IT’S TIME …

A Proposal for Mobile (Hands-On Traffic) Signal Timing Training (MOST)

Prepared for
Federal Highway Administration

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28 September 2004

1. The Need for Traffic Signal Systems Training

Traffic Signal Systems: A Critical Yet Ineffectively Used Technology

The traffic signal is one of the most important devices in the nation's transportation system. Yet many of the traffic signals that are currently in use today are not timed properly, are not installed correctly, are not used to their fullest extent, and are often not maintained properly. While the traffic signal is intended to provide for effective and efficient intersection operations, it is the one device that can require the public to wait unnecessarily if not properly designed and operated.

There are 200 communities in the United States whose population exceeds 100,000. Each of these communities has numerous traffic signals, with a total number estimated at 300,000 nationally. Any one of these traffic signals, or a system of several signals, can cause a motorist to wait unnecessarily when there is no other traffic on the other intersection approaches. It is estimated that three quarters of these signals, or over 225,000 traffic signals nationally, needs some sort of timing or operational improvement.

The traffic control industry itself has compounded this problem through the use of proprietary protocols. Proprietary protocols and communications standards limit the ability of the educational and training community to educate and train end users, whether practicing professionals or university students, on the operations of traffic signal controllers made by different manufacturers. In addition, manufacturers have implemented NEMA or others standards in different ways, often using different definitions for what are seemingly common and well-defined traffic control parameters such as gap extension. The development and publication of National Transportation Communications for ITS Protocol (NTCIP) provides a basis for opening up the way in which traffic control devices are designed and operated.

Universities and other training institutions have also contributed to the problem. Most university classes cover fixed time equivalent traffic signal operations with little or no relationship to the operation of actual traffic signal controllers. Most university laboratories do not have traffic signal controllers and are thus not able to give their students experience in their use.

It is interesting to note that even with the advent of a variety of new ITS systems and technologies, the traffic signal controller remains the basis for most new ITS deployments. For example, it is estimated that over 60 percent of the benefits that resulted from the ITS investments that were made to support the 2002 Salt Lake City Winter Olympics came from improvements in traffic signal timing.

National Operations Initiatives

Several national initiatives focus on the importance of transportation operations. The Institute of Transportation Engineers (ITE) has established an objective of "reducing congestion and delay by regular retiming of traffic signals" in the national dialogue on transportation operations. An ITE working group is overseeing this effort.

The Federal Highway Administration (FHWA) has released a video, “Its About Time”, designed to motivate local elected officials to implement traffic signal management. The video cites six benefits of signal management and traffic signal improvements:

- Improved air quality and reduced fuel consumption
- Reduced congestion with time savings for commercial vehicles, emergency vehicles, transit buses and the public.
- Reduction in the number of accidents and their severity.
- Reduction in aggressive driver behavior.
- Either postpones or eliminates the need to construct additional roadway capacity.
- Receives high public acceptance and support.

Recent Developments

A consortium of state departments of transportation, universities, and technology transfer centers met together in Portland, Oregon in September 2002 to identify education and training needs for traffic signal timing in the Pacific Northwest. In preparation for the workshop, a survey was conducted of ITE members in Idaho, Washington, and Oregon regarding training needs. Even though this is a diverse group that includes designers, planners, and operations personnel, 53 percent of the 328 survey respondents identified a need for training in signal timing and control as a high priority. [Monsere 2002] Workshop participants identified topics for engineering professionals, engineering technicians, and university students including signal timing plans, traffic signal control systems, signal hardware and software, operating parameters of traffic signal controllers, advanced traffic signal control systems, theory behind traffic operations, and traffic signal optimization and simulation models. [Kyte and Lines, 2003]

In January 2004, FHWA proposed a multi-year roadmap for a new traffic signal timing program that is designed to reduce congestion and improve flow and safety by providing dramatic and sustained improvements in traffic signal operations throughout the U.S. This program, to be implemented during the next three years include awareness and outreach, education and training, tool development and guidance, research, and stakeholder involvement. One of the components of this program, hands on training in signal timing using traffic controllers, is the subject of the work to be completed in this current project.

ITE and the University of Maryland have recently initiated an effort to document current signal timing practices throughout the U.S. and assess the knowledge, skills, and abilities needed for conducting signal timing work by both engineers and technicians.

Each of these initiatives promotes traffic signal management by considering an agency’s existing traffic signal equipment and using existing tools, techniques and in some cases improved equipment to more efficiently utilize our city streets and signal systems. But for these initiatives to be successful, they must include training for current and future transportation engineers in the operations of traffic signal systems. Funding to accomplish this needed work is now available through the Fiscal Year 2004 U.S. Department of Transportation appropriation to the University of Idaho's National Institute for Advanced Transportation Technology (NIATT).

2. Proposal: Learning the Basics with Hands-On Training

Definition

Mobile (hands-on) signal timing training is training that will provide the skills and competencies needed by transportation engineers, technicians, and university students to use traffic data, existing traffic signal equipment, software programs, and resource material to determine and establish signal phasing and timing of individual installations of all types and systems of multiple signal installations for effective, efficient, and safe traffic control.

Project objective

The objective of this project is to develop, implement, and test a portable training course for traffic signal timing, including equipment, training materials, and educated instructors.

Guiding principles

We suggest the following principles to guide the development of this important training initiative:

- The training must be based on sound, generally-accepted traffic signal timing principles.
- Common traffic signal design software must be integrated into the training.
- Traffic controllers must be used throughout the training to give hands-on experience implementing the various parameters available in standard controllers.
- Traffic operations models must be used to simulate the operation of real world situations and conditions.
- Vendor's PC based software for configuring and managing controllers must be incorporated into the training.
- Real world problems, with well-documented solutions, must be the basis for all lessons included in the training.
- Class size must be limited so that attendants can practice implementing the hardware and software systems in a hands-on environment.
- Class participants will take a project from start (geometry and volumes) to finish (properly timed system implemented on real traffic signal hardware).
- Written training materials must be widely available, including via the Internet and other electronic distribution modes.
- The training must be given at the local level to the personnel that time traffic signals at minimum cost to the governmental jurisdiction with which they work.

Previous work

These principles are based on two initiatives in which we have been recently involved.

- Purdue University prepared a report for the Indiana Department of Transportation on traffic signal operations training [Nichols and Bullock 01]. The report includes part of the basis for the training materials proposed here.
- The University of Idaho has conducted a Traffic Signal Summer Workshop each August since 2000, now having served sixty students from over twenty-five universities from around the U.S. This workshop includes one week of hands-on experience with traffic signal controllers and support hardware and software [Kyte, Abdel-Rahim, Lines 03]. The notebooks prepared for the workshop would be used as a starting point for the course materials prepared for this project. Two quotes, one from a student and one from an instructor, illustrate some of the benefits of the workshop experience.

> “The best parts of the week were the hands-on work and introductory lectures to the more advanced technologies of video detection and hardware-in-the-loop simulation. Exposure to this technology was worth the trip alone.”
>
> “I think the valuable part is that students don’t just look at pictures or mathematical equations. They get a chance to tinker, make mistakes, and ultimately get various components up and running… much like they will have to in the real world. This means when they are on their first job and things don’t work exactly as expected during a [system] turn-on, they will have their wits about them and know how to debug the system and get it running.”

Proposed course topics

We suggest the following topics to be included in this proposed training, based on the materials already developed by Purdue University and the University of Idaho:

- Parameters critical to safe signal operation.
- Parameters critical to efficient signal system operation.
- Parameters appropriate to special cases.
- Appropriate design periods and volumes used for designing timing plans.
- Appropriate geometric parameters necessary for designing vehicle clearance times and pedestrian times.
- How to design vehicle detector size, location, and operating mode.
- Guidelines for designing permitted, permitted/protected, or protected phasing.
- How to configure controllers and management software to implement new timing plan designs.
- How to design and implement a closed loop signal control systems to improve operation and maintenance efficiency.
- How to coordinate multi-signal installations on arterials and collectors to improve flow.

Proposed concept

We propose that curriculum materials and a portable training environment be developed and tested that can be used by instructors and students throughout the U.S.

- We propose that a committee be established to provide oversight, direction, and review of the program. The committee would oversee the development of the program and the training materials. The committee would assist in marketing the training first in the Pacific Northwest and then nationally. The committee should provide a geographical and technical balance for the program. The committee would not only represent various regions of the country but also the various jurisdictional units such as urbanized counties and cities, mid-sized communities, large metropolitan areas, and small cities. The committee should include educators experienced in developing and conducting the training program. The committee should also include practitioners with experience in signal timing and operations.
- We propose that a set of training materials be developed that would be the basis for the Mobile (Hands-On) Signal Timing Training (MOST) that could be delivered in a variety of venues. The material would include a reference student notebook and a complete set of sample problems and solutions. The materials would include basic signal timing principles and how they are applied. The materials would be based on traffic controllers from more than one manufacturer. The materials would provide the basis for a one to three day workshop for professionals and technicians and multiple classroom and laboratory periods for university students.
- We propose that the materials be developed at three levels
  - University transportation engineering students
  - Engineering professional
  - Transportation technicians
- We propose that the training materials be in the form of case studies based on “guided uncertainty” in which students are encouraged to learn critical thinking and problem solving skills based on actual intersection or arterial studies. The format used for the development of the Highway Capacity Manual Applications Guide [Kittelson and Associates 2004], based on challenging students with open ended problems, will be followed here.
- We propose that ten equipment modules be purchased to become the basis of the hands-on component of this workshop. Each module would include a traffic controller, a controller interface device, and a laptop computer with the appropriate simulation and operations software. Each module would be packaged in a portable case that could be shipped easily. Ten modules would allow up to twenty students at a time, working in groups of two, to participate in a workshop at one site.
- We propose to identify area instructors and mentors who would be trained with the materials developed here and who could then serve as instructors for the course. The mentors would report to a regional instructor, helping him or her to teach the course when it is offered in a local area. Mentors could also run rural

small group classes from a distance in rural locations using the training material developed here and the internet or email.

3. Scope of Work and Schedule

We propose fourteen work tasks to be completed over a 36 month period. Figure 1 shows a timeline for the fourteen tasks. Included in the figure are the estimated start and end dates, as well as the estimated durations for each task.

Task 1. Establish a technical oversight committee that would provide project oversight and oversee the development of the training materials. The oversight committee will include from eight to ten members and provide both a geographic and organizational balance. The committee will include representatives from the Federal Highway Administration, a state department of transportation, both a large and small city, and a university.

Task 2. Identify and establish a Community of Learners, a group of university faculty and other interested professionals who are interested in reviewing and testing the materials that are developed during this project. It is expected that this community will include between five and ten university faculty from around the U.S. who have active research or educational programs in traffic signal systems and operations.

Task 3. Prepare and maintain the project web site. This web site will serve as the repository for all materials developed during the project as well as all progress reports and related materials. The web site will be maintained and updated throughout the project.

Task 4. Prepare a set of guidance documents that form the basis for the development of the case studies and related course materials. These guidance documents will include (1) a description of the signal timing design process including definition of terms and concepts, a list of key issues that must be considered in the design process, and a list of timing parameters that will be considered, (2) a set of learning objectives that describe the skills and competencies that students will be expected to have upon completion of courses in which the materials are used, (3) a set of guidelines that describe architecture and requirements for all case study materials, and (4) a technical memorandum that addresses the kinds of traffic controllers and traffic analysis software that will be used in the case study materials. Although this effort will use vendor equipment, in order to ensure the fundamental educational concepts are vendor neutral, all design parameters will be specified according to the data objects defined in NTCIP 1202:1996 (formerly TS 3.5-1996). This will have several important benefits. First it will provide participants with a dictionary of terms that have an accepted industry definition. Second, it will provide an opportunity to critically review the NTCIP standard to ensure all necessary data items are provided and those that are provided are not ambiguous. Third, once the modules are complete and used with practitioners, practitioners will gain insight into the benefits the NTCIP standard can provide.

Task 5. Conduct review of guidance documents with technical oversight committee. Comments from the committee will be incorporated into a final version of these documents.

Task 6. Based on the guidance documents developed in Task 4, develop a prototype case study for each of the three target groups, university students, engineering professionals, and engineering technicians.

Task 7. Conduct review of prototype case studies with technical oversight committee. The comments of the committee will be used for the development of the final materials to be undertaken in Task 9.

Task 8. Design and construct prototype portable equipment module. This prototype will be designed so that it is portable and can be easily transported to remote sites where workshops or short courses will be held using the materials developed as part of this project. The prototype will be reviewed by the technical oversight committee; suggestions made during this review will be incorporated into the final equipment module design undertaken in Task 10.

Task 9. Prepare final set of instructional materials and case studies for the three target groups described above (university students, engineering professionals, and engineering technicians). Case studies will include (1) an isolated intersection, (2) a corridor or network of signalized intersections that require signal coordination, (3) a diamond interchange or two closely spaced intersections. The materials will include a student notebook with all input data sets and materials, an instructor notebook with all supporting material, and electronic materials to support both students and instructors.

Task 10. Design and construct final portable equipment modules. The design will be based on the prototype module designed and reviewed during Task 8.

Task 11. Review instructional materials and case studies with technical oversight committee. Based on this review, a final set of instructional materials and case studies will be prepared.

Task 12. Pilot test instructional materials and case studies with each of three target groups. Document the results of this pilot test and identify changes to the course materials generated from this pilot test.

Task 13. Conduct second round of classroom testing of instructional materials and case studies. Document the results of these tests. This second round of testing will include the recruitment and instruction of regional trainers and mentors that will be designated to conduct courses in the geographic regions or local areas that they represent.

Task 14. Conduct twelve workshops in selected areas of the Pacific Northwest and in Indiana. It is expected that these workshops will reach over 100 students. The results of these workshops will be documented and included as part of the final report to be prepared in Task 15.

Task 15. Prepare final report. The final report will include instructional materials and case studies as well as a summary of findings and recommendations based on all earlier project tasks.

4. Project Deliverables

The project will produce five deliverables:

- Ten portable equipment modules with traffic controllers, CIDs, and cables
- Instructor's notebook and support materials
- Student notebooks for the three target groups
- Regional and local instructor training workshops
- Final report summarizing findings and lessons learned

5. Project Team

The project team consists of six members. Dr. Michael Kyte of the University of Idaho, Dr. Darcy Bullock of Purdue University, Mr. James Pline of Pline Engineering, Drs. Michael Dixon and Ahmed Abdel-Rahim of the University of Idaho, and Dr. Tom Urbanik of the University of Tennessee.

Dr. Kyte, who will serve as the principal investigator, is the director of the University of Idaho's National Institute for Advanced Transportation Engineering, and holds the rank of Professor of Civil Engineering. He has over thirty years experience in transportation design, operations, and education. He is responsible for development and oversight of the university's Traffic Signal Summer Workshop. He is also a team member of NCHRP 3-64, a project that has developed electronic training materials for the Highway Capacity Manual, known as the HCM Applications Guide.

Dr. Bullock is the Assistant Head of the Department of Civil Engineering at Purdue University, and holds the rank of Professor of Civil Engineering. He has over fifteen years of experience in transportation engineering education and practice. He was the principal investigator for the Indiana Department of Transportation study that resulted in the closed-loop system design guidelines and materials described earlier. Dr. Bullock participated as an instructor for the University of Idaho's Traffic Signal Summer Workshop for four years. He is a member of a number of technical committees including the Transportation Research Board's Committee on Traffic Signal Systems. He is also a co-investigator for NCHRP 3-66, Traffic Signal State Transition Logic Using Enhanced Sensor Information.

Mr. Pline is the president of Pline Engineering, based in Boise, Idaho. He has nearly fifty years experience in transportation engineering practice. He has authored a number of handbooks for the Institute of Transportation Engineers on transportation engineering.

Dr. Dixon is Assistant Professor of Civil Engineering at the University of Idaho. He has experience in developing educational materials for traffic control systems, using hardware in the loop simulation techniques. He has been an instructor for University of Idaho's Traffic Signal Summer Workshop for the past five years.

Dr. Abdel-Rahim is Assistant Professor of Civil Engineering at the University of Idaho. He has experience in traffic signal systems research and education, and is responsible for the development of University of Idaho's new traffic signal controller laboratory. He has been an instructor for University of Idaho's Traffic Signal Summer Workshop for the past four years.

Dr. Urbanik is Professor and Goodrich Chair of Excellence in the Department of Civil and Environmental Engineering at the University of Tennessee, Knoxville. He has over thirty years experience in transportation engineering in academic, consulting, and government settings. He is formerly associate director of the Texas Transportation Institute and is currently chair of the Transportation Research Board's Committee on Traffic Signal Systems. He is the principal investigator for NCHRP 3-66, Traffic Signal State Transition Logic Using Enhanced Sensor Information.

6. Budget

The total cost of this 36-month effort is $881,565. Total funding from FHWA is $705,275 while the local match is $176,290. The projected budget for the project is shown in Table 1. Labor distribution and rates are shown in Table 2.

7. References

[Nichols and Bullock 2001] Nichols, A. and D. Bullock, "Design Guidelines for Deploying Closed Loop Systems," FHWA/IN/JTRP-2001/11, November 2001.

[Kyte, Abdel-Rahim, and Lines 2003] Kyte, M., A. Abdel-Rahim, and M. Lines, "Traffic Signal Operations Education through Hands-On Experiences: Lessons Learned from a Workshop Prototype", accepted for publication in Transportation Research Record, 2003.

[Monsere 2002] Monsere, Chris, "Results of Oregon ITE/NWTTEA's Training Needs Survey", Memorandum, June 26, 2002.

[Kittelson and Associates 2004] Highway Capacity Manual Applications Guide. National Cooperative Highway Research Program, 3-64, 2004.

[Kyte and Lines 2003] Kyte, Michael and Melissa Lines, "NWTTEA Traffic Operations Retreat – Report of September 2002 Workshop on Traffic Signal Training Needs", National Institute for Advanced Transportation Technology, University of Idaho, Moscow, Idaho, January 2003.

ID	Task Name	Start	Finish	Duration
1	Establish technical oversight committee	1/3/2005	1/28/2005	4w
2	Identify community of learners	1/3/2005	1/28/2005	4w
3	Prepare/maintain project web site	1/3/2005	12/28/2007	156w
4	Prepare guidance documents	1/31/2005	4/29/2005	13w
5	Review guidance documents	4/4/2005	4/29/2005	4w
6	Develop prototype case studies	5/2/2005	10/28/2005	26w
7	Review prototype case studies	10/31/2005	12/30/2005	9w
8	Construct prototype equipment module	5/2/2005	7/29/2005	13w
9	Prepare case studies/instructional materials	1/2/2006	12/29/2006	52w
10	Construct final equipment modules	1/2/2006	6/30/2006	26w
11	Review case study and instructional materials	10/2/2006	12/29/2006	13w
12	Pilot test instructional materials/case studies	1/1/2007	3/30/2007	13w
13	Conduct second round of materials testing	4/2/2007	6/29/2007	13w
14	Conduct workshops	7/2/2007	12/28/2007	26w
15	Prepare final report	7/2/2007	12/28/2007	26w

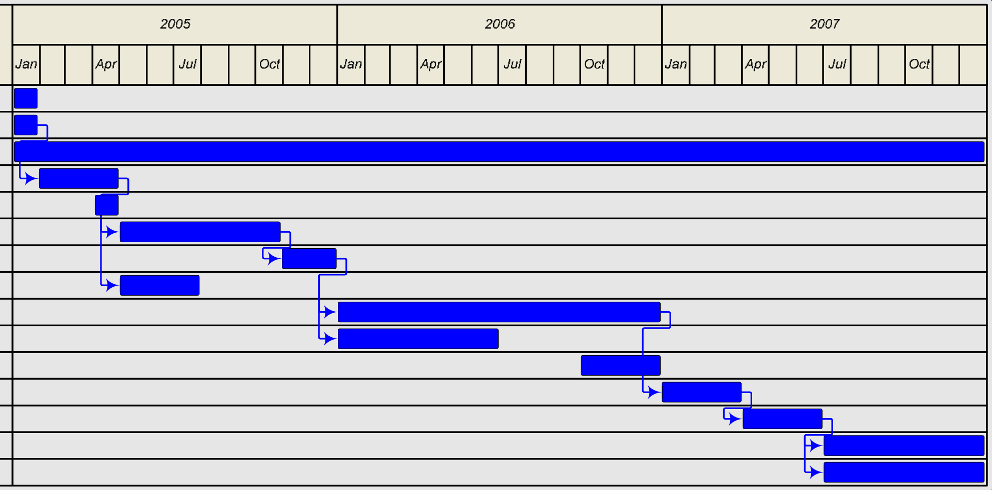

Figure 1. Project timeline

Table 1. Proposed budget

Budget Item	Three Year Summary				Yearly Summary - FHWA funds		
	FHWA funds	Match funds	Total Project Funds		2005	2006	2007
Salaries and Benefits							
Faculty salaries	$102,442	$72,375	$174,817		$29,480	$45,105	$27,858
Faculty fringe	$30,203	$21,713	$51,915		$9,589	$12,260	$8,354
Graduate Salaries (academic year)	$26,080		$26,080		$8,960	$15,840	$1,280
Student IH Salaries							
Graduate Fringe (academic year)	$261		$261		$90	$158	$13
IH (Student) Fringe							
Graduate, summer	$9,120		$9,120		$2,000	$6,800	$320
Graduate summer fringe	$228		$228		$50	$170	$8
Subtotal (salaries & fringe)	$168,334	$94,088	$262,421		$50,168	$80,333	$37,833
Other Costs							
Capital equip > $5000	$125,000		$125,000		$15,000	$110,000	
Equipment (between $300 and 2500)							
Other expenses	$37,000		$37,000		$8,000	$13,000	$16,000
Pline subcontract	$45,150		$45,150		$14,175	$29,400	$1,575
Bullock subcontract	$112,254		$112,254		$35,826	$47,768	$28,661
Urbanik subcontract	$42,991				$12,738	$19,903	$10,350
Instructor subcontracts	$20,000						$20,000
Domestic Travel	$37,000		$37,000		$12,500	$12,500	$12,000
Subtotal	$419,395		$356,404		$98,239	$232,571	$88,585
Total Direct Costs	$587,729	$94,088	$681,817		$148,407	$312,904	$126,418
Total Indirect Costs	$117,546	$43,563	$161,108		$29,681	$62,581	$25,284
Waived Indirect Costs		$38,640	$38,640				
TOTAL	$705,275	$176,290	$881,565		$178,088	$375,485	$151,702

Table 2. Labor hours and rates by person and task

		Hours									
					Grad student						
Task#	Task description	Kyte	Dixon	Abdel-Rahim	Academic year	Summer	Pline	Bullock	Urbanik	Curriculum specialist	Total
1	Establish technical oversight committee	10					5	5			20
2	Establish community of learners	10					5	5			20
3	Prepare/maintain project web site	50			200		0				250
4	Prepare guidance documents	75	30	30	30		40	55	15		275
5	Review guidance documents	25					10	10			45
6	Develop prototype case studies	120	100	100	200	100	55	100	50	50	875
7	Review prototype case studies	50	25	25	50	25	20	50	15		260
8	Construct prototype equipment module	5	5	5	80						95
9	Prepare case studies/instructional materials	175	210	210	740	350	200	200	100	420	2605
10	Construct final equipment modules	5	5	5	150	50					215
11	Review case study/instructional materials	75	75	75	100	25	80	100	25		555
12	Pilot test instructional materials/case studies	25	25	25	15			25	25		140
13	Conduct second round of materials testing	125	100	100	25			100	25	100	575
14	Conduct workshops	40	40	40	40	20		40			220
15	Prepare final report	40	10	10			15	15	15	50	155
Tasks	**Yearly summary**										
1-8	2005	345	160	160	560	125	135	225	180	50	1840
9-11	2006	255	290	290	990	425	280	300	125	420	3375
12-15	2007	230	175	175	80	20	15	180	65	150	1090
	Rates										
	Hourly rate ($/hr)	49.17	33.59	35.26	16.00	16.00	35.00	52.00	80.00	30.00	
	Fringe benefit rate	0.33	0.35	0.35	0.01	0.025	0	0.343	0	0.09	
	Indirect cost rate	0.20	0.20	0.20	0.20	0.20	1.00	0.52	0.00	0.20	