National Evaluation of the SafeTrip-21 Initiative: Final Report
Real Time Intersection Delay

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16. Abstract
Through the U.S. Department of Transportation's (USDOT) SafeTrip-21 initiative, the USDOT is testing a variety of technologies in a number of locations in California as well as along the I-95 corridor on the east coast. As part of this Federal initiative, the California Department of Transportation (Caltrans) tested the use of a traffic volume and signal timing information monitoring system. For the purposes of SafeTrip-21, this system is referred to as the real time intersection delay (RTID) system. During this testing, the USDOT conducted an evaluation to gain an understanding of the technical and institutional issues associated with using this system. The purpose of the evaluation is both to learn how such a system can enable signal phase and timing information, together with lane by lane traffic count data, to be collected in real time and processed from remote locations via the internet, and to determine how that information can be used effectively by State Department of Transportation (DOT) staff to optimize the performance of signalized intersections. The objective of the evaluation was to gather lessons learned from the test deployment of the RTID system in the San Francisco Bay Area. These lessons would serve Caltrans and other similar jurisdictions by providing guidance on successfully implementing RTID systems. In particular, USDOT and Caltrans were interested in learning about the factors that influence which locations are best suited for such systems and, if widely deployed, the changes in existing management policies that may be required for such systems to enhance traffic operations within existing resources. The SafeTrip-21 solicitation sought test sites and test applications. While Caltrans and its partners are providing the Bay Area test bed and using it to test a number of applications of their own, they also agreed to host field tests proposed by others. The field test for the RTID system is a case in point, for which the test was proposed by the vendor of the system, TrafInfo Communications Inc., and tested on the Caltrans test bed in the Bay Area. This document presents the evaluation findings, resulting primarily from in-person interviews the Evaluation Team conducted with institutional partners.

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List of Abbreviations

Caltrans	California Department of Transportation
DOT	Department of Transportation
DRI	Caltrans Division of Research and Innovation
I-95	Intestate 95
ITS	Intelligent Transportation Systems
NTOC	National Transportation Operations Coalition
PATH	Partners for Advanced Transit and Highways
RTID	Real Time Intersection Delay
USDOT	U.S. Department of Transportation

Introduction

Through the U.S. Department of Transportation's (USDOT) SafeTrip-21 initiative, the USDOT is testing a variety of technologies in a number of locations in California as well as along the I-95 corridor on the east coast. As part of this Federal initiative, the California Department of Transportation (Caltrans) tested the use of a traffic volume and signal timing information monitoring system. For the purposes of SafeTrip-21, this system is referred to as the real time intersection delay (RTID) system. During this testing, the USDOT conducted an evaluation to gain an understanding of the technical and institutional issues associated with using this system.
The purpose of the evaluation is both to learn how such a system can enable signal phase and timing information, together with lane by lane traffic count data, to be collected in real time and processed from remote locations via the internet, and to determine how that information can be used effectively by State Department of Transportation (DOT) staff to optimize the performance of signalized intersections.

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The SafeTrip-21 solicitation sought test sites and test applications. While Caltrans and its partners are providing the Bay Area test bed and using it to test a number of applications of their own, they also agreed to host field tests proposed by others. The field test for the RTID system is a case in point, for which the test was proposed by the vendor of the system, TrafInfo Communications Inc., and tested on the Caltrans test bed in the Bay Area.

This document presents the evaluation findings, resulting primarily from in-person interviews the Evaluation Team conducted with institutional partners.

Background

Optimizing Signalized Intersections

Signalized intersections are a common and integral form of traffic control on arterial routes.[1] Intersections are typically equipped with sensors that detect the presence and passage of vehicles. These vehicle detectors are connected to a traffic signal controller, which is mounted in a roadside cabinet. Signal controllers determine which lanes on which approaches may proceed or must stop by sending instructions to the signals faces based on the presence or absence of vehicles in each lane.

[1] FHWA estimates there are 272,000 traffic signal intersections in the United States; see http://ops.fhwa.dot.gov/arterial_mgmt/index.htm

Traffic sensors are usually inductive loops embedded in the pavement, although in California other types of detector are permitted, such as above-ground video detectors.[2] Vehicle detectors provide automatic inputs to the controller that indicate the presence and passage of a vehicle.[3] In much the same way, pedestrians can manually indicate their presence by pushing a button that corresponds to the lanes they wish to cross.

Caltrans uses two types of traffic signal controller.[4] The most common is the 170 controller, and the other is the 2070 controller. The latter has more advanced functionality, and is generally used to replace the 170 controller when new intersections are installed or existing controllers are damaged or upgraded. Statewide, 10-15 percent of the approximately 4,800 signalized intersections under Caltrans jurisdiction are controlled by 2070 controllers, mostly in District 3 (Sacramento region) and District 7 (Los Angeles region). Caltrans District 4, which covers the San Francisco Bay Area, currently has two signalized intersections at which 2070 controllers are used—see Figure 1.

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[2] California Department of Transportation, *California Manual on Uniform Traffic Control Devices for Streets and Highways: PART 4 Highway Traffic Signals*, "Section 4D.103(CA) Vehicle Detectors," September 2006, available at: http://www.dot.ca.gov/hq/traffops/signtech/mutcdsupp/pdf/camutcd/CAMUTCD-Part4.pdf

[3] California Department of Transportation, "Traffic Operations Policy Directive 09-06," effective September 10, 2009, requires bicycle and motorcycle detection on all new or modified approaches to traffic-actuated signals in California. See: http://www.dot.ca.gov/hq/traffops/signtech/signdel/policy/09-06.pdf

[4] A third type of controller not used by Caltrans is the NEMA controller.

Figure 1. Caltrans Districts
(Courtesy Caltrans)

Traffic signals operate in pre-timed or actuated modes or some combination of the two.[5] Pre-timed control consists of a series of signal intervals that are fixed in duration. Collectively, the preset green, yellow, and red intervals result in a deterministic sequence and fixed cycle length for the intersection. In contrast to pre-timed control, actuated control consists of intervals that are called and extended in response to vehicle detectors. Detection is used to provide information about traffic demand to the controller. The duration of each phase is determined by detector input and corresponding controller parameters. Actuated control can be characterized as fully-actuated or semi-actuated. Fully-actuated control is typically used where all approaches have detectors,

[5] Federal Highway Administration, *Traffic Signal Timing Manual*, FHWA-HOP-08-024 (Washington, DC: June 2008), "5.2. Modes of Traffic Signal Operation and their Use," available at: http://ops.fhwa.dot.gov/publications/fhwahop08024/fhwa_hop_08_024.pdf

while semi-actuated control is typically used where side road traffic is light and green time defaults to the major road. Under semi-actuated control, only the side roads need detectors.

For a variety of reasons, the timing of traffic signals may become sub-optimal over time. This can occur because of changing patterns of traffic demand, changes in bus or pedestrian activity, changes in geometric layout, etc. When deterioration in performance occurs, signal retiming may be necessary. To keep pace with changing travel patterns, traffic signal timing should be reviewed and updated at a minimum of every 3 years, and even sooner if there is growth in the number of vehicles using the intersection or changes in traffic patterns.[6] In order to retime traffic signals, a site visit is needed during which traffic patterns are observed during morning and afternoon peak periods. This information is collected manually and, when input into a traffic optimization tool, is used to estimate delay.[7] From this data, improved timing plans can be developed and subsequently uploaded to the traffic signal controller.

Ideally, Caltrans would prefer to conduct a yearly survey of traffic signal timing at each intersection. Due to constrained resources, Caltrans is unable to review traffic signal timing issues as frequently as it would prefer, and often relies on reports from the public to identify traffic signal intersections with timing issues. The benefit the RTID system offers is the potential to reduce the manual effort required to undertake signal retiming, to focus resources on critical intersections (such as intersections that serve as master controllers for groups of intersections with coordinated signals), and to validate that any retiming activities lead to a subsequent reduction in delay. Consequently, the RTID system will result in operational improvements at traffic signal intersections, although the scale of these improvements will depend on the specific circumstances at each intersection or group of intersections.

How RTID Works

The RTID system comprises three components:

- A device known as TrafMate 6, which interfaces with the 2070 controller's RS-232 port;
- A wireless communication antenna connected to the TrafMate 6 device; and
- A remote server, hosted by the product vendor, where all information collection by the RTID system is stored and analyzed.

Typically, the information collected automatically and continuously by the TrafMate 6 device can only be gathered manually by Caltrans. This is done by traffic census staff visiting the intersection and observing traffic flows for each lane on each approach, during each phase and cycle. Traffic census staff typically collects this information during peak periods only. The information collected is subsequently processed by an office-based analyst using traffic optimization software.

[6] National Transportation Operations Coalition, *National Traffic Signal Report Card: Technical Report 2007*, available at: http://www.ite.org/reportcard/technical_report%20final.pdf

[7] Federal Highway Administration, *Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools*, "Appendix E.4 Traffic Optimization Tools," FHWA-HRT-04-039, (Washington, DC: June 2004), available at: http://ops.fhwa.dot.gov/trafficanalysistools/tat_vol2/sectapp_e.htm#top

Evaluation Team Objectives

The objective of the evaluation was to gather lessons learned from the test deployment of the RTID system in the San Francisco Bay Area. These lessons would serve Caltrans and other similar jurisdictions by providing guidance on successfully implementing RTID systems. In particular, USDOT and Caltrans were interested in learning about the factors that influence which locations are best suited for such systems and, if widely deployed, the changes in existing management policies that may be required for such systems to enhance traffic operations within existing resources.

Lessons learned were analyzed and synthesized by conducting interviews with Caltrans headquarters and district staff and the vendor. Some of the headquarters staff were directly involved in the conduct of the test, and together they provided a statewide traffic operations perspective. Participation in the test at the district level was mostly limited to maintenance crews providing access to traffic signal controllers. However a local perspective of the test was provided by the Caltrans District 4 District Traffic Engineer. Caltrans District 4 has jurisdictional responsibility for Caltrans' right of way in the Bay Area. An interview was also conducted with a representative from the California Partners for Advanced Transit and Highways (PATH.) PATH's role was predominantly during Phase I of the test, when the RTID system was tested at PATH's research facility. PATH's role during Phase II of the test, when the RTID system was installed at a traffic signal intersection in the Bay Area, was to coordinate between staff at Caltrans headquarters and Caltrans District 4. (A fuller explanation of the test is provided below.) The Evaluation Team aimed to gain an understanding of:

- The implementation of a device that communicates signal timing and traffic data without interrupting the signal controller;
- The technical and institutional issues associated with gathering real-time volume and signal timing information at traffic signals;
- The usefulness of the speed and delay estimates; and
- The ease of downloading the information.

Test Objectives

The vendor originally proposed to install the RTID system at a series of signalized intersections along an arterial and provide real-time arterial travel time. The arterial travel time would be estimated using two components: the running time and the control delay.

- Running time is estimated based upon the free flow travel time and the traffic volumes. Free flow travel time is the distance between intersections divided by the speed limit (or prevailing speed). Traffic volume is collected by the RTID system.
- The control delay is estimated by the RTID system in real time (i.e., on a cycle-cycle basis) by collecting three major variables: signal timing, cycle length and volumes, and then computing the delay using these variables and algorithms similar to those described in the *Highway Capacity Manual*.[8]

[8] Transportation Research Board, *Highway Capacity Manual 2000*, available for purchase at: http://www.trb.org/Main/Blurbs/Highway_Capacity_Manual_2000_152169.aspx

The vendor’s concept was that this real-time arterial travel time information would be available to both public and private traveler information service providers. In practice the field test was unable to provide real time travel time information because the RTID system was only deployed at a single intersection. Consequently the proposal was refined to focus on signal retiming.

Caltrans did not intend to use the information from the RTID system test to update existing timing plans. Instead, it was interested to learn more about the potential efficacy of the system, and the potential for improved targeting of staff resources for signal timing reviews. In general, it wanted to understand any technical issues associated with connecting the RTID system to an existing traffic signal controller and to gain practical experience with installation. The Caltrans test objectives are as follows:

1. Test the RTID system in conjunction with the 2070 controller as Caltrans works toward eventual replacement of the 170 controller;
2. Ensure the RTID system does not interfere with the normal operation of the 2070 controller; and
3. Understand the installation and operational costs of the RTID system.

In addition to the test objectives, Caltrans required that the TrafMate 6 device could be installed in 30 minutes or less.

The RTID Test

Caltrans tested the effectiveness of the RTID system to augment its signal retiming efforts. The test was conducted in two phases. **Phase I** was a bench test to demonstrate that the RTID system could be connected to a 2070 controller without interfering with the normal operation of the controller. A 2070 controller was selected for the test because use of this type of controller by Caltrans’ Districts will become increasingly prevalent in future years, eventually phasing out the 170 controllers. The bench test was conducted on August 13, 2009, and approval to commence planning for the second phase of the test was subsequently granted by Caltrans Headquarters on September 4, 2009.

Phase II of the test was to install the RTID system at a Caltrans District 4 signalized intersection that is controlled by a 2070 controller (Figure 2).

Figure 2. El Camino Real Intersection at Dumbarton Road
(Courtesy Sudhir Murthy, TrafInfo Communications, Inc.)

Approval for the vendor to install the RTID system was granted by Caltrans District 4 on October 1, 2009. The RTID system was operational from October 22, 2009, through November 2, 2009, after which it was turned off, but left in place until December 28, 2009.[9] During the period when the system was operational, traffic volume and signal timing information was collected from the 2070 controller by the RTID system and transmitted to a remote server hosted by the product vendor. The vendor reported that the information was sent to the server at the end of each cycle, approximately once every 90 seconds. The server was then able to plot that information immediately. Delay calculations were performed on the remote server. The vendor provided access to the remote server via the internet for institutional partners and the evaluation team.

[9] The RTID system was turned off after a discussion between the vendor and Caltrans, during which it was agreed that sufficient data (12 continuous days) had been collected to enable the vendor to analyze the data and finalize the webpage interface. The vendor's plan was to get back to the intersection and do some more testing, with refinements to the firmware if necessary. However this was determined to be unnecessary.

Evaluation Findings

The evaluation findings are summarized for each of the evaluation objectives.

Implementation

Prior to installation of the RTID system at the El Camino Real/Dumbarton Road intersection, Caltrans required the vendor to demonstrate that the TrafMate 6 device could communicate with the 2070 controller without interrupting its normal function. The Trafmate 6 device must use the Caltrans prescribed AB 3418E communications protocol[10] to continuously communicate with the 2070 controller so as to obtain information as to which signal phase is active at any instant, which detection input is active at any instant, and the count information on the system detectors. The Trafmate 6 device communicates with the 2070 controller twice per second in order to determine the signal timing intervals of each phase, the signal cycle length, as well as additional information related to the presence of vehicles within the detection zone.[11]

This Phase 1 test was required to last for 7 days, in continuous operation. Originally the vendor intended to demonstrate this at PATH's "Smart Intersection," located at the Richmond Field Station. The Smart Intersection is located at an isolated facility intended for research that is not open to normal traffic, and thus devices can be tested under controlled conditions without endangering the traveling public. That said, there is very little traffic that uses the Smart Intersection, so it does not directly reflect real world conditions. Using the Smart Intersection's controller cabinet would, however, enable the vendor to demonstrate that the TrafMate 6 device could be installed in 30 minutes or less, as required by Caltrans.

At the time of the planned demonstration, the Smart Intersection was in use for another research program, which required the 2070 controller to be modified from the standard version used by Caltrans. Using the modified 2070 controller would not have enabled valid test testing of the RTID system. Temporarily converting the Smart Intersection's 2070 controller back to a standard version would have disrupted PATH's research and required extensive resources by PATH engineers, for which no compensation was available. Waiting for the PATH research program to conclude was not viable within the RTID test's schedule. Consequently Caltrans and the vendor agreed to undertake a bench test, using a portable 2070 controller and a vehicle detection simulator. The simulator generates inputs to the controller that represent vehicles passing over the loop detectors. The 2070 controller in turn changes the signal faces (green, yellow, red) to control traffic flow. The problem with the bench test was that the simulator required manual toggling of some buttons to simulate a vehicle on an intersection approach. In other words, the inputs generated by the simulator to the 2070 controller required continuous human inputs to toggle the buttons. Without these human inputs the simulator would not generate any vehicle inputs, and hence would not generate communications between the 2070 controller and the TrafMate 6 device.

[10] California Department of Transportation, "CTNET Field Protocol Specification AB3418 Extended (AB3418E)," http://www.dot.ca.gov/hq/traffops/elecsys/reports/AB3418E_FieldProtocolSpec_2003_.pdf The AB 3418E communications protocol is an "extended" version of the original AB3418 communications protocol for traffic signals in California (see http://www.dot.ca.gov/hq/traffops/elecsys/reports/ab3418sp.pdf)

[11] See the vendor's revised SafeTrip-21 technical proposal, March 27, 2009.

The bench test was functionally identical to the test that was previously planned at the Smart Intersection, except without a controller cabinet it was no longer feasible to demonstrate the 30 minute installation requirement. With respect to the continuous 7 day operation requirement, it was not feasible to toggle buttons on the simulator manually for this length of time. Consequently, Caltrans saw no reason to continue the bench testing for seven days. Caltrans primarily wanted to ensure the interface between the 2070 and the TrafMate 6 device did not affect signal operation. Given that the TrafMate 6 device had been previously deployed elsewhere in a real-world environment (Massachusetts, for example), Caltrans was not unduly concerned about the 7 day requirement.

Under the supervision of a Caltrans employee over a period of several hours, and briefly observed by a representative of the evaluation team, the TrafMate 6 device demonstrated it could communicate with the 2070 controller without disrupting its normal function. Despite the bench test conditions, the vendor was able to demonstrate the ease of installation of the TrafMate 6 device, and the wireless communications antenna. The vendor claims that installation of the TrafMate 6 device takes 15 – 30 minutes. The normal connections are:

- TrafMate 6 connects to 2070 controller's RS-232 port;
- The antenna connects to a mini-UHF connector at the rear of the TrafMate 6 device; and
- TrafMate 6 has a DC power jack to plug in a standard AC adapter that can output 12V DC (1.5 Amps).

For the Phase 2 test, a small hole was drilled on the top of the controller cabinet for the antenna cable. After the cable was inserted into the hole, the antenna was stuck to the top of the cabinet (the antenna comes with a peel-off glue).

During the site inspection for the Phase 2 test, the vendor requested (and Caltrans agreed) that the loop detector cards that were installed in the controller cabinet be changed for the test. These cards interface between the inductive loops and the 2070 controller. While the installed detector cards were not defective, they did not provide the necessary functionality for the test, because they did not count vehicles. Instead, they simply indicated the presence of a vehicle on the inductive loop. The RTID system cannot estimate delays reliably without vehicle counts covering all lanes. To address this issue, the vendor considered two options:

- Reno Detectors: These cards are essentially a 4-channel replacement for a standard 2-channel loop detector card. The additional two channels are used to mimic a traffic count loop. If the outputs of these two channels are connected to a 2070 controller, the controller considers it is receiving signal from a "system" loop which is typically used for traffic counting purposes. The advantage of this option is that the TrafMate 6 device only needs to communicate with the 2070 controller to get both the signal timing as well as the traffic count information. The disadvantage is that some additional wiring is needed within the controller cabinet to connect the two "extra" channels on the Reno detector to the 2070 controller.

- Canoga Detectors: These cards have a front serial port which allows extraction of traffic count information. The advantage of this is that there is no need to do any additional wiring between the detector and the controller. The disadvantage is that the TrafMate 6 device must communicate with both the 2070 controller as well as each of the Canoga detectors.

While the Reno option was a potentially simply option, it placed most of the burden of field deployment on Caltrans District 4. This was not the case with the Canoga option, which placed most of the burden of field deployment on the vendor, with minimal support from Caltrans District 4. Consequently Caltrans and the vendor agreed to replace the installed detector cards with the Canoga cards. It is noted that the possible need to replace detector cards depends on the specific configuration at the intersection, and may not be necessary in all situations.

The replacement Canoga cards took about 2 hours to install (Figure 3). This is because each channel on the 4-channel Canoga card needed to be calibrated so that the vehicle counts were accurate. In total five Canoga cards, provided by the vendor, were used.[12]

The vendor indicated that in the version of the TrafMate 6 device that was tested, the only way to know if there was a problem in the communication between the loop detector and the Trafmate 6 device was missing data. A more recent version of the device can send out an email if any problems occur in communication either with the loop detector or the controller.

[12] Each Canoga card has an RS-232 interface on its front panel via a DB-9 connector. To connect the TrafMate 6 device to each of the five Canoga cards, the vendor built a simple serial splitter board, so that one serial port on the TrafMate 6 device could talk to each of the serial ports on each of the Canoga cards. The TrafMate 6 device also has a DB-9 connector that provides the RS-232 interface.

Figure 3. TrafMate 6 Device (top) and Five Canoga Cards (mid-left).
(Courtesy Sudhir Murthy, TrafInfo Communications, Inc.)

Technical Issues

There were only minor issues encountered during the test, as described below.

Loop Detector Cards

As mentioned above, the loop detector cards installed in the 2070 controller at El Camino Real/Dumbarton Road functioned correctly in detecting the presence of vehicles, but were inadequate for vehicle counts. The vendor swapped the existing detector cards with five Canoga cards for the duration of the test. The existing detector cards are widely used by Caltrans and are less expensive than the Canoga cards.

Loop Detectors

While planning the Phase 2 test, a second 2070-controlled traffic intersection was inspected as a candidate for the test. Caltrans and the vendor discovered that some of the inductive vehicle detector loops at this second intersection were not in proper working order. While the precise nature of these defects is not known, it meant that the 2070 controller would receive erroneous presence indications from the loop detectors concerned, e.g. vehicles would not be detected when present, or vehicles would be detected when not present.

Unlike the El Camino Real/Dumbarton Road intersection where the detector cards (in the controller cabinet) were functionally inadequate but the inductive loops were operational, at this second intersection the issue was not the detector cards but the actual inductive loops. For operational purposes at the intersection, a non-functioning inductive loop is not necessarily critical, depending on which lane it is monitoring. A non-functional left turn lane inductive loop is more critical than a through lane, particularly where there are adjacent through lanes with functional inductive loops. Left-turning vehicles may queue back beyond their dedicated lane and block the adjacent through lane. Drivers of these left turning vehicles may be forced to make unsafe or illegal maneuvers, risking their safety and that of other drivers, pedestrians, and cyclists.

Faulty loop detectors will result in sub-optimal operations at any intersection, regardless of whether the RTID system is installed. However, the vendor stressed that the RTID system cannot reliably estimate delays without vehicle counts covering all lanes.

Antenna

A final technical issue to consider for any future deployment of the RTID system is the installation of the antenna. For the Phase 2 test, Caltrans drilled a hole for the antenna cable, and the antenna was stuck to the top of the controller cabinet (Figure 4). While this arrangement will work for a temporary situation, it may be less desirable in the longer term. Also, when the antenna is removed, the hole must be plugged.

Summary of Technical Issues

No technical issues were encountered with communications between the TrafMate 6 device and the 2070 controller at the El Camino Real/Dumbarton Road intersection, or with the transfer of data to the remote server. This remained the case for the 12 day operational period, during which time there were no reports of abnormal traffic operations at the intersection. In summary, the RTID system depends on:

- Correctly working inductive loops in all approach lanes;
- Loop detector cards with the ability to count vehicles, not simply detect presence, for all approach lanes.

Institutional Issues

There were only minor issues encountered during the test, as described below.

Caltrans District 4 Jurisdiction

The only institutional issue encountered related to jurisdiction of the El Camino Real/ Dumbarton Road intersection, which falls under Caltrans District 4. Consequently, access to the controller cabinet, installation of the TrafMate 6 device, and swapping out the loop detector cards could not be accomplished without the involvement and approval of a responsible Caltrans District 4 employee. This is primarily to ensure the safety of the public by preventing any disruption to the safe operation of the intersection and to protect state

Figure 4. Antenna Mounted on Top of Controller Cabinet (White Dish on Left-hand Side).
(courtesy Sudhir Murthy, TrafInfo Communications, Inc.)

property from theft or damage while the controller cabinet door is open. No problems were encountered in this regard. The role of formal partner was performed by Caltrans Headquarters – Division of Research and Innovation (DRI), which does not have jurisdiction over any district's traffic signal controllers. A representative from PATH facilitated the coordination between the vendor and Caltrans District 4, on behalf of DRI. Being locally based in the Bay Area, PATH is very accustomed to working with District 4.[13]

Ease of Downloading

For the RTID test, the intent was to make information regarding real-time delay conditions at the El Camino Real/Dumbarton Road intersection available to any Caltrans employee with an interest in the test. This information was provided on the vendor's website in the form of graphical representations of delay estimates.[14] While the website did not require a secure login with an account and password, it was not on a page that could be directly accessed from the vendor's home page. Other than by chance or intuitive searching, the only way to access the website was for the vendor to provide a link to the specific webpage, which was done on request.

Ease of downloading is a somewhat subjective concept. In practice it was very easy for users with internet access to visit the project website after the vendor had provided the website's address. The information provided (delay estimates prepared by the vendor) could be viewed and searched, and the charts could be printed using a menu function. In addition, the actual data collected, and delay estimates, can be downloaded in a tabular form. However, since it was not Caltrans' intent to use this information to develop and upload new timing plans, Caltrans made no request for the data collected from the intersection on which the vendor's estimates are based. Consequently it was not possible to assess the ease of downloading that data, other than to note that it was clearly available to the vendor.

Usefulness

The vendor's delay estimates are understood to be based on normal methods of delay estimation using widely available tools. Information is presented graphically, with plots of average delay against time of day for a 24 hour period for a given (user specified) lane (Figure 5).

[13] PATH received no funding for the test and its participation was voluntary
[14] TrafInfo Communications website, "Average Delay by lane, El Camino Real at Dumbarton Rd - Redwood City, CA," http://www.trafinfo.com/delay.php?intid=5

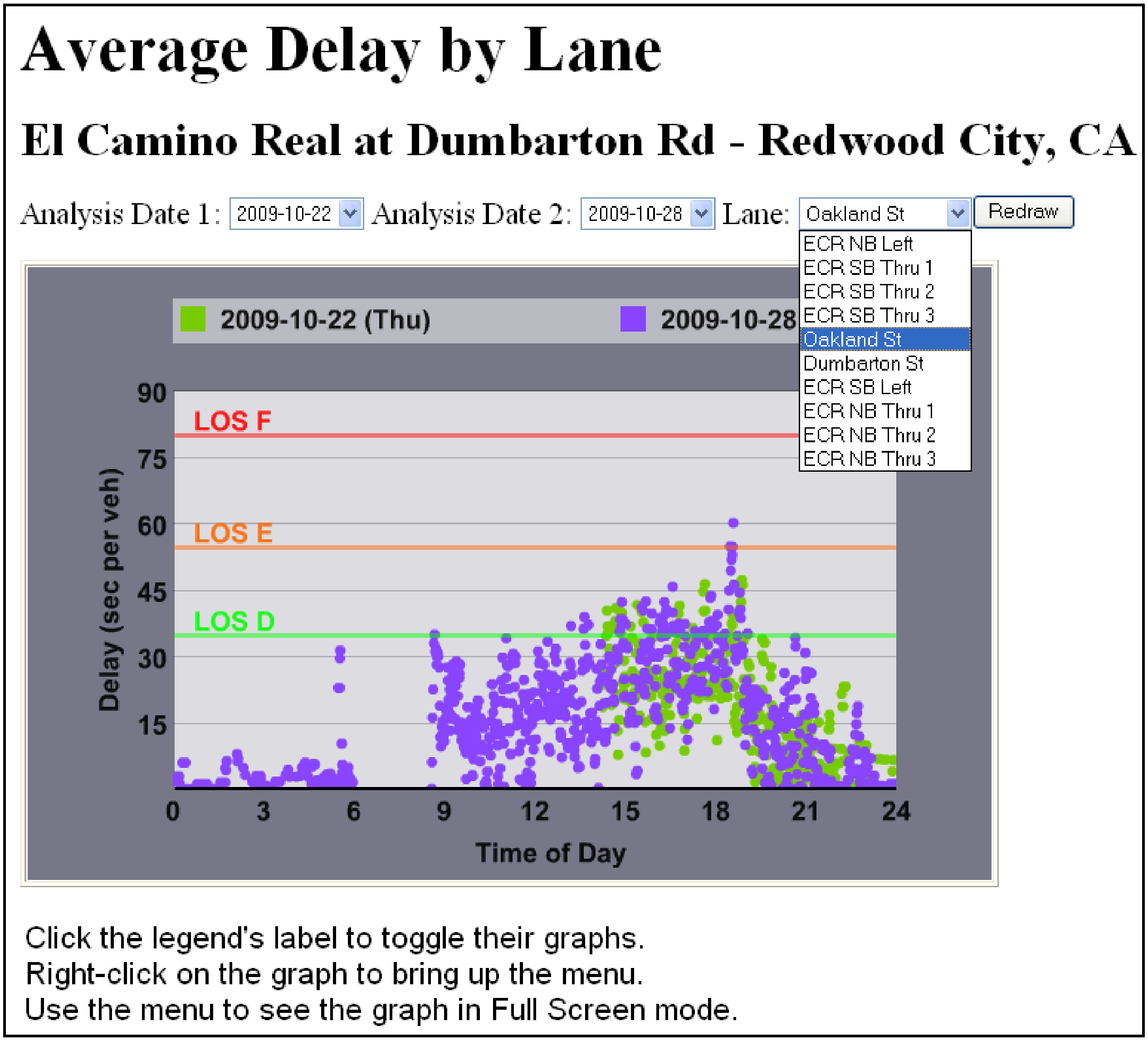

Figure 5. Sample Screenshot of Average Delay by Lane

The user can select two dates, and the plot will compare the results for the two dates. In this way, it is possible to compare operations on different days. In the event that a new timing plan is uploaded to the 2070 controller, this feature can be used to make a before and after comparison.

Caltrans staff did not validate the delay estimates through any independent review by their own traffic operations or planning groups. This was primarily because there was no intent (as part of the test) to use the estimates to develop or upload new timing plans. As mentioned previously, the El Camino Real/Dumbarton Road intersection falls under the jurisdiction of Caltrans District 4, which was not an active partner in the test. Consequently, no definitive conclusions can be drawn regarding the usefulness of the information on the vendor’s website.

Potential Future Uses

Selected senior managers at Caltrans Headquarters participate in a formal Traffic Operations Group, which leads the policy direction for the agency. The group meets monthly, and traffic operations managers from the Districts may participate remotely. At the group's meeting on August 9, 2010, the vendor was invited to make a technical presentation on the test, covering what was done and how it worked, followed by a question and answer session. While the details of the discussion are not available, a Caltrans Headquarters participant at the meeting indicated that one Traffic Operations Group demonstrated a broad level of interest in the RTID system and indicated it was considering what steps should be taken to gain more detailed experience with the system. This could include deploying the system in two or three different Caltrans Districts, to gain experience in different jurisdictions, and under different operational circumstances.

A Caltrans representative indicated to the evaluation team that the procurement model for systems such as RTID will likely break new ground. This individual considered that rather than buy devices which would then have to be installed in controllers – inevitably requiring training, inventory control, maintenance, replacement, and a host of other issues – Caltrans would more likely adopt a procurement model in which transportation data was directly purchased from an information provider. While there are issues associated with this approach also – pricing, data quality, and access to controllers to name a few – it seems inevitable that consumers of transportation data will eventually choose to purchase information services rather than follow the traditional path of investing in equipment.

One area of concern raised by a member of the Caltrans Traffic Operations Group is the cost of replacing standard detector cards (the type that detect presence, but cannot count vehicles) with the more sophisticated Canoga cards (or equivalent.) In response to this concern, other members of the group pointed out the additional functionality that can be achieved, and the benefits of more frequently improved timing plans. Also, following the theme of purchasing data rather than equipment, this is more of an issue for information services providers.

Three potential areas for future use are discussed below.

Monitoring Intersection Delay in Real-Time

This could include using the RTID system with 170 controllers and with more complex coordinated systems of traffic signals rather than the isolated intersection that was the subject of this test. While Caltrans has made a long-term commitment to migrate to 2070 controllers, the majority of controllers will likely be 170 controllers for the foreseeable future.

Retiming Traffic Signals

The RTID system is an operational assessment tool, and does not generate optimal signal timing plans. The actual determination of new optimal signal timing plans can be done off-line using the data collected by the RTID system. The RTID system does provide the communication means to upload new signal timings. However, this function was not tested. Using the data collected by the RTID system to develop and upload new timing plans, and then compare the performance with modified timing against previous timing plans, however, would provide invaluable feedback to traffic engineers.

Integrating the RTID System with Existing ITS Assets for Traveler Information

The functionality of the RTID system offers the potential to use the system to estimate travel times along a corridor if multiple intersections were monitored. This travel time information could supplement other traveler information systems by potentially providing more accurate and useful traveler decision information.

Conclusions

The test met the vendor's objective to demonstrate that the RTID system could collect the three major variables required for estimating delay at signal intersections: signal timing, cycle length and volumes, on a cycle-cycle basis, and then use this information to compute the delay and make it available for the internet for development and testing of signal retiming plans.

The RTID system met Caltrans objective of being tested with a 2070 controller and demonstrating that it did not interfere with the normal operation of the 2070 controller both in a simulation test and in the field. The installation worked continuously through a 12 day period without disruption to traffic flow or any know performance failure. The RTID system also met Caltrans' requirement to be installed within 30 minutes.

With regard to the evaluation objectives, the RTID system demonstrated it is possible to collect real time volume and signal timing information at traffic signals, making such information available in a way that offers the potential to review and, if necessary, update timing plans to reflect current conditions. This addresses an issue that has been repeatedly raised within the transportation community that inaction on signal timing and maintenance (including reliability of loop detectors) leads to avoidable delays, increased fuel consumption, greater safety concerns, and more pollution. The RTID system requires working detectors on all lanes and all approaches, without which the system is unable to reliably estimate delays.

Within the constraints of the test, the information generated by the RTID system was easy to access and useful. While Caltrans never intended to use this information to review and update timing plans, senior traffic operations managers indicated their broad support to further explore the potential of systems like RTID.

Benefits

The benefits of the RTID system cannot be determined quantitatively, as no actions were taken as a result of the information generated by the system. However it is possible to discuss the potential benefits in a qualitative manner. These benefits will most likely occur in three ways:

- More frequent review of traffic signal timing;
- Targeted use of resources; and
- Reduced delay to travelers

These benefits are discussed below.

More Frequent Review of Traffic Signal Timing

As mentioned previously, to keep pace with changing travel patterns, traffic signal timing should be reviewed and updated at a minimum of every 3 years and even sooner if there is growth in the number of vehicles using the intersection or changes in traffic patterns. In order to retime traffic signals, a site visit is needed during which traffic patterns are observed during morning and afternoon peak periods. Currently, this information is collected manually, and then used to estimate delay by inputting these observations into a traffic optimization tool. Once installed the RTID system will automate this process. The system can be left in place indefinitely if so desired. If improved timing plans are developed, they can be subsequently uploaded to the traffic signal controller using the RTID system versus being uploaded manually, as is the current practice. The RTID system can then be used to compare the effect of the new timing plan against the previous plan.

The vendor indicated that in the version of the TrafMate 6 device that was tested, the only way to know if there was a problem in the communication between the loop detector and the TrafMate 6 device was missing data. A more recent version of the device can send out an email if any problems occur in communication either with the loop detector or the controller.

Targeted Use of Resources

In addition to the potential benefit (described above) of using the RTID system to review traffic signal timing more frequently, the system also offers the potential to raise productivity and efficiency by better target resources at intersections where problems are known (or are more likely) to exist. Using the RTID system's feature to compare delay on different days, it is possible to easily remotely validate that any signal retiming activities have led to a subsequent reduction in delay.

Reduced Delay to Travelers

By uploading new timing plans, intersection delays may be reduced. NTOC has noted that transportation professionals have long recognized the value of effective traffic signal timing and maintenance to meet changing travel patterns and user characteristics. In addition to mitigating congestion and reducing delay, there is the potential for several secondary impacts. Improved signal timing practices can reduce accidents, fuel consumption, and air pollutants. However, as the scale of these improvements will depend on the specific circumstances at each intersection or group of intersections, it is not possible to estimate the magnitude of any such improvements.

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