Rating	Identifier	Statement Of Functional Requirement
		Category: Evaluation
		Features that provide assistance for intersection or system evaluation
1	G 1	Provide offline, "Expert system" calculation of desirable values for intersection/system measures of effectiveness specific to the control objective
1	G 2	Provide ONLINE, "Expert system" calculation of actual values for intersection/system measures of effectiveness specific to the control objective
		Category: Data Collection
		Features that have to do with storage of ancillary data
5	H 1	Provide for storage of detector data
5	H 2	Provide for storage of system activity log
2	H 3	Provide for storage of signal operation details e.g. Actual phase timing, hardware performance
		Category: Execution / Verification / Data Collection
		Features which provide system wide communications
4	I 1	Encode/decode data for regular,repetitive communications
2	I 2	Encode/decode data for demand specific communications
4	I 3	Modulate/demodulate carrier frequency for communications over different media
1	I 4	Provide for inter-system communication of both processed and raw data, control and status information

APPENDIX B: DESCRIPTION OF FUNCTIONAL REQUIREMENTS MOST LIKELY TO BENEFIT FROM NEW RESEARCH INITIATIVES

CATEGORY: DATA COLLECTION
FEATURES THAT HAVE TO DO WITH DATA COLLECTION

A2. Provide Processing of Data From Other Data Collection Devices/Techniques
Many new or enhanced methods of detection (in addition to loops) are available now or are in development. Other types of data (in addition to traffic volume and occupancy) are also available, e.g. weather information. Traffic Signal Control Systems have typically been designed to respond to loop generated traffic data only.

There are many implications that will arise from the integration of these new detection devices and their control techniques into Advanced Traffic Signal Control Systems. For example:

- The type of hardware interface (subsystem processor or direct control);
- The type of software interface (data format, acceptable data ranges, status information formats);
- The frequency at which data is available (each second, 1 minute upload, on demand, etc.);
- The quantity of data generated; and
- The quantity of data which should be stored and the appropriate storage device(s).

Relates to: Technology, Techniques

CATEGORY: DATA COLLECTION
FEATURES THAT HAVE TO DO WITH DATA COLLECTION

A4. Provide Arterial Incident Detection
Knowledge of "arterial incidents" would allow ATSCS to perform more global system optimization. TSCS have typically reacted to volume and occupancy numeric thresholds only. Improved control decisions could be made if the available data collection technology and processing techniques could be used to achieve reliable Arterial Incident Detection.

It is possible that research in this area could drive further development of additional detection hardware.

Relates to: Techniques, Strategy

CATEGORY: DATA COLLECTION
FEATURES THAT HAVE TO DO WITH DATA COLLECTION

A5. Provide Travel Time Estimation and Verification
Travel time along an individual link or along a specified route is an important item of information/measure of effectiveness regarding system operation. ATSCS could directly use link travel time to verify the delay estimates used to modify signal timings. IVHS could use link and route travel time to make decisions regarding routing strategies and traveller information.

New detection technology should offer improved capability to estimate travel time, perhaps by combining data from several sources. Vehicle identification (either transit or private vehicles) offers the possibility of tracking specific vehicles and therefore providing information which could be used to verify actual travel time. This requirement is intended to focus on use of the data.

Relates to: Techniques, Strategy

CATEGORY: DATA COLLECTION
FEATURES THAT HAVE TO DO WITH DATA COLLECTION

A6. Provide Measures of Long Term Traffic Trends
It is very important for transportation personnel to be aware of the long term trends in traffic volume and distribution in order to analyze the performance of existing systems and to determine the most appropriate use of future resources. Although most TSCS provide some historical storage of loop based traffic data, there is very little post processing or analysis available. ATSCS should be able to assimilate traffic data from various collection devices including manual counts and regularly provide growth statistics and other trend indicators.

Relates to: Techniques, Strategy

CATEGORY: DECISION MAKING
FEATURES THAT HAVE TO DO WITH OVERALL TRAFFIC PLAN CREATION

B1. Provide for Integration of Available Data From Multiple Sources into Required Traffic Plans
New detection capabilities along with data available from other IVHS components will provide significant additional detail on the operation of the arterial street system, e.g. travel time data, queue production, construction details. Managers, users and operators of ATSCS must decide how to use this data to develop more efficient traffic plans (phasing, timing and related functions). Knowledge based, expert systems may be invaluable in attempts to structure a procedure for integrating all the available data prepared.

Relates to: Strategy

CATEGORY: DECISION MAKING
FEATURES THAT HAVE TO DO WITH OVERALL TRAFFIC PLAN CREATION

B4. Provide Techniques for Short Term Traffic Flow Prediction
Traffic plans are typically created and selected in response to traffic flow patterns observed anywhere from five minutes to over a year in the past. A reliable technique for predicting short term trends in traffic flow has eluded researchers. The integration of data from more than one type of device may offer new possibilities. Potential benefits are significant since a lot of delay is incurred during the time it takes most jurisdictions/systems to react to a change in traffic flow.

Related to: Techniques

CATEGORY: DECISION MAKING
FEATURES THAT HAVE TO DO WITH OVERALL TRAFFIC PLAN CREATION

B5. Provide Online (Real Time) Creation or Modification of Traffic Plans
The task of designing traffic plans (phasing, timing and related functions) will continue to increase in scope due to several factors:

- Network complexity;
- Recognition of varying control objectives;
- Recognition of varying control boundaries; and
- Better ability to detect unique traffic flow patterns.

ATSCS need to be able to use recently collected traffic data and the short term traffic predictions and formulate new traffic plans which maximize any specified control objective.

Relates to: Strategy

CATEGORY: DECISION MAKING
FEATURES THAT HAVE TO DO WITH TRAFFIC PLAN SELECTION

C5. Provide Selection by Notification of Congestion or Near Saturation Conditions
Given the existence of more traffic plans responsive to a greater variety of traffic conditions. ATSCS must be able to base its selection between these plans on a wider selection of parameters. In particular, ATSCS should be able to select special intersection or subarea plans which implement specific congestion (i.e., blocked intersection) relief measures upon notification by some type of congestion alarm.

Relates to: Strategy

CATEGORY: DECISION MAKING
FEATURES THAT HAVE TO DO WITH TRAFFIC PLAN SELECTION

C8. Provide Several Control Objectives
C9. Provide Selection of Control Objective by Signal Grouping, By Time or By Other Conditions
At certain times and under certain conditions an ATSCS should be able to select traffic plans based on different control objectives. For example, minimizing exhaust emissions in order to improve air quality may be a desirable objective during some time periods; however, during peaks demand control (gating of traffic into a capacity constrained or otherwise sensitive area) or dissipating queues which are blocking cross streets may become the overriding control objective.

ATSCS must have the capability to select traffic plans which maximize the defined control objective for the existing traffic conditions. A separate set of traffic responsive selection parameters may be required for each control objective.

An ATSCS also requires the ability to implement different control objectives for separate groups of signals. Changes in the controlling objective may be based on the jurisdiction (different cities), the subarea (CBD/Suburban), the time of day (peak/off peak), or the weather (dry/wet/snow).

Relates to: Strategy

CATEGORY: DECISION MAKING
FEATURES THAT HAVE TO DO WITH TRAFFIC PLAN SELECTION

C10. Provide a Variable Transition Timing Strategy Dependent on Control Objective and/or Source of New Selection
All TSCS provide some means of transition between different signal and or timing plans. The transition is usually based on maintaining minimum pedestrian and vehicle clearance and green displays. Given the requirements for ATSCS to support different selection techniques and control objectives, a more sophisticated transition routine is required.

The transition routine should recognize the new and old conditions and perhaps check the actual need for certain minimums at the specific time in order to maximize response time while maintaining safety.

Relates to: Techniques, Strategy

CATEGORY: EXECUTION
FEATURES THAT HAVE TO DO WITH OPERATIONAL CAPABILITIES

D1. Provide Variable System Architecture (Central or Distributed)
Significant differences exist between central systems designed for locally intelligent controllers (local controller executes signal/timing plan, collects and does initial summarization of detector data, etc.) and systems designed for central intelligence (controller timing decisions are made by the central computer). A system can also be split up into sectors, each with their own computer, and a master computer which oversees the sectors. Some optimization routines require central intelligence (SCOOT); however, the capabilities of locally intelligent controllers may be beneficial.

Therefore, ATSCS should be able to handle different types of controllers (actuated, pre-timed, etc.) under both types of system architecture. Impacts on communication schemes and communication equipment may be significant.

Relates to: Technology, Techniques

CATEGORY: EXECUTION/VERIFICATION
FEATURES THAT HAVE TO DO WITH OPERATOR MONITORING AND CONTROL OF THE SYSTEM

F12. Provide an Online Presentation of Traffic Demand, Short Term Estimates and Available System Responses
Although ATSCS should have the capability to respond automatically to changing traffic conditions, it is desirable for operators to be able to monitor the process and modify the system's recommended decision. This capability is extremely important in building user confidence and in giving the user an online method for adjusting system response to new or unexpected conditions. Perhaps traffic responsive selection parameters could be "learned" from the operator's response to the presented traffic conditions/estimates.

Relates to: Strategy

CATEGORY: EVALUATION
FEATURES THAT PROVIDE ASSISTANCE FOR INTERSECTION OR SYSTEM EVALUATION

G1. Provide Offline, Expert System Calculation of Desirable Values for Intersection/System Measures of Effectiveness Specific to the Control Objective
G2. Provide Online, Expert System Calculation of Actual Values for Intersection/System Measures of Effectiveness Specific to the Control Objective
In order to know how well the system is meeting the control objective, actual performance must be compared to desired performance. New measures of effectiveness directly related to each control objective must be developed and desirable thresholds set.

By developing real-time methods for calculating the measures of effectiveness for actual conditions, system operation (i.e., traffic plans) can be fine tuned.

Relates to: Techniques, Strategy

CATEGORY: EXECUTION, VERIFICATION, AND DATA COLLECTION
FEATURES WHICH PROVIDE SYSTEM WIDE COMMUNICATIONS

I4. Provide for Inter-System Communication of Both Processed and Raw Data, Control and Status Information
Incorporating ATSCS within IVHS means that ATSCS will be one of many subsystems, (possibly including adjacent ATSCS) each receiving data from and controlling operation of different devices. Control signals and the resulting driver information provided through these various subsystems will often require direct coordination to maintain safety. Data from one system will often be required for decisions made by other systems.

Therefore, ATSCS must be developed with the internal software and hardware ports to allow communication with other systems and the common application logic to know what data or control requests may be passed to/from these systems.

Relates to: Technology, Techniques

RESEARCH PROBLEM STATEMENTS

A total of 38 problem statements were developed by members of the Traffic Signal Systems Committee of the Transportation Research Board. The statements listed below are those determined to represent the greatest need for research and development:

- "Development of Zone to Zone Route Guidance System which would be incorporated into a Decentralized Traffic Signal System."
- "Visualization of Intelligent Vehicle Highway System Operations."
- "Online (Real Time) Creation or Modification of Traffic Plans."
- "Time Space Diagrams in Computer Models for Off-Line and Real-Time Applications."
- "Automatic Signal Phasing for Real-Time Control."
- "Utilization of Several Control Objectives."
- "Travel Time Estimation and Verification."
- "Measures of Long Term Traffic Trends."
- "Integrated Arterial Signals and Diamond Interchange Operations."
- "Analysis of Central versus Distributed Traffic Control Systems."
- "Analysis of Different Fiber Optics Communications and System Interface Techniques."
- "Analysis of a Multi-Vendor Environment for Traffic Signal Controllers."
- "Detectorization Requirements for Real-Time Traffic Signal System Operation."
- "Incident Detection on Major Arterials."
- "Loop Detector Technology."
- "Evaluation of use of advance left-turn arrow on two-way streets with a single lane in each direction."
- "Modelling IVHS Vehicles in Simulation Models."
- "Green Wave Improvement."
- "Expansion of Arterial Analysis Package *AAP2NEMA* program."

The problem statements are not listed in order of priority, rather they are grouped into various categories (i.e. Advanced Systems, Real-time Traffic Pattern Development, System Analysis, System/Communication Design, Detectorization, Off-Line Timing Analysis). Each problem statement represents a need for research and development.

The following Problem Statements describe the problems and objectives for each of the subjects listed above. They are provided for guidance in future work by public agencies and researchers and developers including private enterprise.

PROBLEM NUMBER 1 DEVELOPMENT OF ZONE TO ZONE ROUTE GUIDANCE SYSTEM WHICH WOULD BE INCORPORATED INTO A DECENTRALIZED TRAFFIC SIGNAL SYSTEM

Problem

Route guidance techniques are being developed. The use of smaller computers permits the utilization of decentralized systems. Decentralized traffic control and route guidance systems can reduce the cost of communications in larger urban areas. All data and command information does not need to be transmitted between the field and central computer thus reducing the need for large central computers.

Objective

To develop a design which will permit decentralized computer control for traffic control and route guidance systems. These systems could locate both traffic control and route guidance computer at the same location, thus gaining greater coordination, easier implementation, easy maintenance, and lower communications costs. Route guidance information could be passed through the use of small computers within each zone.

Key Words

Decentralized traffic control, Route guidance.

Related Work

Work is underway in Europe, Japan and the USA on route guidance. It appears that the work to date applies to application of a central computer.

Urgency/Priority

Since work is underway on both new traffic control systems and route guidance, this project would have a high priority.

Cost

$300,000 for development of concept and application in a small system. Results would lend to full implementation and testing in a future project.

User Community

All traffic control/route guidance systems in the U.S.

Implementation

Installation in all larger cities within the U.S.

Effectiveness

Excellent operational effectiveness since considerable work is already underway.

PROBLEM NUMBER 2 VISUALIZATION OF INTELLIGENT VEHICLE-HIGHWAY SYSTEM OPERATIONS

Problem

Effective traffic information, data processing, multi-media communications, management techniques, and automatic vehicle control has received worldwide attention. The Intelligent Vehicle Highway System (IVHS) has potential to increase mobility and safety on existing highways with improved en route traffic information. Visualizing IVHS operations can improve understanding and support of IVHS system conceptualization.

Objective

This study proposes to demonstrate improved communication between motorists and control systems by visualizing potential IVHS operations. A microcomputer graphics-based simulator will be developed to illustrate information exchange on conventional control systems and new IVHS systems in an integrated driver–vehicle–roadway environment.

Key Words

Dynamic Visualization, Signal Operations, IVHS System.

Related Work

Relevant research does not exist.

Urgency/Priority

Very High.

Cost

$300,000

User Community

Traffic Signal System Engineers.

Implementation

This study will illustrate improved IVHS operations and identify information processing and interface requirements through existing control systems and improved control technologies.

Effectiveness

Improved operations.

PROBLEM NUMBER 3 ONLINE (REAL TIME) CREATION OR MODIFICATION OF TRAFFIC PLANS

Problem

The task of designing traffic plans (phasing, timing and related functions) will continue to increase in scope due to several factors:

- Network complexity;
- Recognition of varying control objectives;
- Recognition of varying control boundaries; and
- Better ability to detect unique traffic flow patterns.

Traffic signals and traffic signal systems need to be able to use recently collected traffic data, develop short term predictions, and formulate new traffic plans online (real time) which maximize any specified control objective.

Objective

To develop algorithms for designing traffic movement based on real time and short term traffic predictors.

Key Words

Traffic Signal Systems, Traffic Signal System Operation, Real Time System Control, Traffic Pattern Generation.

Related Work

OPAC traffic signal and traffic signal system development.

Urgency/Priority

High.

Cost

$550,000. $200,000 for intersection traffic signal development and testing; and $350,000 for traffic signal system timing

User Community

Traffic signal manufacturers, traffic engineers, researchers.

Implementation

The results of the study will be incorporated into intersection control and traffic signal systems.

Effectiveness

The resulting implementation will provide significant improvements in traffic signal system operation.

PROBLEM NUMBER 4 TIME SPACE DIAGRAMS IN COMPUTER MODELS FOR OFF-LINE AND REAL-TIME APPLICATIONS

Problem

Significant development has been made by various operating agencies in the past several decades to design and implement microcomputer-based signal timing plans. Recent advancement has allowed engineers to take advantage of advanced traffic management. There are several application concerns on the time-space diagram outputs available in most traffic engineering packages. These problems include: the user friendliness features, the ability to adjust splits, cycle lengths and offsets, line drawing accuracy, and necessary details of input information for both off-line and on-line applications. Improved time-space diagram design for traffic analysis, report generation, and on-line screen display are needed.

Objective

It would be advantageous to manually adjust the splits, cycle lengths and offsets of a system on a scaled computer model diagram, such as a CAD System and provide perpendicular green bands automatically.

Key Words

Adjustment of intervals, User friendly, diagrammatic.

Related Work

PASSER, TRANSYT.

Urgency/Priority

High Priority.

Cost

Moderate.

User Community

Traffic Engineering Community.

Implementation

The results of this research could be immediately implemented in existing traffic control systems and software.

Effectiveness

Time effective - accuracy.

PROBLEM NUMBER 5 AUTOMATIC SIGNAL PHASING FOR REAL-TIME CONTROL

Problem

Traffic signal control is moving toward real-time, traffic adaptive operation. Existing schemes of determining and implementing phase sequences are not sufficiently flexible to accommodate such operations. The choice of phase sequences can have significant impact on the efficiency of signal control. There is a need to develop an algorithm to automatically determine the optimal phase sequence on a cycle by cycle basis in response to changing flow conditions.

Objective

To develop an algorithm for automatic determination of optimal phase sequence to support real-time, traffic-adaptive control.

Key Words

Algorithm; optimization; phase sequence; real-time control.

Related Work

Signal optimization tools, such as MAXBAND and PASSER II, have been used for the selection of phase sequences. These tools, however, are suitably only for off-line applications. The phase sequences determined from such tools cannot satisfy the needs to vary quickly to changing flow conditions.

Urgency/Priority

Improving phase sequences is one of the few areas in which significant gains can be expected of signal control.

Cost

$250,000

User Community

Signal jurisdictions.

Implementation

These studies are most useful when used for a real-time control system. They can also be used to generate phasing plans for existing systems.

Effectiveness

The efficiency of signal systems can be significantly improved.

PROBLEM NUMBER 6 UTILIZATION OF SEVERAL CONTROL OBJECTIVES

Problem

At certain times and under certain conditions, a traffic signal system should be able to select and develop traffic plans based on different control objectives. For example, minimizing exhaust emissions in order to improve air quality may be a desirable objective during some time periods; however, during peaks demand control (getting traffic into a capacity constrained or otherwise sensitive area) or dissipating queues which are blocking cross streets may become the overriding control objective. Constraints caused by incidents are also a factor to consider. The traffic signal system must have the capability to select and develop traffic plans which maximize the defined control objective for the existing traffic conditions. A separate set of traffic responsive selection parameters may be required for each control objective. A traffic signal system also requires the ability to implement different control objectives for separate groups of signals. Changes in the controlling objective may be based on the jurisdiction (different cities), subarea (CBD/Suburban), time of day (peak/off), or weather (dry/wet/snow).

Objective

To develop an approach with algorithms needed to select and develop traffic plans based on different control objectives for separate groups of traffic signal systems. The results will provide guidelines on when to change traffic control patterns under different traffic control objectives and the algorithms needed to implement the guidelines into traffic signal system design.

Key Words

Traffic Control Objectives, Traffic Signal Systems.

Related Work

None at present.

Urgency/Priority

High to achieve optimum operations to reduce delay, vehicle emissions and fuel consumption.

Cost

350,000

User Community

Traffic engineers and traffic signal system operators.

Implementation

The results of the study will provide: (1) guidelines for determining which traffic control objective to implement and, (2) the design requirements needed to implement different traffic control objectives in traffic signal systems.

Effectiveness

Since the results of the study will provide information which can be used by any traffic control system operator and the algorithms needed for implementation in traffic signal systems, the results will have both immediate and future payoff.

PROBLEM NUMBER 7 TRAVEL TIME ESTIMATION AND VERIFICATION

Problem

Travel time along an individual link or along a specified route is an important item of information/measure of effectiveness regarding system operation. Engineers could directly use link travel time to verify the delay estimates used to modify signal timings. They could also link and route travel time to make decisions regarding routing strategies and traveller information and other IVHS applications. New detection technology should offer improved capability to estimate travel time, perhaps by combining data from several sources. Vehicle identification (either transit or private vehicles) offers the possibility of tracking specific vehicles and therefore providing information which could be used to verify actual travel time.

Objective

To develop a computer model which will analyze short term information for improving current traffic signal system operation and for use in developing route strategies for IVHS applications.

Key Words

Traffic data, traffic signal system, route movement.

Related Work

None at present.

Urgency/Priority

The 1990 Clean Air Act Amendments and the 1991 ISTEA require that vehicle emissions be decreased. Also improved traffic operations, reduced vehicle delay, and fuel consumption is vital. In order to achieve and maintain optimum traffic signal operation and provide route information, it is urgent that a computer model be developed. This project should be given a high priority.

Cost

$250,000

User Community

Traffic engineers and traffic signal system operators.

Implementation

City/Metropolitan Area traffic signal systems.

Effectiveness

The project will allow traffic engineers to adjust existing traffic signal system patterns and provide information for routing information and traveler information system use.

PROBLEM NUMBER 8 MEASURES OF LONG TERM TRAFFIC TRENDS

Problem

It is very important for transportation personnel to be aware of the long term trends in traffic volume and distribution in order to analyze the performance of existing systems and to determine the most appropriate use of future resources. Although most systems provide some historical storage of loop based traffic data, there is very little post processing or analysis available.

Objective

To develop a computer model which will assimilate traffic data from various collection devices including manual counts, analyze these data, and regularly provide existing and anticipated level of service measures, growth statistics, and other trend indicators.

Key Words

Traffic data, traffic signal system, traffic data analysis, measures of effectiveness, traffic control measures.

Related Work

Metropolitan Planning Organizations, State Departments of Transportation and cities gather traffic data and project growth. These are not utilized on traffic signal systems at present. Traffic Control Systems gather detector data primarily for short term applications.

Urgency/Priority

The 1990 Clean Air Act Amendments and the 1991 ISTEA require that vehicle emissions be decreased. Also, improved traffic operations reduce delay and fuel consumption is vital. In order to maintain optimum traffic signal system operation, it is urgent that a long term analysis system be developed for traffic signal systems. The project should be given a high priority.

Cost

$300,000

User Community

Traffic engineers and traffic signal system operators.

Implementation

City/Metropolitan Area traffic signal systems.

Effectiveness

Allows traffic engineers to anticipate poor levels of service and improve traffic signal system operation.

PROBLEM NUMBER 9 INTEGRATED ARTERIAL SIGNALS AND DIAMOND INTERCHANGE OPERATIONS

Problem

In the United States, many urbanized areas suffer from congested freeway operations. In addition, motorists may use freeways to avoid uncoordinated arterial signals. Integrating arterial street and interchange control can effectively improve freeway management.

Objective

The study will improve interconnection schemes, timing design, and improve the guidelines for applying technologies such as: PASSER II-90, PASSER III-90, and FHWA's TRAF-NETSIM packages and applications for on-line real time operations.

Key Words

Signal timing, corridor coordination, traffic simulation.

Related Work

Relevant research does not exist.

Urgency/Priority

High

Cost

$300,000

User Community

Traffic signal system engineers.

Implementation

The study will provide effective arterial and freeway interconnection for effective signal timing and improved arterial operations for the involved agencies.

Effectiveness

Improved operations.

PROBLEM NUMBER 10 ANALYSIS OF CENTRAL VERSUS DISTRIBUTED TRAFFIC CONTROL SYSTEMS

Problem

Effective signal coordination, with traffic responsive and adaptive traffic optimization capabilities, can significantly alleviate the inadequacies of urban signal operations. Three adaptive control systems are currently available with various degrees of central versus distributed intelligence. Often, system designers are unsure of the advantages, disadvantages, costs, and benefits of each system, yet some critical system design differences do exist in the basic hardware and software configurations.

Objective

To complete an extensive analysis of the advantages, disadvantages, costs, benefits, and other topics of interest regarding central versus distributed architecture of traffic signal systems.

Key Words

Central, distributed, architecture, traffic signal systems.

Related Work

Not assessed.

Urgency/Priority

Information needed for system designers.

Cost

Unknown.

User Community

Traffic system designers.

Implementation

Useful information for all traffic system designers.

Effectiveness

Allows the design of the most effective system for a particular environment.

PROBLEM NUMBER 11 ANALYSIS OF DIFFERENT FIBER OPTICS COMMUNICATIONS AND SYSTEM INTERFACE TECHNIQUES

Problem

There are several different communication and system interface techniques or variations available for fiber optics. System designers may not be aware of these or know the advantages, disadvantages, or costs.

Objective

To complete an analysis of the different variations and techniques available for fiber optics communications and system interface, including analog, digital; spares needed; single mode, multimode; single versus multiple cables; cost effectiveness; SONET, together with: communications/central computer; communications system interface/subsystem communications/controller interface.

Key Words

Fiber optics communications.

Related Work

Unknown.

Urgency/Priority

Information needed for effective traffic systems design.

Cost

Unknown.

User Community

Traffic system designers.

Implementation

Useful for system design throughout the country.

Effectiveness

Allows designers to develop more effective systems.

PROBLEM NUMBER 12 ANALYSIS OF A MULTI-VENDOR ENVIRONMENT FOR TRAFFIC SIGNAL CONTROLLERS

Problem

Many signal systems with different programming details and system control features have been developed by various manufacturers. At present, most microcomputer-based closed-loop systems cannot communicate except with controllers from the same manufacturer. This creates enormous problem for government agencies to maintain statewide equipment standards, cost-competitive procurement processes, and system operational practices. It is possible to establish a standard communications protocol such that controllers from multiple vendors can be integrated into a traffic control system.

Objective

To complete an extensive analysis of the problems of a multi-vendor environment in traffic control systems and to develop a standard of communications protocol for traffic signal controllers.

Key Words

Traffic signal controllers, communication protocol, multi-vendor environment.

Related Work

Some organizations (NEMA) are working on this, with little success to date.

Urgency/Priority

Needed to allow controllers from multiple vendors to be integrated into a traffic system.

Cost

Unknown.

User Community

Cities, states, traffic system designers.

Implementation

Cities and states throughout the country.

Effectiveness

High - allows easier development of systems.

PROBLEM NUMBER 13 DETECTORIZATION REQUIREMENTS FOR REAL-TIME TRAFFIC SIGNAL SYSTEM OPERATION

Problem

It is possible to install traffic control system detectors in advance of each signalized intersection and within each left turn lane for determining on-line real time operation. The detector input is used for automatic calculation and implementation of traffic patterns, such as used in the 2nd and 3rd Generation operations. The large number of detectors require an excessive amount of maintenance and always result in questions of how many are working and how accurate is the information received. In addition, what is the optimum number of detectors needed?

Objective

To determine the minimum and optimum number of traffic control system detectors required for calculation and implementation of traffic patterns on a real time basis.

Key Words

Traffic signal system, system detectors, detectors, real time.

Related Work

Some work has been carried on in Canada and possibly in Europe. Also, PASSER II has been applied in 1½ Generation with FACTS arterial systems in Texas (SDHPT-TxDOT).

Urgency/Priority

The design of new traffic signal systems is underway. The need for determining the number of detectors for on-line real time operation is urgent.

Cost

$400,000

User Community

All urban traffic engineers involved with traffic signal installation, operation, and/or maintenance. Also manufacturers of traffic signal systems.

Implementation

Immediate implementation

Effectiveness

High. Results will be incorporated into new traffic signal systems.

PROBLEM NUMBER 14 INCIDENT DETECTION ON MAJOR ARTERIALS

Problem

Freeway and arterial incidents often occur unexpectedly and cause undesirable congestion and regional mobility loss, even where surveillance, communications, and control (SC&C) systems are in operation. Automatic incident detection should efficiently apply available traffic information to reduce the impact of incidents. Traffic management systems need an accurate, effective method of detecting incidents on both freeways and major arterial systems. Traffic signal systems need an accurate, effective method of detecting incidents on major arterials. Can loop detectors be used, or will vehicle detection via TV surveillance be needed?

Objective

To develop an effective incident detection algorithm and method, and determine the best means of detection for incidents.

Key Words

Incident detection, arterials, loop detectors, TV detection.

Related Work

Not assessed.

Urgency/Priority

Needed to provide incident detection on major arterials.

Cost

Unknown.

User Community

Traffic engineers and traffic system designers.

Implementation

Immediate needs.

Effectiveness

Could be integrated into all traffic signal systems.

PROBLEM NUMBER 15 LOOP DETECTOR TECHNOLOGY

Problem

Loop Detectors have a number of problems, including:

1. Loop Detectors are costly to install and maintain.
2. Loop Detector replacement is not done in a timely fashion.
3. Loop Detectors are vulnerable to the elements of construction.
4. Loop Detectors should be installed in series and not series/parallel.
5. Loop Detectors must be installed in ideal pavement.

Objective

The objective is not necessarily to replace the loop detector in total but to come up with a viable alternative. Because the methodology of installing loop detectors is considerable, replacement becomes a major obstacle. A detector external to pavement would be cost effective, easy to install, and easy to replace.

Key Words

High cost, replacement, properly installed.

Related Work

Microwave, laser, radar.

Urgency/Priority

High priority.

Cost

Unknown.

User Community

City, county and state.

Implementation

As deemed necessary.

Effectiveness

Resulting in a cost-effective alternative to loop detectors.

PROBLEM NUMBER 16 EVALUATION OF USE OF ADVANCE LEFT-TURN ARROW ON TWO-WAY STREETS WITH A SINGLE LANE IN EACH DIRECTION

Problem

At an intersection where there is a single lane in each direction and a moderate left-turn traffic in one direction, at what volume of left turns for given through movements in each lane should an advance left-turn arrow be employed?

Objective

To enable the designer to have some guidance in terms of traffic volumes to when an arrow will provide improved Level of Service (LOS). A secondary objective, guidance on lead or lag arrow should also be considered.

Key Words

Not assessed.

Related Work

Not assessed.

Urgency/Priority

High.

Cost

Not assessed.

User Community

Traffic engineering community.

Implementation

A left-turn arrow in one-lane situation always delays opposing traffic and provides benefit only if the initial cars in the queue for the duration of the green arrow actually turn left. If no vehicles turn left, the arrow period and following clearance is a total waste of time to opposing traffic. There must be a percentage turning mix for any one volume condition which improves LOS. and another percentage (0-x) which degrades LOS.

PROBLEM NUMBER 17 MODELLING IVHS VEHICLES IN SIMULATION MODELS

Problem

IVHS projects will permit individual vehicles to be tracked in the network. Current simulation models cannot likewise track individual vehicles and make decisions consistent with IVHS control strategies.

Objective

Modify and verify TRAF-NETSIM, CORFLO and possibly other simulation models to track identified vehicles and model such IVHS tactics as route planning, diversion, etc.

Key Words

Simulation, IVHS, Network Modeling.

Related Work

None.

Urgency/Priority

High.

Cost

$150,000

User Community

All medium to large metropolitan areas.

Implementation

Distribute through McTrans and PC-TRANS.

Effectiveness

Improved modelling of proposed IVHS projects.

PROBLEM NUMBER 18 GREEN WAVE IMPROVEMENT

Problem

Due to irregular cross-street spacings, differences in timing, and other irregularities, it is usually impossible to have a green band uniformly progressing down the arterial. However, the designer can choose how to start the green for perfect progression. With pre-timed controllers, it was common practice to have the starts of green sequence along the arterial. With semi-actuated controllers, the length of the side street green determined the beginning of arterial green. It is possible to develop timing methods for the semi-actuated local controllers which would duplicate the pre-timed beginning of green perfect progression. Which is the more beneficial from standpoints of fuel efficiency and stops and delays for a given operating speed? Timing the starting green provides a "pacer" effect and discourages the lead cars from speeding up at locations where the green comes early and then being possibly stopped at the next intersection. Timing the trailing yellow clears all the vehicles in the platoon, leaving none stopped to delay, and often requires stopping of cars in the platoon.

Objective

To determine whether the irregular start of green results in lower efficiency of operation as compared to a perfect starting sequence and an irregular ending of artery green.

Key Words

Signal Progression.

Related Work

Not assessed.

Urgency/Priority

High.

Cost

Not assessed.

User Community

Traffic Engineering community.

Implementation

Arterial signal coordination practice.

Effectiveness

Some quantitative data based on field experimental data as well as computer-based calculations could be helpful to the decision maker.

PROBLEM NUMBER 19 EXPANSION OF ARTERIAL ANALYSIS PACKAGE *AAP2NEMA* PROGRAM

Problem

The current Arterial Analysis Package (AAP) includes the capability to transfer timing plan information from PASSER or TRANSYT-7F to a closed loop control system via a program called *AAP2NEMA*. However, this transfer is only in one direction. It is not possible to transfer timing plan information from the closed loop control system to the AAP for analysis.

Objective

The object of this project would be to complete the *AAP2NEMA* portion of the AAP to allow transferring data to and from a closed loop control system. This effort should also include enhancing the *AAP2NEMA* program to incorporate improvements that have been suggested by initial users and closed loop control manufacturers. The changes outlined for the *AAP2NEMA* program will provide the traffic engineer with a very useful tool for optimizing the timing of closed loop control systems.

Key Words

Arterial Analysis Package, AAP, *AAP2NEMA*.

Related work

This would be related to any other planned changes to the Arterial Analysis Package.

Urgency/Priority

There are thousands of intersections currently being controlled by closed loop control systems. The project outlined above would allow improving the optimization process for these intersections. This would allow completing the optimization in a more timely manner and thus more often. This could result in significant savings when applied to the growing number of closed loop systems.

Cost

$50,000

User Community

Traffic engineers using closed loop control systems.

Implementation

The project requires modifying the AAP and *AAP2NEMA* software originally developed at the University of Florida.

Effectiveness

This will allow feedback analysis of the signal timing plan from the closed loop control system.