SIGNAL OPERATION & MANAGEMENT

Description

Signal improvements are among the most common, readily available, and cost-effective strategies to alleviate congestion. These involve a combination of technology and institutional cooperation. Four primary categories of improvements increase travel speed and reduce stop-and-go traffic:

- Updating signal equipment.
- Improving signal timing.
- Coordinating and interconnecting signals.
- Removing signals.

City of Carlsbad, CA

Cost:	●●○○○
Time:	**Short**
Impact:	**Spot / Corridor**
Who:	**City / County / DOT**
Hurdles:	**Manpower**

Updating older hardware and software allows more efficient systems that rely on improved vehicle sensing technologies and communications. Newer traffic signal control equipment can also be diagnosed and repaired more readily than outdated traffic signal control hardware, reducing down time. The latest traffic signal controllers offer greater flexibility in traffic signal timing and open the door to more adaptive, traffic-responsive signal control. Newer control equipment also features an improved interface with area-wide signal control systems, which agency staff can use to monitor and adjust signal timing in real time.

Improving signal timing and coordination involves optimizing timing plans to allow the best flow of traffic: giving the main traffic flows green time when they need it most. Intersection efficiency can be increased by adjusting factors such as the number of signal phases, the amount of green time for each movement, the overall cycle length, and how phases are paired or split (e.g., combining a left turn and through phase). Ideally, the length of green time for all approaches at an intersection balances the amount of demand on each approach with how much roadway capacity is available.

Coordinating signals creates a "window" of green as traffic moves between signalized intersections along a street, minimizing the number of stops or slowdowns. Signals can be timed to create this window, and they are interconnected and linked in time to ensure the integrity of the timing plan. State-of-the-art signal management systems facilitate the exchange of traffic flow information between signals, allowing for automated, real-time signal coordination. Technological advances now allow signals to learn from historical and real-time patterns. Using this information, signals can automatically retime and coordinate themselves to the most efficient plan, reducing delay up to 40 percent.

As traffic patterns shift, signals may be removed when they are no longer needed. This reduces unnecessary delay and stops at an intersection.

Motivation for Signal Operations and Management

There should be a process for re-evaluating signal timing on a periodic basis, as described below:[1]

- *Improve traffic flow through a group of signals*. By coordinating or sequencing the signals in relation to each other, vehicles can travel through the series of signals with minimal or no stopping.
- *Reduce overall intersection delay tim*e at an intersection by balancing the green time. Signal timing can be analyzed to see if reallocating existing cycle time may reduce delay at that intersection.
- *Adjust for changes in traffic characteristics*. With developments such as the addition of new homes or stores, traffic will increase or will be redistributed to different roads or turning movements and create the need to adjust the timing of affected traffic signals.
- *Accommodate diversion of traffic off a freeway due to an incident* (accident or event), associated with a computerized signal system.
- *Reduce motorist frustration* caused by excessive delay or stops by adjusting timing to provide coordinated flow through groups of signals.
- *Reduce emissions and fuel consumption* by optimizing signal timing and coordinated traffic flow.
- *Save time* for emergency vehicles, buses, and commercial vehicles.
- *Reduce the number of collisions* on city streets by producing smoother traffic flow and fewer stops.
- *Postpone or eliminate the need for costly reconstruction* by providing improved flow using existing resources in a more efficient manner or with minor equipment and/or roadway improvements.
- *Adapt to changes in traffic flow* for different times of the day or days of the week by developing signal timing plans to match predictable periods of traffic flow, such as the rush hours to and from work and holiday/seasonal demands.
- *To accommodate moderate- and long-term construction*. Signal retiming performed during a reconstruction project where a lane closure or a traffic detour causes a significant change in demand or capacity will alleviate traffic congestion.

Target Market

Local and Arterial Streets

The most substantial benefits from signal timing are realized at intersections with moderate to high volumes relative to capacity and along higher-volume street corridors. As the link between the local street system and freeways, major streets are the locations where improved signal timing can have the most substantial system-wide impacts.

Major Activity Centers and Downtown Areas

These locations directly influence freeway congestion as exit ramps in downtown and other developed areas are often short and spaced at frequent intervals. Improperly timed signals could back up traffic on exit ramps causing the congestion to spill back into the freeway's main lanes.

How Will This Help?

Properly timed signals immediately reduce congestion by balancing capacity and flow at an intersection. Coordinated signals provide greens for groups of cars, resulting in fewer stops along a corridor. Fewer and shorter stops mean more cars can pass through with less delay.

Upgrading equipment and optimizing signals have a relatively low cost when compared to other congestion strategies (such as adding lanes or grade separation). This strategy also delivers a high benefit return for the investment. This technique can be easily implemented with little or no disruption.

As intersection safety improves, congestion caused by collisions that close down the intersection or corresponding lanes will be reduced. Safety benefits are a lesser-known benefit of well-timed arterial roadways. Though data are not frequently collected regarding the safety impacts of signal retiming, smoother flow and fewer stops reduce the potential for crashes; this is especially true if groups of vehicles on arterials do not arrive toward the end of green.

Implementation Examples

Texas: A study of 26 projects in Texas showed an overall benefit/cost ratio of 38:1. A total of $1.7 million was spent among the projects, which resulted in average delay reductions of 19.4 percent, an 8.8 percent reduction in number of stops, and a 13.3 percent reduction in fuel consumption.[2] More recent system-wide equipment upgrades in the City of San Antonio, Texas, yielded annual road user delay savings of over $159 million across 60 busy street corridors.

Maryland: Since summer 2002, the Maryland Department of Transportation has re-timed about 215 signals in the Washington suburbs and an additional 30 signals on the Route 650 (New Hampshire Avenue) corridor between Montgomery County and the District of Columbia. An analysis showed that delays on those roads shrunk by about 13 percent and vehicles made 10 percent fewer stops. Fuel consumption also dropped by about 2 percent.[1]

California: The city of Los Angeles uses adaptive signal control to adjust traffic signal timing based on current traffic demand at 375 intersections in their system. After the system was deployed, a study found that overall intersection delay decreased by an average of 21 percent and the overall traffic flow improved. The benefits of adaptive signal control were greatest for the two-phase intersections. Benefits were lower at intersections with multiple phases (e.g., protected left turns) because of the minimum time required for each phase (leaving less flexibility for adjusting the green time for each traffic movement).[3]

Application Techniques and Principles

Cities should have an inventory of their traffic signal equipment, noting the capabilities of the controller and any other special equipment present. Data needs should also be collected and stored using a process that can be easily updated as information ages. The results from inventory and data collection should be used to understand where the greatest needs are located and if improvements are necessary.

Cities should balance the need for signal timing maintenance to combat congestion with practical time and fiscal restraints. Since this strategy represents a simple, low cost solution with a short time horizon, cities should also invest in maintenance and equipment upgrades.

Advanced signal equipment, well-maintained timing patterns, and communication links are important elements of the signal system. Signal timing evaluations are pivotal to ensuring that as development shifts traffic, the timing plans are modified. Signals that alert operators to problems or unusual events can assist agencies to rapidly respond when needed.

Issues

Upgrading and maintaining proper signal timing can be labor intensive and time consuming. Many cities do not allocate the resources or manpower to constantly assess traffic signal timing plans. Coordination of signals across jurisdictional boundaries can also be problematic. Cases where policies and procedures are in place with regard to major streets that cross jurisdictional boundaries demonstrate best practices and ensure compatible and coordinated operation.

Who Is Responsible?

Cities bear the primary burden of operating and maintaining traffic signal equipment and signal timing plans. On state-designated roads, this

responsibility may fall to the local TxDOT office. In this case, cities should work with the state to coordinate with street networks that are under city control. Signal coordination presents a special difficulty since busy streets are rarely contained in one jurisdiction. Properly managing networks along a corridor will require cooperation from multiple jurisdictions.

Project Timeframe

Signal timing improvements and equipment upgrades can occur quickly. Updating a signal timing program may take less than a week or up to a couple months if more analysis is needed. However, cities should take time to assess where and what actions will provide the best benefit.

Cost

Costs for improving signal operation vary significantly, depending upon what will be done. Upgrading equipment can cost as low as $500 or up to $30,000 per intersection. Updating signal timing plans, though labor intensive, cost much less on average at $3,500 per intersection. Coordinating signals can cost significantly more, and the average cost for adding communications equipment to a signal is around $8,000. Though relatively inexpensive per intersection, costs can quickly accumulate along a corridor.

Data Needs

Updating and maintaining traffic signals and their timing plans requires a significant amount of information from each intersection. A detailed list of hardware and the controller's programming ability must be catalogued for each intersection. This list must include controller type, sensor type (e.g., loop, camera) and exact location (if a loop sensor), signal coordination systems and abilities, signal preemption systems, or other hardware affecting the traffic signal timing.

Necessary data for timing plan development include peak hour volumes for each direction (including turning volumes) for all approaches, current signal timing plan data, intersection geometrics, block length between signals, pedestrian volumes, speed limit data, and if possible, volumes by time of day (especially helpful for corridors with highly directional flows).

Signal Operations Best Practice

- Type of Location: Higher volume intersections and arterial roadway corridors.
- Agency Practices: Staffing at a level of one engineer per 100 signals and one technician per 50 signals, preventive maintenance plan, communications infrastructure for remote monitoring, and control.
- Frequency of Reanalysis: Every three years in growth areas, every five years for other intersections.
- Supporting Policies or Actions Needed: Regular funding for timing review, multi-agency agreements, and policies where roadways cross jurisdictional boundaries.

For More Information and References

1. Sunkari, S. et al. Benefits of Retiming Traffic Signals. Technical Committee TENC 101-02, Institute of Transportation Engineers, Washington, DC, 2005.

2. Fambro, D. et al. Benefits for the Texas Traffic Light Synchronization Grant Program, Research Report 0280-1F, Texas Transportation Institute, Texas A&M University, College Station, TX, 1995.

3. "In Los Angeles, Adaptive Signal Control Systems Improved Travel Time by 13 Percent, Decreased Stops by 31 Percent, and Reduced Delay by 21 Percent," United Stated Department of Transportation, ITS Benefits and Costs Database, http://www.itsbenefits.its.dot.gov/its/benecost.nsf/0/CA4E16B4E7167BCF8525725F0073EBF3. Accessed: December 14, 2011.