U.S. Department of Transportation

Intelligent Transportation Systems

for Traffic Signal Control

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Poor traffic signal timing accounts for an estimated 10 percent of all traffic delay – about 300 million vehicle-hours – on major roadways alone.[1] Americans agree that this is a problem: one U.S. Department of Transportation (DOT) survey found that 47 percent of people believe delays caused by congestion are the top community concern.[2] Recognizing that congestion has become a national problem, the U.S. DOT launched the *National Strategy to Reduce Congestion on America's Transportation Network*. One element of this strategy is to reduce congestion by promoting operational and technical improvements that will enable existing roadways to operate more efficiently.[3] ■

Traffic Signal Control

Intelligent Transportation Systems (ITS) applications for traffic signals – including communications systems, adaptive control systems, traffic responsive, real-time data collection and analysis, and maintenance management systems – enable signal control systems to operate with greater efficiency. Sharing traffic signal and operations data with other systems will improve overall transportation system performance in freeway management, incident and special event management, and maintenance/failure response times. Some examples of the benefits of using ITS applications for traffic signal control include:

- Updated traffic signal control equipment used in conjunction with signal timing optimization can reduce congestion. The Texas Traffic Light Synchronization program reduced delays by 23 percent by updating traffic signal control equipment and optimizing signal timing.[4]
- Coordinated signal systems improve operational efficiency. A project in Syracuse that connected intersections to a communications network produced reductions in travel time of up to 34 percent.[5] An added benefit to connected intersections is a simplified signal timing process and automated monitoring of equipment failures.
- Adaptive signal systems improve the responsiveness of signal timing in rapidly changing traffic conditions. Various adaptive signal systems have demonstrated network performance enhancement from 5 percent to over 30 percent.[6,7] ITS communication and sensor networks are the enabling technologies that allow adaptive signal control to be deployed.

Incorporating ITS into the planning, design, and operation of traffic signal control systems will provide motorists with recognizable improvements in travel time, lower vehicle operating costs, and reduced vehicle emissions. ■

BENEFITS

Traffic Signal Timing: Moving State-of-the-Practice Closer to State-of-the-Art

There are more than 330,000 traffic signals in the United States, and, according to U.S. Department of Transportation estimates, as many as 75 percent could be made to operate

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more efficiently by adjusting their timing plans, coordinating adjacent signals, or updating equipment.[8] In fact, optimizing signal timing is considered a low-cost approach to reducing congestion, costing from $2,500 to $3,100 per signal per update.[9]

ITS technology enables the process of traffic signal timing to be performed more efficiently by enhancing data collection and system monitoring capabilities and, in some applications, automating the process entirely. ITS tools such as automated traffic data collection, centrally controlled or monitored traffic signal systems, closed loop signal systems, interconnected traffic signals, and traffic adaptive signal control help make the traffic signal timing process efficient and cost effective.

Several municipalities have worked to synchronize, optimize, or otherwise upgrade their traffic signal systems in recent years. Below are a few examples of the benefits some have realized:

- The Traffic Light Synchronization program in Texas shows a benefit-cost ratio of 62:1, with reductions of 24.6 percent in delay, 9.1 percent in fuel consumption, and 14.2 percent in stops.[10]
- The Fuel Efficient Traffic Signal Management program in California showed a benefit-cost ratio of 17:1, with reductions of 14 percent in delay, 8 percent in fuel consumption, 13 percent in stops, and 8 percent in travel time.[11]
- Improvements to an 11-intersection arterial in St. Augustine, Florida, showed reductions of 36 percent in arterial delay, 49 percent in arterial stops, and 10 percent in travel time, resulting in an annual fuel savings of 26,000 gallons and a cost savings of $1.1 million.[12]

Although communications networks allow almost instantaneous notification of equipment failure, without which some failures may go unnoticed for months, there must be staff available to respond. A general rule of thumb for operations and maintenance of traffic signals is 1 traffic engineer for every 75 to 100 signals and 1 signal technician for every 40 to 50 signals;[14] however, a network containing numerous intersections with multiple lanes and phases will likely need more staff than a central business district with many two-phase intersections. Retiming should be performed every 2-to-3 years at a minimum – more often in areas of rapid change or where new signals are being added.[15] ■

> *"The payback in terms of capacity and public acceptance is significant. It's the one investment we can make in the near term that will make a difference in people's lives every day."*[13]
>
> — Seattle Mayor, Paul Schell.

BENEFITS

L.A.'s Adaptive Traffic Control System Reduces Delays and Stops

The city of Los Angeles has topped the Texas Transportation Institute's annual list of the most congested cities in the country since well before the turn of the century. It's no wonder that the Los Angeles Department of Transportation developed its own Adaptive Traffic Control System (ATCS) to adjust traffic signal timing in response to real-time traffic demands.[16]

The purpose of the L.A. system is to control all three critical components of traffic signal timing – cycle length, phase split, and offset – on a cycle-by-cycle basis. Extensive detector data collected in the signal network is continuously analyzed and evaluated, and the most appropriate signal timing for the existing condition is then implemented within one signal cycle. Any long-term traffic pattern changes and short-term variations in traffic conditions are automatically accommodated by ATCS. The result is fewer stops, fewer delays, and greater intersection operational capacities.

In a study to determine the benefits of L.A.'s ATCS over the Urban Traffic Control System that had been in operation as the city's central traffic control system, ATCS was shown to reduce travel time by 12.7 percent, reduce average stops by 31 percent, and decrease average delays by 21.4 percent. Improvements in delay were more significant during the evening peak hours than at other times, but travel time and average stops were improved for all time periods.[17] ■

ACS-Lite Now Available

ACS-Lite is a scaled-down version of the Federal Highway Administration's (FHWA) Adaptive Control Software (ACS).[18] It is designed to monitor and evaluate traffic conditions and provide refinements to signal timing on a cycle-by-cycle basis. ACS Lite is intended to be a low-cost solution that adjusts traffic signal timing for real-time traffic conditions in small-to medium-sized communities. It was designed specifically for the closed loop arterial traffic signal system, which is representative of 90 percent of the traffic signal systems in the United States.

For more information on this resource, contact Raj Ghaman, FHWA, raj.ghaman@dot.gov.

COSTS

Funding Is Out There – Ask for It!

Get the word out: *Federal funds can be used for arterial management programs*, including operations and maintenance of traffic signal control systems. In addition to project costs, operating costs are also eligible for Federal reimbursement from National Highway System and Surface Transportation Program funding. This aid is distributed to project sponsors in the following ways:

1. Transportation Improvement Program (TIP) and State Transportation Improvement Program (STIP). Program funds are typically available for capital improvement projects requiring new or

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reconstructed infrastructure. The installation of traffic signal systems and traffic control centers will usually be funded under these programs. These funds are programmed into the State's Long Range Transportation Plan (LRTP).

2. Congestion Mitigation and Air Quality (CMAQ) Improvement Program funds. For projects located in air quality non-attainment and maintenance areas, CMAQ funds may be used for operating costs for a 3-year period as long as those systems measurably demonstrate reductions in traffic delays. Typical eligible operating costs include labor costs, administrative costs, costs of utilities and rent, and other costs associated with the continuous operation of the system, such as costs for system maintenance.
3. U.S. Department of Transportation (DOT)/Federal Highway Administration (FHWA) Division Offices. These offices provide oversight and technical assistance per stewardship agreements with the State DOT for Federal-aid-funded projects.

The project sponsor must communicate the need for the project with either the State DOT or metropolitan planning organization (MPO) to determine whether the program fits into the local LRTP and whether the current TIP can be amended, if necessary, to include the project. If not, the project sponsor must work with the MPO or local State DOT representative to make sure the project makes it into the next TIP update cycle. The planning partners' responsibility is to help qualifying projects obtain funding from either Federal or other sources.

Where to Start

The first step is to call the local MPO planning office.

For localities that are not in an MPO area, the first step is to call the State DOT planning office to find out where they are in the LRTP and the TIP development process.

For more information on Federal aid, call the State FHWA Division Office.

Remember: the key to obtaining aid is reaching out to regional partners to locate local funding sources and working with them to ensure successful project delivery. ■

Sample Signal System Project Costs

Location	Treatment	Cost
Syracuse, NY[19]	Installed a computerized traffic signal system and optimization of signal timing for 145 intersections.	$8,316,307
Salt Lake Valley, UT[20]	Implemented an advanced transportation management system to allow the Utah Department of Transportation Traffic Operations Center (TOC) to monitor and manage freeway and arterial traffic flow in the Salt Lake Valley. More than 600 of the 900 signals in the Salt Lake Valley are connected to the TOC.	Signal Control System: $2,205,000
Arlington County, VA[21]	Brought 65 intersections (expandable to 235) under an adaptive signal control system. The cost included software, hardware, roadside equipment, cabling, traffic mobilization and maintenance, installation, training, maintenance and test equipment, and system documentation.	$2.43 million total, including: Field equipment and installation: $1.76 million Office equipment and installation: $208,000 Training: $28,800 Maintenance: $48,200 Traffic control and mobilization: $237,400 Software: $149,000

DEPLOYMENT

U.S. Traffic Signals Get a D- on 2005 Report Card

America's traffic signals rate only a D-, according to the findings of the *2005 National Traffic Signal Report Card*, a report published by the National Transportation Operations Coalition (NTOC).[22] NTOC attributes the Nation's low scores on its report card to inadequate resources, particularly among smaller cities.

So, How Do We Get an A?[23]

- Devote resources. To achieve an "A" on traffic signal performance, more sustained resources must be devoted to signals and the professionals who design, operate and maintain them.
- Make wise investments. Investment must be made in current signal hardware, timing updates, and maintenance resources.
- Provide training. Well-trained traffic signal technicians and engineers are needed to properly operate and maintain traffic signals and to preserve the investment in the hardware and timing updates. ■

The Benefits of an "A" Grade

The following are just a few of the benefits that can be realized from an "A" grade:

- Reductions in travel time up to 25 percent. If you commute 2 hours per day to and from work, you would save 50 hours per year because of improved traffic signal operations.[24]
- Reductions in fuel consumption of up to 10 percent, resulting in a savings of 17 billion gallons of motor fuel per year.[25]
- Reductions in harmful emissions (carbon monoxide, nitrogen oxides, volatile organic compounds) by up to 22 percent.[26]

LESSONS LEARNED

Traffic Signal Control – Lessons from Experience

The following are lessons learned on how to plan, design, operate, and maintain traffic signal control systems and are taken from both evaluation research and the ITS Lessons Learned Knowledge Resource.

Funding

- ***Craft a program of sustainable funding for ITS Systems deployed in signal operations.***[27] Funding for ITS deployments must consider the requirements for ongoing traffic operations and maintenance; it is directly proportional to the type, complexity, and quantity of technologies deployed. Any successful program must specifically define its objectives; establish the methods and processes to meet the objectives; provide resources, time, personnel, and equipment to meet the objectives; and have specific quantifiable performance measures in place to make certain the objectives are met. Without a sustainable funding source, additional benefits from ITS deployment will be hard to sustain throughout the life cycle of the program. Federal resources can be used to provide a significant portion of funding to sustain this program.

Leadership and Partnerships

- ***Implement a communication structure across jurisdictions that facilitates the flow of traffic data and allows agencies to coordinate traffic signal timing.***[28] In the Scottsdale/Tempe area, the boundary for coordination previously existed at a jurisdictional separation. By moving this coordination boundary to a functional boundary defined by a roadway – an area at which traffic signal coordination is less of an issue – drivers are able to make a seamless commute from one jurisdiction to the next. For the Phoenix area, regional traffic signal coordination has been achieved through careful planning, increased coordination efforts, and a well developed cross-jurisdictional communication infrastructure.

Requirements and Design

- ***Focus on solving existing transportation problems when considering ITS and introduce technologies as part of the solution.***[29] The purpose of Delaware's Statewide Integrated Transportation Management System Integration project, now called DelTrac, is to solve transportation problems by ensuring that only the most appropriate and needed technology solutions are deployed. For example, much of the traffic in Delaware is carried on signalized highways, and controlling signal timing is a key factor in maintaining throughput on those highways; therefore, a long-term objective for DelTrac is establishing an adaptive signal control system.

Operations and Maintenance

- ***Retain properly trained staff to deploy, operate, and maintain systems.***[30] Without the proper knowledge, agencies can find themselves in a quagmire of software, hardware, maintenance, and communications problems. A 2002 synthesis of best practices reveals the tremendous need to hire knowledgeable employees and to keep them current in the ever-advancing technologies that influence the design, deployment, and operation of traffic signal systems. Without proper staffing and training, agencies will be hard pressed to exploit the additional capabilities gained through a successful ITS deployment. Synthesis interviewees stressed the need to have agency staff attend technical professional conferences, meetings, and seminars through which professional networks can be established and new information is readily available.

For these and other lessons, visit: www.itslessons.its.dot.gov. ■

LESSONS LEARNED

Peers, Mentors, and Low-Cost Classes Can Supplement Operator Training

Computerized traffic signal systems can be extremely useful in managing street traffic, but advancements in control technology, signal optimization programs and other traffic engineering tools are sophisticated, and, for these systems to operate at their full potential, signal engineering staff need training. Although there is often a constant pressure to minimize spending at departments of transportation, low-cost options do exist and can be used to assist staff in performing their maintenance and operations duties. These options may include:

- Regional mentoring programs, wherein less experienced engineers are paired with those with greater experience to guide them and offer professional advice.[31]
- Peer-to-peer programs between agencies, which can be very beneficial in matching individuals seeking specific knowledge of a system with those who have both implemented and maintained such a system.[32]

There are also a number of supplemental training options available for minimal cost from universities, transportation associations, and the Federal government, including:

- The Institute of Transportation Engineers: www.ite.org/education/clearinghouse
- The National Highway Institute: www.nhi.fhwa.dot.gov
- The ITS Professional Capacity Building Program: www.pcb.its.dot.gov/Calendar.asp
- The Consortium on ITS Training and Education, based at the University of Maryland: www.citeconsortium.org/curriculum.html ■

THERE'S MORE ONLINE!

ITS Applications Overview: www.itsoverview.its.dot.gov

FHWA Office of Operations Arterial Management Program: www.ops.fhwa.dot.gov/arterial_mgmt/index.htm

National Traffic Signal Report Card: www.ite.org/reportcard

The online version of this document contains a full list of sources: www.its.dot.gov/jpodocs/repts_te/14321.htm

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Document Referenced	Location	Cost to Retime Each Signal
Fee Estimate – Millennia Mall Retiming and Scope and Schedule – Millennia Mall Retiming (Bid submitted to the City of Orlando, FL in October 2005 by TEI Engineering.) ITS Costs Database Entry: **www.itscosts.its.dot.gov/its/benecost.nsf/0/965159F6165B89CD8525725F00775FDA** Report: **orlapp1.ci.orlando.fl.us/asv/paperlessagenda.nsf/6acecff5f30ecb0d85256bd0005abae0/2e9835a4a025b7448525709800515d3b?OpenDocument**	Orlando, FL	$3,100
Heminger, S., *Regional Signal Timing Program – 2005 Cycle Program Performance* (Memorandum to the California Metropolitan Transportation Commission's Operations Committee), Oakland, CA: October 2006. ITS Costs Database Entry: **www.itscosts.its.dot.gov/its/benecost.nsf/0/714A1417F0A45AF18525725F00757ABD**	California	$2,400
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Conversation with Mr. Jerry Luor, Traffic Engineering Supervisor, Denver Regional Council of Governments (DRCOG), October 2006. ITS Costs Database Entry: **www.itscosts.its.dot.gov/its/benecost.nsf/0/F81461CF059C24AD8525725F007B0947**	Denver, CO	$1,800-$2,000 – includes consultant time and DRCOG staff review time

NOTE: While a range of $2,500 to $3,100 is reasonable, costs could be slightly more or less.
For more information, see ITS Costs Database Entry: **www.itscosts.its.dot.gov/its/benecost.nsf/0/28A2F8923ACE84468525725F00 7B88EE**

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18. For more information about ACS-Lite, contact Raj Ghaman, Travel Management Team Leader in FHWA's Office of Operations Research & Development, 202-493-3270, raj.ghaman@dot.gov. Or, visit the FHWA Resource Center, **www.fhwa.dot.gov/resourcecenter/teams/operations/index.cfm**

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