Los Angeles Signal Synchronization

PREFACE

"Signal synchronization" is the term to describe the operation of the city's traffic signal system. This document summarizes the key features of signal synchronization.

GOALS

The main goals of the system are to:

- Safely manage the movement of different modes (pedestrians, cyclists, transit, and other vehicles)
- Improve the efficiency of the traffic signal system by optimally allocating green time to different modes and in different directions
- Provide the capability to remotely monitor and adjust signal timing in real-time to respond to specific traffic conditions or occurrences
- Provide the ability to analyze traffic data
- Implement special traffic signal timing as required

SIGNAL TIMING

General Framework

Traffic signals are timed by LADOT traffic engineers based on a number of technical and policy criteria, including conformance with state law as codified in the California Manual on Uniform Traffic Control Devices (CA MUTCD). The requirements of the CA MUTCD change periodically to reflect changes in the federal MUTCD as well as new practices and solutions in the field of traffic engineering.

Operation

Signal Cycle

Most signalized intersections have a cycle length, typically 90 to 120 seconds, with a few as high as 180 seconds. Other intersections remain green in one direction unless there is vehicular or pedestrian traffic in the other direction that triggers the signal to change.

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Signal Phases

The time in each cycle length is divided into phases to accommodate different transportation modes moving in different directions:

- Vehicular through traffic (frequently concurrent with right and/or left turns)
- Left turn only phase or arrow
- Right turn only phase or arrow
- Light rail or bus rapid transit
- Bicycle phase or bike signal
- Pedestrian phase or Walk signal

Protected Phases

Directional phases can be protected, meaning that only one or a limited number of movements are allowed at the same time. One example of a protected phase is a left turn arrow where vehicles can only make the turn on the green arrow, and are stopped on a red arrow.

Protected phases are used to improve the operational efficiency, orderliness, and safety of an intersection.

Signal Changes

Signal changes are triggered in one of three ways, and the city uses a combination of signal timing strategies depending on the situation. At some intersections two strategies are used in conjunction with each other.

Adaptive

The most advanced parts of the system are adaptive, meaning that the system monitors traffic volumes in real time by direction using detector loops between and at intersections, and changes the signal timing as traffic conditions change. This could mean that an intersection with low traffic volume in the east-west direction in the morning may have a short green signal, while later in the day as traffic volume increases the amount of green time provided to east-west traffic can increase.

Pre-Timed

Other parts of the system are pre-timed. In these areas, traffic engineers study the traffic patterns and calculate the optimal allocation of time to different phases. An intersection can have different signal timing on different days and times of day to account for different traffic patterns. Most intersections have different signal timing during weekday peak hours (i.e. Monday-Friday, 6 a.m.-10 a.m. and 3 p.m.-7 p.m.) and for special events.

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Pre-timed signals also are used where traffic engineers determine that it is more efficient than actuated timing, such as locations with continuous demand on all approaches. Pre-timed operation may be used when there are no intersection loops, for example when loops have been removed for street resurfacing or as part of a development project and replacement is pending.

Many intersections also have pre-programmed signal timing plans for emergency operations and special situations.

Actuated

Finally, parts of the city have actuated signal timing. This means that a signal will not change unless actuated by a specific action. The most common ways to actuate a green signal are to push a pedestrian button or actuate (i.e. pass over or stop on) a detector loop at an intersection (including left turn lanes, which will trigger a green left turn arrow). Semi-actuated intersections have a default allocation of time to a particular direction and movement, but the timing can change as different traffic volumes are detected on cross streets.

Allocation of Time

The amount of time allocated to each phase of the cycle varies depending on a number of factors.

Policy

The signal timing reflects policy and value judgments about different transportation modes. Currently, the Mayor and City Council have directed LADOT to prioritize transit services. This means that trains and buses will run faster on city streets, and motorists may have to wait a little longer than if vehicles were prioritized and transit services were not.

Pedestrians

For pedestrian phases, the time is calculated based on the width of the street and the prescribed walking speed, as defined in the CA MUTCD. At intersections with high pedestrian volumes, LADOT extends the walk phase to provide pedestrians more time to cross the intersection before the signal turns red.

Light Rail Transit & Bus Rapid Transit

For light rail transit and bus rapid transit, a window of green time is provided that is matched to the train or bus schedule. If the train or bus is running behind schedule, the system preempts the signal cycle, holding the train signal green, generally for up to ten percent of the cycle, e.g. 12 seconds for a 120 second cycle. A preempted signal cycle shortens – or takes away from – the time available for another phase in the cycle. If the train or bus is further behind schedule, it may have to wait for the crossing or intersection to run through its entire cycle.

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The city does not provide full preemption, i.e. we do not change every train/bus signal to green every time a transit vehicle approaches an intersection. LADOT already prioritizes transit and full preemption would have severe negative impacts on vehicular, bicycle, and pedestrian traffic. The city's signal timing relies on Metro running their service as scheduled. LADOT works cooperatively with Metro and changes signal timing as required by Metro's operation.

Rapid Bus

For Metro rapid bus service, the city provides priority. (This is referred to internally as the Transit Priority System".) The system detects where each rapid bus is physically located on city streets and makes signal timing adjustments to maximize the probability that the bus will not have to stop. If the light is about to turn red, the system holds the green signal for up to ten percent of the cycle. If the light already is red, the system shortens the other phases to make the signal green for the bus up to ten percent earlier than the normal cycle settings.

Other Vehicles

For all other vehicles, the allocation of time at an intersection generally is based on the relative traffic volume by direction and movement (through traffic, right turn, left turn, and pedestrians). LADOT also coordinates signal timing on contiguous signals on a corridor and makes timing adjustments to synchronize traffic lights, especially on major arterial streets. Where high volume major arterials cross lower volume streets, LADOT frequently gives the green signal to the major arterial exclusively and only provides green signals for the other street if actuated.

Limits of the Signal System

The system optimizes the movement of pedestrians, cyclists, vehicles, and transit. However, once the volume of traffic reaches a certain point (which varies by street based on the number of lanes, the directional mix of traffic, the complexity of the intersection, etc.), travel time will increase. However, the system minimizes the delay experienced compared to operating the city streets without the system.
Also, as population continues to increase, if driving also increases, traffic may get worse even with the system fully operational. No traffic signal system is capable of "fixing traffic." Our system will, however, continue to enable optimal street operations considering both safety and traffic volumes and provides other important functionality described below.

Finally, while LADOT continuously reviews signal timing to optimize signal synchronization on major streets, complete synchronization on every street, at every time of day, and under all traffic conditions, is impossible.

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TRAFFIC CONGESTION RELIEF BENEFITS

Analysis by LADOT and independent third parties show that signal synchronization on major corridors reduces congestion (i.e. time delay experienced by vehicles versus free flow conditions) and increases average travel speeds.

LADOT Analysis

LADOT's before and after studies between 1997 and 2013 produced the following average results:

Change	Average	
Travel speed (mph)	+16%	(increase)
Travel time	-12%	(decrease)

These benefits are based on LADOT field surveys for selected major corridors in 25 sub-regions in the city immediately following system implementation and are illustrative of the system's benefits. Data was collected without the system and then with the system.

Benefits of System to Motorists

While each motorist's travel differs, the following illustrates typical travel speed and travel time from the system before signal synchronization and after using the average change in travel speed systemwide.

Change	Before	After	Change
Travel distance (miles)	5	5	NA
Travel speed (mph)	15.0	17.3	+15.5%
Travel time (minutes)	20:00	17:20	-13.4%

A commuter who drove this roundtrip 250 days a year (to represent 50 weeks worked, 5 days a week) would save 22 hours and 23 minutes (22:23) annually compared to the same trip without the system on.

Due to the almost infinite number of travel patterns possible, precise benefits cannot be calculated for every possible trip on the city's road network.

Third Party Validation

LADOT engaged the Texas A&M Transportation Institute (TTI) in 2012 to evaluate the city's signal synchronization efforts. The TTI study looked at two corridors in different parts of the city as representative of the city's system (Evaluation of the ATSAC System for the City of Los Angeles, Texas A&M Transportation Institute, January 2013). TTI reached similar conclusions to LADOT's internal analysis. The researchers concluded that corridors with signal synchronization would produce benefits in three areas.

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Measure of Effectiveness	Range	
Travel speed (mph)	+13%	(increase)
Travel time (delay)	-32% to -43%	(decrease)
Emissions	-3% to -4%	(decrease)

OTHER FUNCTIONALITY & BENEFITS

The signal system enables a number of important benefits beyond the efficient operation of the city's road network and traffic signal system.

Monitoring

The system enables LADOT to remotely monitor traffic conditions from its control center. Engineers see graphical representations of traffic conditions, are automatically notified when traffic conditions are abnormal (which could be the result of a crash, police or fire emergency, etc.), and can visually observe conditions using cameras installed at major intersections.

Signal Re-Timing/System Management

The system enables LADOT to remotely change signal timing at any signalized intersection in response to planned events and unplanned situations that may arise. This can include police and fire operations where the exact timetable is unknown or during special events.

Fire Department

The system preempts normal signal timing when equipped Los Angeles Fire Department engines and ambulances have their sirens on and are approaching signalized intersections on transit priority corridors. This ensures that LAFD gets to their destination as quickly as possible and improves safety by stopping other traffic.

Transit Support

The system allows the operation of light rail transit in street running mode, bus rapid transit, and rapid bus while still efficiently moving vehicles, bicycles, and pedestrians.

Special Events & Emergency Operations

LADOT programs the system with special signal timing for major special events at venues such as the Coliseum, Dodger Stadium, and Staples Center/LA Live. The signals are timed to accommodate very high traffic volumes (vehicle, transit, pedestrian, etc.) arriving and departing the venues, usually within a very short time window.

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LADOT also can manually re-time signals based on actual traffic flow and other occurrences that disrupt the normal timing, e.g. an unexpected serious traffic collision at a major intersection along the egress route from a venue.

Historical Data

The system allows LADOT to collect and analyze historical traffic data.

NEXT STEPS

LADOT continues to upgrade and improve our signal synchronization system. The following are the major efforts underway.

System Upgrades

LADOT is adding additional detector loops to improve the overall system performance and to enable adaptive signal timing throughout the city.

Turn Arrows

LADOT is adding left and right turn arrows as needed to ensure safe and orderly traffic flow as traffic volumes increase or travel patterns change.

Transit Priority System

LADOT is continuing to expand TPS to support Metro's rapid bus operations.

Bicycle Detection

LADOT is installing detector loops on new bike lanes or on existing bike lanes when streets are resurfaced. This is part of making Los Angeles more bike friendly and ensures that cyclists get a green signal at actuated signals when no vehicles are present.

Pedestrian Signal Timing

LADOT is assessing where longer pedestrian phases are appropriate to make the city more pedestrian friendly and to address the special needs of students, seniors, and the disabled.

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Scramble Crosswalks

LADOT is converting selected intersections to "scramble crosswalks" that have a dedicated phase where only pedestrians can cross in all directions, including diagonally.

Advanced Analytics

LADOT is working to improve our ability to collect and analyze traffic data through our signal system.

BACKGROUND

System Size

As of December 2016, the system includes 4,689 signalized intersections that control over 7,500 centerline miles of city streets. LADOT operates and maintains the system on city streets, state highways within the city's geographic boundaries, and certain intersections in other municipalities and the incorporated part of Los Angeles County. The system includes over 25,248 vehicle detectors and over 560 cameras.

Origin

Signal synchronization was developed in-house by LADOT engineers. The initial system was deployed around the Coliseum to improve the efficiency of the city's road network during the 1984 Olympics. The system is called ATSAC – or Automated Traffic Surveillance And Control.

Completion

LADOT completed the connection of every signalized intersection to the system and began operations of the final implementation area in February 2013. Field studies for the last sub-region were completed in January and February 2013.

For more information about LADOT's signal synchronization system, please contact our communications office at **dot_public_info@lacity.org** or **(213) 972 - 8406**.

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