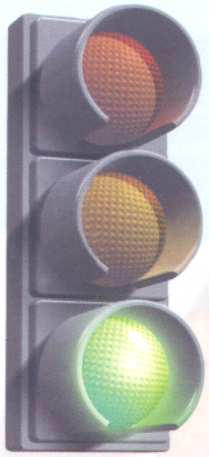


Red Light, Green Light

by John Halkias and Michael Schauer

Appropriate timing of traffic signals can decrease congestion, improve air quality, reduce fuel consumption, and minimize aggressive driving behavior.

Virtually all major intersections and many driveways now are controlled by traffic signals. Although traffic signals are critical to the safe operation of roadways, they also can be a source of inefficiency. From signals that require drivers to stop late at night when no other vehicles are present to those that seem to take too long to turn green, such inefficiencies in timing can cause frustration for drivers.

"Traffic signals are some of the most visible operations tools to the traveling public," says Martin Knopp, team leader of the Operations Technical Service Team for the Federal Highway Administration's (FHWA) Resource Center. "The public may not know how traffic signals work beyond red-yellow-green, but they know when the signals aren't timed well."

Research has shown that of the nearly 330,000 traffic signals in the United States, more than 75 percent of them could be improved by updating equipment or simply adjusting the timing. "Poorly timed traffic signals cause more than driver frustration," Knopp says. "They increase traffic congestion, which is already a growing concern."

Researchers at Oak Ridge National Laboratory estimate that poor signal timing causes 296 million vehicle hours of delay. Given that arterial and collector roadways now make up only 30 percent of all highways, yet carry 56 percent of the total vehicle miles traveled, inefficient signal timing will continue to compound traffic problems associated with population growth and increased travel. As congestion increases, so do fuel consumption, pollutant emissions, highway operating costs, and the potential for crashes.

"What is more, poorly timed signals lower credibility and public trust in a jurisdiction and decrease safety by contributing to aggressive driving, including red-light running and neighborhood shortcutting," says Knopp.

Properly timed signals—with appropriate cycle lengths, clearance intervals, and coordination—can help alleviate or avoid these negative consequences. To date, traffic signal retiming programs have resulted in travel time and delay reductions of 5 to 20 percent, and in fuel savings of 10 to 15 percent nationwide. Plus, by reducing congestion, properly timed signals cut vehicle emissions and can postpone or sometimes even eliminate the need to construct additional capacity. Further, the technologies available to support improved traffic signal timing and system operations can be used to improve data collection and communication.

So, why are traffic signals not timed more efficiently?

A Closer Look at The Problem

A variety of factors contribute to poorly timed traffic signals, including equipment malfunction, insufficient staffing of traffic professionals, and out-of-date traffic analysis. Primarily, however, insufficient resources and agency attention are to blame, according to Philip J. Tarnoff, director of the Center for Advanced Transportation Technologies at the University of Maryland.

"The poor state of the Nation's traffic signal timing reflects our failure to provide adequate resources,"

The traffic signal (circled) hanging above this residential intersection is unwarranted, given the low traffic volume in the area.

Tarnoff says. "This failure is apparent from the fact that 35 percent of the Nation's signals have not been retimed in more than 10 years, and nearly 10 percent of the agencies in the United States are operating outdated electromechanical equipment."

Indeed, when it comes to managing traffic signals, there is much room for improvement. A review of the history of traffic signals sheds more light on the issue.

Until the 1950s, most traffic signals were operated by electromechanical controllers that could be configured manually to have up to three timing plans during any particular day (generally covering the morning peak, the offpeak, and the afternoon peak). However, they were difficult to reprogram and could not respond to traffic from side streets. These controllers operate according to the same patterns day after day, and many still remain in service. Although their continued usage is a testament to their endurance, it is also a major cause of inefficiency in traffic management, given the current level of demand and changing traffic patterns.

Today, even at intersections with updated controllers, traffic detection on the minor or side streets is often missing. Consequently, such intersections function in a preset mode, where green signals are terminated on main streets even if no vehicles are present on the side streets—thereby causing unnecessary traffic delay.

In addition to the need for updated equipment, resources also are required on a continuous basis to maximize traffic signal attention. "Although many cities in the United States have new, up-to-date signal systems in place, few actually have the money or personnel to operate them efficiently," says Paul R. Olson, traffic operations engineer at FHWA's Resource Center. "Some agencies seem to adopt a 'set it, then forget it' mentality with regard to new equipment," he adds, "as they believe that updated infrastructure is capable of running itself—which is a total myth."

Inefficiencies still abound in traffic signals that have been updated or modified to include detection capabilities at the time of installation. Such signals are prone to malfunction, especially following excavations or repaving activities conducted by utilities or local transportation agencies, since detection loops are located beneath the pavement. When loop detectors are compromised, controllers need to operate in recall mode, where they function as fixed-time controllers, subject to the inherent inefficiencies of fixed-time controllers.

This traffic signal is operated by an old electromechanical controller box (circled) barely visible on the pole to the right. These cars are stopped even though no cars are approaching the intersection from the side street.

"Some agencies that I have worked with do not even know which loop detectors in the system work and which do not," Olson says.

Even traffic signals with updated controllers and functioning detectors may suffer from inappropriate green time apportionment in the absence of adequate coordination or regular updates. This can be true for intersections that experience increased traffic on one or more approaches, or at intersections with new developments in the area, such as the construction of a new shopping center. Likewise, if traffic signals are located close to one another but not coordinated, signal timing efficiency will not be maximized.

Quite simply, proper traffic management requires updated equipment and consistent attention from qualified staff. Fortunately, a variety of technologies are available to help.

State-of-the-Art Solutions

To respond to the changes in traffic demand, FHWA recommends retiming signals regularly. Those signals that operate independently can work more efficiently with only minor investments in equipment and labor. For example, agencies can enhance efficiency by coordinating or interconnecting closely spaced signals so they share a common time reference. Connecting traffic signals to a computer so they can be reprogrammed on short notice and timing patterns can be changed remotely is another means of achieving far-reaching improvements.

The latest controllers use microprocessors that are essentially computers capable of multiple timing patterns and remote communications. Also, hardware and software have progressed to the point where a laptop computer can control a multitude of signals from virtually any location. In addition, detector technology has progressed beyond the tried-and-true pavement loop detectors. Today, agencies can install magnetic, microwave (or radar), acoustic, or video detection technologies, some of which are installed above the roadway and are not affected by adverse weather or typical utility and roadway work.

In addition, numerous software packages available from both the public and private sectors have been developed to analyze and optimize traffic signal timing and offset plans prior to implementation. These packages use models to simulate traffic and evaluate operations. The software clearinghouses at the University of Florida's Center for Microcomputers in Transportation (McTrans™) and Kansas University Transportation Center's PC-Trans are typical sources for this type of software.

The microwave detector shown in this photo (circled) is pointing directly at the ground instead of the roadway, highlighting the need for continuous maintenance of traffic signal controls.

The high volume of traffic on this roadway suggests an insufficient distribution of green time.

Making Progress

According to the Institute of Transportation Engineers (ITE), as a general rule of thumb, the proper operation and maintenance of a traffic signal system requires one traffic engineer for every 75 to 100 signalized intersections, and one technician for every 40 to 50 intersections. Also, signal timings should be updated at least every 5 years, with 3 years being the accepted industry standard.

"Traffic signal management is one of the most cost-effective ways to improve traffic flow and make our streets safer," says Associate Administrator for Operations Jeff Paniati at FHWA.

The costs for retiming traffic signals generally range from around $500 to $3,000 per intersection. Optimizing signal timing produces average benefit-to-cost ratios that approach 40 to 1. In addition, management programs for traffic signals are eligible for Federal-aid funding. (For more information, visit www.ops.fhwa.dot.gov/Travel/ops-memo.htm.)

Two areas reaping the benefits of improved signal timing are Oakland County, MI, and Syracuse, NY. In Oakland County, the retiming of 640 signals substantially reduced the total number of crashes, traffic delays, and emissions of pollutants at benefit-to-cost ratios of well over 50 to 1.

In the city of Syracuse, where a computerized traffic signal system was installed and the signal timings at 145 intersections were optimized, the number of stops and traffic incidents decreased substantially. Travel times, fuel consumption, and vehicle emissions also were lowered significantly.

"Although traffic signal management is a highly cost-effective way to improve traffic flow and make our streets safer," Tarnoff says, "signal timing is still woefully out of date in many jurisdictions."

FHWA Initiative

To broaden the reach and associated benefits of improved signal timing, FHWA recently formulated a program to provide leadership in mainstreaming traffic signal timing and retiming and to promote coordination as a fundamental and continuing part of any transportation improvement plan. Accordingly, FHWA will focus on several general areas including awareness, outreach, education, tool development, and guidance.

The awareness and outreach focus area aims to raise the level of support for investment in traffic signal operations among managers and decisionmakers (such as metropolitan planning organizations and elected officials), and transportation practitioners responsible for signal timing. Toward that end, FHWA, ITE, and the National Transportation Operations Coalition are working to establish a national outreach campaign. Beginning in 2005, a national report card on traffic signal operations will be published to increase awareness among policymakers. The goals are to generate national attention to signal timing and retiming in the United States and to educate decisionmakers regarding the availability and effectiveness of solutions.

FHWA also will disseminate case studies, best practices, and standards of practice to raise the level of awareness among practitioners. FHWA and ITE will partner with universities, private vendors, and other organizations to develop an integrated training curriculum for traffic signal timing to improve the knowledge base. The training initiative will include three major efforts:

- To identify the knowledge, skills, and abilities necessary for signal technicians, traffic engineers, and midlevel managers

Signal Retiming in Oakland, MI

In 2002, the Road Commission for Oakland County—in cooperation with the Michigan Department of Transportation, the Southeast Michigan Council of Governments, Wayne County, the Road Commission of Macomb County, and the cities of Ferndale, Pontiac, and Royal Oak—began a program to retime traffic signals. The program included developing and implementing traffic signal timing and coordination plans for nearly 900 signals. The commission now is in Phase III, with 640 signals retimed during the first two phases. Already, the program boasts impressive benefits:

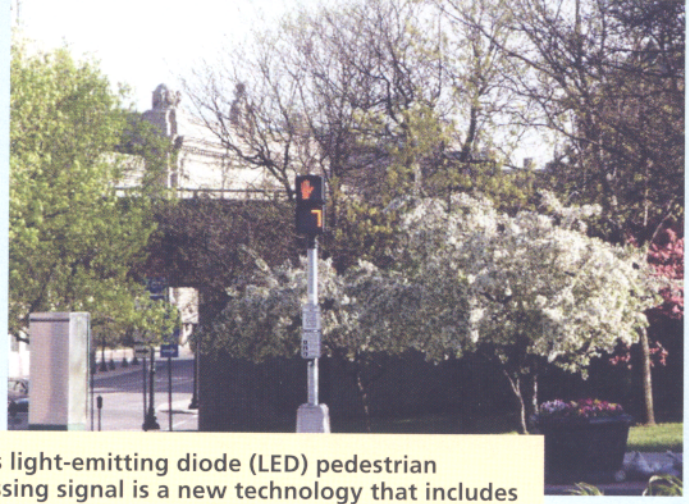
Phase I Benefits:

- Benefit/cost ratio of 175 to 1 due to reduction in delays
- 2.5-percent reduction of carbon monoxide (CO)
- 3.5-percent reduction of nitrous oxides (NOx)
- 4.2-percent reduction of hydrocarbons (HC)

Phase II Benefits:

- Benefit/cost ratio of 55 to 1 due to reduction in delays
- 1.7-percent reduction of CO
- 1.9-percent reduction of NOx
- 2.7-percent reduction of HC

The county's remaining 260 signals will be retimed by the end of 2005.



This light-emitting diode (LED) pedestrian crossing signal is a new technology that includes a numeric countdown display that activates when the orange hand begins flashing. Such signals increase safety for pedestrians by providing extra information on signal timing to enable them to make more informed decisions before crossing.

This photo of downtown Albany, NY, shows a roadway with five consecutive green lights. Successful timing of traffic signals makes for less frustrated drivers.

- To inventory and assess the existing training courses and core expertise
- To develop new educational and training materials to fill the gaps between current training programs and the necessary knowledge, skills, and abilities

The curriculum will be tiered in such a way that managers gain the foundational knowledge necessary to oversee the design of quality signalization projects, and practitioners develop the detailed technical skills necessary to optimize and manage traffic signals more effectively and efficiently.

The focus area dealing with tool development and guidance will provide recommended practices, how-to manuals, and other resources to improve the knowledge base among practitioners. The first step involves developing a Web-based toolbox for middle managers and technical staff. The toolbox will provide resource materials, including guidance documents, manuals, program descriptions, and self assessments to assist practitioners in timing their signals or upgrading existing systems.

Driving the Message Home

When it comes to traffic signal timing, the facts are clear: poorly timed signals result in additional traffic delays, red-light running, neighborhood shortcutting, higher fuel consumption, and emission of air pollutants. With enhanced management, agencies can reduce or avoid these negative consequences in a cost-effective manner.

FHWA recognizes the importance of raising the issue of signal timing to a level of national prominence. Transportation practitioners and decisionmakers should strive to update signal timings regularly and ensure that traffic engineers and technicians are staffed and trained accordingly. All that remains is for the transportation community to accept the challenge and rise to the occasion.

Signal Timing in Syracuse, NY

In the city of Syracuse, NY, where traffic signals are owned by the city and the New York State Department of Transportation, each agency historically chose the type of equipment it deemed most appropriate for its system, and communication among adjacent signals was nonexistent. Several years ago, however, the city implemented the Signal Interconnect Project, which involved implementing a computerized traffic signal system.

Through the project, Syracuse optimized and interconnected the signals at 145 intersections in the central business district, University Hill area, and key arterials, with the goals of reducing vehicle delays and stop times at traffic signals and improving air quality in downtown Syracuse and Onondaga County. After the traffic signal system had been operating for more than 3 years, the New York State Department of Transportation conducted an evaluation, which recently revealed the extent of the project's benefits, including:

- 15.7-percent reduction in stops
- 18.8-percent reduction in delays
- 16.7-percent decrease in travel times
- 13.8-percent drop in fuel consumption
- 13-percent reduction in vehicle emissions and noise pollution

The evaluation also found notable reductions in response times to equipment failures, the number of crashes, and associated stress on highway users. Finally, the evaluation revealed increased flexibility in signal control and traffic management strategies, as well as improved data collection capabilities.

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Michael Schauer, M.E., P.E., P.T.O.E., is the senior transportation management engineer with the New York Division of FHWA. He also is the cochair of the Arterial Operations Workgroup within the FHWA Operations Council. He led the FHWA Region 1 Traffic Signal Systems Team reviewing municipal signals throughout the northeast. He performed graduate work at Rensselaer Polytechnic Institute involving traffic signals, and his graduate project involved the analysis and optimization of a major suburban arterial. He also has served as president of the New York Upstate Section of ITE.

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