Signal Systems Committee Triennial Strategic Plan Appendix

1.1 Health & Relevancy of the Committee/Weaknesses

The Traffic Signal Systems Committee Action Plan which has been updated periodically, and at last count contained 14 activities. An assessment of the Committee's achievements relating to these activities was completed at the 2003 Summer Meeting. The following is a summary of that assessment.

Activity 1: *Update* the Action Plan every three years.

Responsibility: Strategic Plan Subcommittee

How well did we do? Generally speaking the action plan was continuously updated in accordance with the activities of interest to the Committee members. The Committee was slow in dropping activities from the action plan when there was zero progress because no one was prepared to take responsibility for that activity.

Activity 2: *Review* the Problem Statement list in three-year intervals and recommend 6 problem statements to actively pursue.

Responsibility: Research Problem Statement Subcommittee

How well did we do? The Committee reviewed the Problem Statement List annually and submitted Problem Statements each year for possible funding. The stated goal of pursuing 6 problem statements is probably too ambitious.

Activity 3a: *Continue the program* of providing an annual workshop on Adaptive Traffic Signal Systems and the associated system functions.

Responsibility: Adaptive Traffic Signal Control Task Force

How well did we do? The Committee was very successful in organizing either full day or half day workshops on Adaptive Traffic Signal Control at the annual January TRB meetings over the past 3 – 4 years.

Activity 3b: *Identify a strategy* to integrate adaptive signal control into small and medium size traffic signal systems.

Responsibility: Adaptive Traffic Signal Control Task Force

How well did we do? There has been no progress in this area. It is probably premature to expect agencies with small or medium size traffic signal systems to venture into adaptive traffic signal control.

Activity 3c: *Develop* an education or outreach program that informs all of the agencies involved in traffic signal operations of the opportunities and advantages of adaptive traffic signal operation.
Responsibility: Adaptive Traffic Signal Control Task Force

How well did we do? The education / outreach program was delivered in the workshops provided at annual TRB meetings (Activity 3a). There was no education / outreach program targeting those who do not or can not attend TRB meetings.

Activity 4: *Cause to be developed* a Primer on Traffic Signal Systems.

Responsibility: Manual and Publications Task Force

How well did we do? There has been no progress in this area. There is a wide variety of federal / state / university publications available to the traffic community on this topic, possibly rendering any Committee activity superfluous.

Activity 5: *Continue the program* of providing a one-day educational workshop held in conjunction with the mid-year TRB Signals Systems meeting.
Responsibility: Committee Chair

How well did we do? The one-day education workshop has become a permanent feature of the Committee's mid-year meetings, and has contributed to the success of the mid-year meetings, attracting not only Committee members and friends but also the participation of the local traffic community.

Activity 6: *Cause to be developed* a State of the Practice for transit priority at signalized intersections.

Responsibility: Unassigned

How well did we do? The subject of transit priority appears frequently in the agendas of the January and mid-year meetings. However, there has been no progress in terms of developing a "State of Practice".
There is a wide variety of federal / state / university publications available to the traffic community on this topic, possibly rendering any committee activity superfluous.

Activity 7a: <u>*Cause to be developed*</u> a State of the Practice for vehicle detection devices.

Responsibility: ***Unassigned***

How well did we do? The subject of vehicle detection devices appears frequently in the agendas of the January and mid-year meetings. However, there has been no progress in terms of developing a "State of Practice".
There is a wide variety of federal / state / university publications available to the traffic community on this topic, possibly rendering any Committee activity superfluous.

Activity 7b: <u>*Cause to be identified*</u> the functional improvements in vehicles detection devices to meet current and future practice needs.
Responsibility: **Unassigned**

How well did we do? A recent mid-year meeting was held jointly with the Freeway Operations Committee, at which a workshop was held on "Functional Improvements in Vehicle Detection Devices". While the workshop raised awareness on the important issues there was no formal documentation of the workshop results or follow up after the meeting.

Activity 8a: <u>*Review and comment*</u> on the FHWA update of the Traffic Control Systems Handbook.
Responsibility: Traffic Control Systems Review Task Force

How well did we do? There was no formal Committee involvement on this project although individuals who are Committee members did participate in the FHWA review process.

Activity 8b: <u>*Cause to be developed*</u> a State of the Practice and future direction for communications networks used for traffic signal systems.
Responsibility: Traffic Control Systems Review Task Force

How well did we do? The Committee organized a January TRB Workshop on this topic which was well attended and very successful. Apart from that there has been no other progress in this area.
There is a wide variety of federal / state / university publications available to the traffic community on this topic, possibly rendering any Committee activity superfluous.

Activity 9: *<u>Investigate</u>* the objectives and various measures of effectiveness for traffic signal timing and recommend future study or methodology enhancements.

Responsibility: Unassigned

How well did we do? The subjects of "Performance Objectives" and "Measures of Effectiveness" appear frequently on the agendas of the January and mid-year meetings. However, there has been no progress in terms of recommendations for future study or methodology enhancements.

Activity 10: *<u>Cause to be developed</u>* a list of issues concerning the impact of the future ITS infrastructure.

Responsibility: Unassigned

How well did we do? There has been little progress on this subject to date. However, the 2004 mid-year meeting includes a workshop entitled "Management of Urban Arterials (especially traffic signals) and our Ability to Support other ITS Services".

1.2 Connection to Other Committees

The following table includes a summary of our Members and Friends and their participation in other committees.

Name	AHB25		Other Committees		Other Relevant Activities
	Member	*Friend*	*Member*	*Friend*	
Ahmed Aburahmah	x				
Rahmi Akcelik	x				
Darcy Bullock	x				
Larry Corcoran	x			Freeway Operations (Incident Mgt subcommittee)	
Frank Dolan	x				
Gary Duncan	x			Freeway Operations (AHB20)	NTCIP Joint Committee, NTCIP ASC, NTCIP SCP Working Group, ATC Joint Committee, ATC Controller Working Group
Roelof Engelbrecht	x			Highway/Rail Grade Crossings (AHB60)	
Dennis R. Eyler	x			Freeway Operations	
Raj Ghaman	x				
Larry Head	x			Traffic Flow Theory (AHB45)	NTCIP SCP Working Group
Lap T. Hoang	x				
Leslie Kelman	x				
Peter Koonce	x		Bus Transit Systems Committee	Interchange Ramp Terminals Subcommittee of the Highway Capacity and Quality of Service	
Peter Martin	x			Freeway Operations	
Paul Olson	x				NTCIP SCP Working Group
Brian Park	x			Traffic Flow Theory, statistics, Freeway Operations	
Gary Piotrowicz	x				
Farhad J. Pooran	x				
James Powell	x			Highway Capacity Committee (past member,subcommittee member of Ramp Terminal Subcommittee), Freeway Operations Committee (official AHB25 liaison to the Freeway Simulation Modeling Subcommittee)	
Craig Roberts	x				
Tom Urbanik (Chair)	x		Freeway Operations (AHB20)		Co-Chair NTCIP SCP Working Group
Brian Van deWalle	x				
Jim Williams	x		Traffic Flow Theory (AHB45)		
Henk Taale		x			
Rick Denney		x	Traffic Flow Theory (AHB45)		
Henk Taale		x		Traffic Simulation Subcommittee	
Bruce Zvaniga		x		Freeway Operations (AHB20)	
Alex Skarbardonis		x	Traffic Flow Theory (AHB45)	Highway Capacity and Quality of Service (Task 5 - validation), Traffic Simulation subcommitttee	
Ron Allen		x			

Joe Perrin		x		Traffic Flow Theory, Freeway Operations, Highway Capacity and Quality of Service	
Montasir Abbas		x		Highway Capacity and Quality of Service (AHB40), Traffic Flow Theory and Characteristics (AHB45), Committee on Artificial Intelligence and Advanced Computing Applications in Transportation (ABJ70)	
Peter Furth		x	Bus Transit Systems, Transit Performance and Management		
Scott Beaird		x			
Ron Atherley		x			Chair of the NTCIP Signal Control and Prioritization working Group, Member of the TCIP Work Group 10 on Transit Signal Priority
Ahmed Abdel-Rahim		x	Statistical Methodology and Statistical Computer Software in Transportation Research		
John D. Bullough			Visibility Committee		
Douglas Gettman		x		Freeway Operations (AHB20), Traffic Flow Theory	
Steve Shelby		x			
Scott Wainwright			Traffic Control Devices		
Mike Kyte		x		Highway Capacity and Quality of Service (AHB40)	
John Black		x			NTCIP 1210 - Field Management Stations
Kent Kacir		x		Signal System Committee, Freeway Operations Committee, Traffic Control Devices Committee, Intelligent Transportation Systems	
Jim Dale		x			
Abdul Rahman Hamad		x	Freeway Operations (AHB20), Highway Capacity and Quality of Service (AHB40) (chair of Freeway/Multilane subcommittee)		
James Young		x			
John Abraham		x		Railroad Highway Crossing Committee, Pedestrian Committee; Roundabouts Subcommittee	
David Guth		x			
Vijay Korvalli		x		Traffic Flow Theory and Characteristics Committee, HCM Capacity and Quality of Service	

1.3 Goals of the Committee

2.0 ELEMENTS OF THE TSP

2.1 Committee Activities

2.2 Critical and Cross-Cutting Issues

2.3 Research Problem Statements

2.3.1 Submitted Research Problem Statement (RPS) 2000-2003

A summary of the RPS is included on the next few pages.

2.3.2 Submitted Research Problem Statement (RPS) Sept 2003 through Jan 2004

TR1. Detection Data Quality and Accuracy.
Define how to measure these in a standard method. This could also deal with video detection and other non-loop technologies, as well as loops. Given that SAFETEA is talking about real time data collection on a huge scale this might provide a foundation for some of it. These measurements will be the basis for real-time performance monitoring system, which in turn will be tied to funding.
Other questions:

- How much accuracy is needed for a given application?
- How much cumulative error over long time periods is acceptable?
- How much archived data is needed to make a reasonable projection at locations where detectors have failed?

TR2. Best Practices for Traffic Signal Timing.
Update NCHRP 172 to further the transportation profession's understanding of signal timing practices. Conduct research to identify benefits of key signal timing improvement practices and address common misconceptions in the industry. Include signal coordination aspects.

TR3a. Determine Effectiveness and Optimize Existing Controller Adaptive Features (MAX1, MAX2, adaptive splits, Quick Response Plans) in Conjunction with Vendors.

TR3b. Effective Pattern Switch Times in a Time-Of-Day Schedule.

TR3c. Effective Configuration of Traffic Responsive Systems.

TR3d. Evaluate Effectiveness of Signal Systems (e.g., *icons*, i2TMS, ACTRA, Streetwise, etc.) in Microsimulation, with Development of an NTCIP Interface to Simulators (an NTCIP interface to CORSIM was started under the ACS-Lite project).

TR4. Performance of Adaptive Signal Control Systems
Traffic Adaptive Signal Control (ASC) systems vary widely in their methods. They are known to be effective in easing congestion, coping with incidents, and adapting to traffic pattern fluctuations. Traffic engineers, however, are reluctant to embrace them. There are so few installations. The problem is a divide between research and practice. The researchers know the ASC capabilities, but the practice is reluctant to trust. Micro simulation of traffic systems has advanced to the point whereby we can now model ASC. The research should systematically build several adaptive control systems on a common simulation platform. The results will serve to inform traffic engineers of the true effectiveness. Instead of reliance on small anecdotal and idiosyncratic evaluations, traffic engineers will benefit from a systematic multi-system evaluation, based on a single controlled simulated network.
Key questions:

- How dependent are ASC systems on detector integrity?
- Do ASCs cope with routine congestion, or are they best suited to incident mitigation?
- Do ASCs age slower than Fixed-Time systems?
- Can ASCs draw from data sources, other than detection? (e.g., DTA, probe vehicles)

TR5. Investigation of SYNCHRO Ability to Find the Best Timing Plan.

TR6. Validation of MOEs Generated by Traffic Models (SYNCHRO, PASSER) vs. Field Data

TR7. State-of-the-Practice and Needs Assessment on Rail-Signal Operations.

TR8. Recent Trends in Traffic Signals.

2.4 Millenium Paper

As a part of this Strategic Plan, the Committee Chair and FHWA liaison Paul Olson provided an update to the Millenium Paper. This update is provided here.

Traffic Signal Systems: Meeting the Needs of System Users

Tom Urbanik[1] and Paul R. Olson[2]

Abstract

There are many issues, spanning a broad range of technical, social and political boundaries, which traffic signal systems will need to address in the future. With the increase in urbanization and traffic congestion comes a greater demand to operate our roadway systems with maximum effectiveness and efficiency. Traffic volumes will continue to increase while roadway capacity will increase at a slower rate. New technology such as innovative traffic signal systems using advanced surveillance and traffic management centers will become increasingly critical for City, County and State organizations to meet transportation needs. Such systems are highly dependent on field infrastructure such as vehicle detection, distributed microprocessor based control systems, and near real time interaction over diverse communication media. It is critical to have all of these elements operating in a stable well maintained environment, even during maintenance and construction. This is particularly challenging given the diversity of government agencies that are often responsible for different portions of what motorists perceive as a single transportation system. Each government agency typically has traffic signal control technology of varying vintages and different procedures for operating traffic signal systems. Signal system operation is even further complicated by the recent trend that views traffic signal systems as a small component of an integrated multi-modal transportation system. When such a perspective is adopted, the "customer" of traffic signal systems is much broader then just automobile drivers and requires a high degree of agency cooperation.

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Current and Future Technical Challenges

Traffic signal research has been conducted in two distinct areas: roadside equipment and analytical type operations research. Government agencies and vendors have performed virtually all the roadside equipment research. Similarly, universities have performed virtually all the research in analytical type operations research. Although there have been significant advancements in both the roadside equipment and analytical models, neither area has been particularly closely coordinated with the other. Many of the following research issues fall outside the typical DOT, commercial, and university organizational structure, but show considerable promise.

System Integration Research

As a result of past research, government agencies and vendors have perfected systems that do an excellent job of meeting today's needs when considered in isolation, but do not provide the building blocks for cost effectively implementing integrated and interoperable systems manufactured by a variety of vendors. Similarly, many of the promising control algorithms proposed over the years have never been implemented, because many of the assumptions, assumed by the universities developing the models, do not reflect the technical limitations or traffic engineering conventions that are imposed by modern controllers.

Adaptive Control

Recently, the FHWA has been attempting to bridge this gap with the development of the real-time traffic adaptive control projects initiated in 1993. Several industry/academic teams emerged to develop new adaptive control systems that offer the potential to reduce the effort to develop and maintain good traffic signal timings. During this process, a variety of models were proposed and are in the process of being deployed. However, the concepts underlying adaptive control are still not mature and there is no clear consensus regarding the models. Significantly more effort will need to be placed in understanding and resolving the issues differentiating competing approaches. Bringing together the diverse models in a standard architecture is the challenge for streamlining deployment. Such a deployment will provide a mechanism for conducting comprehensive field evaluations of individual models under alternative traffic patterns and network topologies. It is unlikely that any one approach will provide a universal solution, instead, different models will likely perform better (or worse) on specific network topologies or traffic flow patterns.

Sensors

Sensors are the eyes and ears of any traffic signal system. Sensors are viewed by many as the weakest link in developing better traffic control systems. Sensing needs include queue estimation, train detection, non-ferrous bicycle detection, emergency vehicle detection, transit vehicle detection, pedestrian detection, vehicle detection, and environmental sensors (weather, air quality). Not only must new sensing technology be developed, but reliability must increase and costs decreased in order to facilitate wide spread deployment. Furthermore, standards need to emerge for integrating these sensors into traffic signal systems. The standard practice for bringing any sensor information into a traffic signal controller is via discrete logic (contact open/contact closed) which is very limiting and needs to improve. For example, data such as bus number and passengers loading must be available to integrate into control algorithms that might selectively provide priority depending upon how late the bus was or how many people were on board. Similarly, much of the information provided by image based vehicle detection equipment that can track vehicles or measure queue length is currently discarded before it reaches the traffic signal controller because the detection equipment must emulate the contact open/contact close function of a loop detector. Traffic signal systems will require that emerging sensors not only use new technology, but also convey new information to the control system.

Application of Traffic Models

Many, many modeling procedures and techniques have been developed over the years and have achieved varying levels of acceptance and use. These models can be broadly classified as Macroscopic and Microscopic. Macroscopic models are based upon average flow rates and average signal timings. Microscopic models are based upon car following theory and cycle by cycle signal times. Macroscopic models are particularly useful for signal system timing design software because macroscopic models provide efficient procedures for formulating objective functions used in optimization logic. In the past decade many of the macroscopic models have incorporated more and more detail to account for actuated signals and coordination between. However, these macroscopic models only provide analytical estimates of average system performance and do not provide insight into the actual signal system operation, particularly during non steady state conditions such as emergency preemption or timing plan transitions.

Microscopic models have significant potential to evaluate and visualize alternative control concepts for traffic signal systems because they consider the car following dynamics of traffic streams and they can model many of the characteristics of advanced systems such as coordinated actuated controllers. These microscopic simulation procedures can be used to directly analyze and tune coordinated-actuated systems because they consider a majority of the parameters used in modern coordinated-actuated signal systems. However, microscopic models have not incorporated the wealth of new research that has been conducted in support of enhancing highway capacity manual procedures. Although simulation packages provide a reasonable picture of how basic signal systems will operate, many practitioners' view the simulation models somewhat skeptically because of this discrepancy. Given the potential of these tools to help advance the state of the practice and resolve issues between alternatives, a need exists to reconcile concerns and formulate systems that can aid both researchers and practitioners.

Improved Design Procedures

Current design practice is largely based on individual preferences with limited ability to objectively resolve the effects of alternative designs. Many features exist which are not user and/or not well understood. Sound traffic simulation based upon an accepted microscopic simulation package could lead to better practice through the ability to both understand and quantitatively evaluate available features as well s alternative design decisions. The development of an accepted reference model for selecting features and evaluating a variety of alternatives including alternative traffic signal designs and controller settings would greatly improve the state of the practice.

Emerging Issues and Opportunities

The nature of market forces and technology evolution makes it nearly certain that technical issues will be addressed, with varying levels of success. Resolution of institutional and user issues are much more difficult to predict since they often reflect policy decisions of elected officials, or changing public attitudes. However, on a much broader perspective, the profession must figure out how to deal with the following issues:

- Changing or modifying the mission of traffic signal systems (and organizations that operate them) from *primarily serving the needs of vehicles (regardless of type or nature of its cargo)* to *serving broader transportation needs* based upon priority of a vehicle reflecting the nature of its cargo.
- Raising public awareness of transportation in general, and traffic signal systems in particular. The public must be educated on the complexities of system operation, and the benefits of long term investments in transportation management and operations compared to roads and bridges.

Changing or modifying missions to serve broad transportation objectives will certainly be controversial because of jurisdictional and institutional issues. The challenges of the past have primarily revolved around resources. Resources for traffic signal systems were often limited partly because of a limited constituency for traffic signal systems versus the more tangible result of a construction project. If the customers of traffic signal systems are viewed more broadly, then the costs associated with operating and maintaining the system can be shared among more groups, lowering the cost per unit served. However, with this shared cost also comes a need to provide more services and respond to more constituencies. The array of potential services include improved emergency vehicle operation, improved public transit service, more efficient (and perhaps safer) accommodation of pedestrians, improved response to natural hazards, improved support of national defense, and the more traditional improvements for the single-occupant journey to work vehicle. When all these users are viewed as customers with varying priority needs, the market for traffic signal systems takes on new dimensions, which include greater support.

The emphasis on technology in recent years has created a new, but limited, public awareness of the potential of advanced technologies to address transportation issues. This awareness has created a significant opportunity for transportation professionals to advance the operations and management of surface streets by adopting a view that these new technologies can provide services to a larger user community. To reach this new level of operation and management, a variety of educational developments must take place. Efforts must begin at a young age to interest bright students to pursue transportation careers, as well as developing informed future consumers of improved transportation services. Visits to the local fire or police departments should be augmented by visits to the local traffic management center. Existing professionals must be educated in the new vision of transportation services, which focuses on consumers of transportation services and their relative priorities. Transportation professionals must redouble their efforts to broaden support for their ability to contribute to better transportation service by educating the public and elected officials. Finally, the necessary tools must continue to be developed to support the vision. The vision will take time to achieve, but it will occur as we continue to make the best use of our extensive transportation infrastructure.

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