OPTIMIZING TRAFFIC SIGNALS

We wait at red lights while there is no cross traffic in sight even though we see the traffic light computer box on the corner. It is as if there is a total disconnect between the traffic lights, the computer and the centralized traffic control center.

Improvements to traffic signals are few and far between. Signal coordination along major arterials is weak or absent. There are rare occasions when one motorist can go through five consecutive signals, even along the Nuuanu portion of the Pali Highway which is not interrupted by any significant cross streets.

Signal light optimization can reduce in town travel times by 30 percent but it will take a significant upgrading of current staffing of traffic engineers to implement it.

Honolulu's traffic signals operation is comparable to San Francisco's. They have about 1200 intersections with traffic lights; we have a little over 800.

Honolulu does have direct communications with the local traffic controllers, most critical intersections have CCTV surveillance cameras, and all intersections have sensors to detect traffic and respond to it. So most of the infrastructure needed to run an efficient operation is there.

What we do not have enough of is traffic and electronics engineers specializing in urban traffic control (UTC) operations to make the most out of the infrastructure. Our small and overburdened staff barely makes the system work. They cannot make it work well. Honolulu needs at least six experts added to its UTC operation. Once this is done, it should not surprise anyone if travel times on some routes are cut by one third or more.

It is as if City Administrations over the last twenty years keep telling us they are fixing the traffic lights but somehow no significant actions take place. One could be forgiven for believing that it has been deliberate neglect to keep voters anxious for solutions such as rail transit.

****

The following article is from the U.S. Federal Highways Administration's *Public Roads* magazine edition of **January/February 2002 — *Managing Traffic Flow Through Signal Timing*** by S. Lawrence Paulson

It's a commuter's dream: The avenue is thick with traffic, but green lights appear with regularity. Traffic flows smoothly, and lane changing is minimal. Tailgating is rare. When a red light does appear, no one tries to sneak through. Driving seems almost ... civilized.

It sounds like a miracle, but it may just be another success story resulting from traffic signal management, one of the most cost-effective ways of keeping traffic moving smoothly and making streets safer.

Traffic signal management can be defined as using improved tools, techniques, and equipment to make existing traffic signal control systems operate more efficiently. It helps:

- Improve air quality and reduce fuel consumption.
- Reduce congestion and save time for commercial and emergency vehicles, buses, and the public.
- Reduce the number of serious accidents.
- Reduce aggressive driving behavior, including red-light running.
- Postpone or eliminate the need to construct additional road capacity.

The Federal Highway Administration (FHWA) is now engaged in a campaign to inform local and regional decision-makers about the eligibility of traffic signal management programs for existing federal funding and about the benefits to their constituents, as highway authorities get the most out of existing arterials before planning costly new construction projects.

Room for Improvement

There are more than 300,000 traffic signals in the United States, according to the Institute of Transportation Engineers (ITE), and their importance in the nation's transportation network can hardly be overemphasized. In some urban areas, signals at busy intersections may control the movement of more than 100,000 vehicles per day. Two-thirds of all miles driven each year are on roadways controlled by traffic signals. In California alone, motorists drive more than 60 billion miles (97 billion kilometers) each year on signal-controlled streets. And, according to FHWA estimates, as many as 75 percent of all traffic signals could easily be improved by updating equipment, or by simply adjusting their timing plans, or by coordinating adjacent signals.

There are great disparities in the amount of attention different localities have paid to traffic signal management, said Pamela Crenshaw, transportation specialist for FHWA's Office of Travel Management. "Basic signal timing is a problem in many localities," Crenshaw said. She noted that one survey showed that some municipalities haven't retimed their signals for as long as 20 years. FHWA recommends retiming every two to three years.

"That's why we're trying to work this from all angles," she said. "We're trying both to advance the state of the practice and the state of the art and move the state of the practice closer to the state of the art."

One of FHWA's main tools in this effort is a 13-minute video, "It's About Time." The video features testimonials by three public officials on the effectiveness of signal-timing programs in their cities.

"The payback in terms of capacity and public acceptance is significant," said Seattle Mayor Paul Schell. "It's the one investment we can make in the near term that will make a difference in people's lives every day." Retiming signals in Seattle increased efficiency on three major arteries by 26 percent, 22 percent, and 16 percent to 18 percent, respectively.

Traffic Signal Management is one of the most cost-effective ways to keep the traffic moving.

Schell has been particularly outspoken in promoting Seattle's signal optimization program. "Synchronizing our traffic signals has been one of my highest priorities since day one," he said in a press conference in July 2001. Schell reported that more than 232 signalized intersections had been optimized since 1998, and another 309 intersections were scheduled to be completed by the end of 2001. "This commitment is paying off every day as our engineers continue to update our signal system."

The video also features an interview with Richard Plastino, director of public works in Lakewood, Colo. Plastino said, traffic signal retiming is "one of the few low-cost alternatives ... to physical reconstruction of intersections and streets."

And John Poorman, staff director for the Capital District Transportation Committee in Albany, N.Y., said, "It [produces] a phenomenal amount of benefit in the aggregate. And every little bit helps when we're talking about higher fuel prices and nonattainment of air quality standards and so forth."

Proven Benefits

The video's primary audience is elected and appointed officials who control funding for highway projects, said Crenshaw.

"There are proven benefits to traffic signal retiming," she said. "It's very cost-effective in comparison to a lot of alternatives, especially construction. The benefit ratio can be as high as 40 to 1. It's something we would like elected and appointed officials to look at when it's time for them to allocate their funds."

Still, Crenshaw is cautious about overselling the low-cost aspects of traffic signal management. "It's relatively inexpensive compared to construction, but you do have to make an investment in keeping the system up. Plus there are outlays for labor because it requires manpower to do the work in the first place. This isn't a one-person job," she said.

What kinds of expenditures are involved? According to *Improving Traffic Signal Operations*, a primer prepared by ITE for FHWA in 1995, optimizing the timing of already interconnected traffic signals annually costs about $300 to $400 and is the most cost-effective timing project. Interconnecting and optimizing noninterconnected signals cost from $760 to $2,700 per signal per year.

An FHWA brochure intended to accompany the video quotes the ITE *Traffic Control System Operations: Installation, Management and Maintenance* publication on estimated labor requirements. A signal retiming program should take around 20 to 25 staff hours per intersection. And a general rule of thumb is that it takes one traffic engineer to properly operate and maintain every 75 to 100 signals and one

signal technician to operate and maintain every 40 to 50 signals. The brochure notes that consultants are often used to supplement staff on retiming projects.

It's possible to quantify the benefits of retiming. Each dollar spent optimizing signal timing could yield a 15- to 20-gallon (57- to 76-liter) savings in fuel, the ITE primer states.

Motorists also save through a reduction in time lost in traffic. A study in York County, Va., estimated that traffic signal improvements on a 1.5-mile (2.4-kilometer) stretch of U.S. Route 17 are saving motorists $65,000 a year, calculating the costs of wasted time and vehicle operation at $5 per hour. And fuel consumption has decreased 11 gallons (42 liters) per 1,000 vehicles during some of the study periods.

Field studies conducted after 41 California cities retimed 1,535 signals at a cost of $2 million in 1983 showed that vehicle stops and delays were cut by more than 14 percent, travel time was reduced by 6.5 percent, and fuel use declined by approximately 6.4 million gallons (24 million liters).

A new signal system and improved signal timing in Abilene, Texas, produced a 13-percent reduction in travel time, a 37-percent reduction in delay, and a 6-percent savings in fuel use.

While signal retiming should be considered at least every two or three years, FHWA says that there are special circumstances that could make immediate signal retiming desirable: when a new signal is added or a signal is updated; when traffic, pedestrian volumes, or turning movements change significantly; when access to a roadway changes; and when there is a change in the geometry of a roadway.

Proper tools, such as traffic analysis models, can help with planning and managing traffic flow along a corridor.

An Unseen Revolution

Traffic signal technology has undergone something of a revolution in recent years, but it's a revolution that has gone largely unnoticed by the motoring public. There are still two basic types of traffic controllers: pretimed and traffic-actuated. Pretimed controllers actuate a predetermined, regularly repeated signal sequence. For example, the pretimed controller for the signal at one intersection might be set to give the primary street 40 seconds of green time, and the secondary street might be assigned 15 seconds of green. Several seconds would be allowed for the yellow signal. The signal would rotate through this cycle in a constant fashion, so pretimed controllers are most suitable for intersections with predictable, stable, and fairly constant traffic volumes.

Traffic-actuated controllers are best for intersections with irregular traffic volumes or where it's desirable to minimize interruptions to the flow of traffic on the street carrying the heavier volume of traffic. A simple traffic-actuated signal installation has four components: the controller unit, the detectors, the traffic lights, and the connecting cables. The detectors are usually placed in the pavement although they are sometimes positioned on the signal poles themselves. Commonly used detectors are

inductive loop, magnetic, magnetometer, and microwave. The inductive loop - by far the most common type of detector - consists of a loop of wire embedded in a saw-cut slot in the pavement and covered with a protective epoxy sealant. The metallic mass of a vehicle traveling over the detector changes the inductance of the loop. The detector processes this change and notifies the controller unit of the presence of a vehicle.

There are three basic types of traffic-actuated controllers:

- Semi-actuated, which assigns a continuous green signal to the major street, except when a car on the minor street signals that it is waiting to enter the intersection.
- Fully actuated, which requires detectors on all lanes approaching the intersection and is most useful when vehicle volumes vary over the course of a day.
- Volume-density, which records and retains traffic information, such as volumes, and thus calculates the duration of the minimum green time based on actual traffic demand.

It is in the latter category that the greatest technological advances have been seen. "Things have become very sophisticated," Crenshaw said. "There are better and faster signal controllers, much more expansive operating systems. We've gone as far as adaptive signal control, where the traffic volume is read on a second-by-second basis and the signal timing is automatically adjusted. Traffic conditions are actually anticipated - the detectors up the street will detect approaching traffic and, therefore, the controller down the street will change the timing at the intersection as the traffic is approaching."

Computerized traffic simulation models help traffic engineers design and develop proper signal timing. Some of the programs in current use include TRANSYT-7F, designed to optimize traffic signal systems for arterials and networks; SIGNAL97, for analyzing, designing, and optimizing multiphase signalized intersections using the methods in the 1997 update to the *Highway Capacity Manual*; SYNCHRO, which uses logic and algorithms similar to TRANSYT-7F but can analyze fully actuated, coordinated signal systems; and the PASSER II, III, and IV programs, which aid arterial analysis.

Besides enabling engineers to replicate traffic conditions and thus work out optimal signal timings, computers can permit signals to be controlled from a central location, enabling someone in an office to modify a signal without visiting the intersection. This can both reduce costs and allow changes to be made quickly.

Signal retiming should be re-evaluated whenever a new signal is added or when access to a road changes.

Such centralized control aids in coordinating signal operations within a municipality and even across jurisdictional boundaries. Many regions have successfully implemented this approach. This kind of coordination in the Denver area led to greatly improved traffic flow on overloaded regional arteries.

"The way we did it here in the Denver area," said Plastino on the video, "our regional planning organization, the Denver Regional Council of Governments, took the lead in setting up a program for coordinated signal timing,"

"Between the computer programs and the more sophisticated software; the faster, more high-powered traffic controllers; and the different operating systems that private companies have, it's become much easier, if you have the necessary tools, to get a handle on managing traffic congestion." Crenshaw said.

But the tools and the manpower needed to use them properly aren't free, she noted. And while the use of federal funds is allowable for traffic signal management, the subject may be far from the thoughts of elected and appointed officials when budget time rolls around. Crenshaw hopes the video and brochure will raise the profile of a program that has proven its cost-effectiveness.

"We realize that there are a myriad of things to invest in at a given time," she said. "This is one that enhances safety, reduces fuel consumption, and improves traffic flow. We may never be able to reduce the number of vehicles on the road, but we can manage the flow better. That's what traffic signal management is all about."

S. Lawrence Paulson is a partner in Hoffman Paulson Associates, a writing/editing and public relations firm in Hyattsville, Md. He has written and edited numerous studies for the Federal Highway Administration, Federal Transit Administration, and National Highway Traffic Safety Administration. He also spent seven years covering Congress as the Washington, D.C., bureau chief of a national daily newspaper, *The Oil Daily*.
