MTC IDEA Program | Category 2

Town of Los Gatos

Deliverable 5b: Final Concept of Operations (ConOps)

February 21, 2019

Submitted to:

10187 | Prepared by **Iteris, Inc.**

DOCUMENT VERSION CONTROL

DOCUMENT NAME	SUBMITTAL DATE	VERSION NO.
Draft ConOps –Initial Draft released for internal Iteris review	12/11/2018	1.0
Draft ConOps – Draft released to MTC staff for review	12/21/2018	1.1
Draft ConOps – Comments received from MTC	1/16/2019	1.2
Draft ConOps – Released to Stakeholders	1/22/2019	1.3
Draft ConOps – Comments received from Stakeholders	2/6/2019	1.4
Final ConOps – Initial Draft released for internal Iteris review	2/12/2019	2.0
Final ConOps – Released to MTC staff for review	2/15/2019	2.1
Final ConOps – Released to MTC staff for review (includes updated inventory information received from Town of Los Gatos)	2/21/2019	2.2

TABLE OF CONTENTS

1 Purpose of document 1
2 Scope of Project 1
2.1 MTC IDEA Category 2 Program Background 1
2.2 Los Gatos Project Background 1
2.3 Stakeholder Roles 4
2.4 Technical Challenges 4
3 Referenced documents 5
4 Background 5
4.1 Existing Conditions 5
4.2 Proposed Development and Approach to Improving the System 7
5 Concept for the Proposed System 9
5.1 Potential System Concepts 9
5.2 Project Element Integration 13
6 User-Oriented Operational Description 14
6.1 Stakeholders 14
6.2 Current Method of Accomplishing Goals and Objectives 15
7 Operational Needs 15
7.1 Adaptive Traffic Control System (ATCS) 15
7.2 Automated Traffic Signal Performance Measures (ATSPM) 18
7.3 Virtual Bicycle Detection/Bicycle Signal Priority (VBD/BSP) 20
8 System Overview 22
8.1 ATCS System Overview 22
8.2 ATSPM System Overview 24
8.3 VBD/BSP System Overview 26
9 Operational Environment 28
9.1 Adaptive Traffic Control System (ATCS) 28
9.2 Automated Traffic Signal Performance Measures (ATSPM) 28

9.3 Virtual Bicycle Detection/Bicycle Signal Priority (VBD/BSP) 29
10 Support environment 29
10.1 Adaptive Traffic Control System (ATCS) 29
10.2 Automated Traffic Signal Performance Measures (ATSPM) 31
10.3 Virtual Bicycle Detection/Bicycle Signal Priority (VBD/BSP) 31
11 Operational Scenarios 32
11.1 ATCS Operational Scenarios 32
11.2 ATSPM Operational Scenarios 34
11.3 VBD/BSP Operational Scenario 36
12 Summary of Impacts 36
12.1 Stakeholders 36
12.2 System Constraints 37

TABLES

Table 1 – Project Stakeholders and Roles 4
Table 2 – Existing Traffic Signal Infrastructure 5
Table 3 – Project Stakeholders and Current Roles 14

FIGURES

Figure 1 – MTC IDEA - Los Gatos Project Area 3
Figure 2 – VBD/BSP High Level Conceptual Architecture 8
Figure 3 – Virtual Bicycle Detection (VBD) 13
Figure 4 – Town of Los Gatos High-Level ATSPM System Architecture 26

1 PURPOSE OF DOCUMENT

The scope of this document covers the consideration of adaptive signal control technology (ATCS) in conjunction with an Automated Traffic Signal Performance Measures (ATSPM) solution as well as the piloting of a smartphone-initiated bicyclist signal detection system along a portion of Los Gatos Boulevard within the Town of Los Gatos, CA. This document describes and provides a rationale for the expected operations of the proposed systems. It documents the outcome of stakeholder discussions and consensus building that has been undertaken to ensure the systems implemented are operationally feasible and have stakeholder support. The intended audience of this document includes: system operators, administrators, decision-makers, nontechnical readers and other stakeholders who will share the operation of the system or be affected by it.

2 SCOPE OF PROJECT

2.1 MTC IDEA Category 2 Program Background

As the Metropolitan Planning Organization (MPO) for the nine counties that comprise the San Francisco Bay Area, the Metropolitan Transportation Commission (MTC) helps guide surface transportation priorities for a dynamic and technologically innovative region. MTC seeks to improve arterial operations and enhance the Bay Area's readiness for connected and autonomous vehicle technologies. To that end, MTC established a new regional initiative, the Innovative Deployments to Enhance Arterials (IDEA) program that is modeled similarly to MTC's previous Next Generation Arterial Operations Program (NGAOP). IDEA is both a funding program and a technical assistance program to support local Bay Area agencies in deploying advanced technologies along arterials to enhance mobility, sustainability, and safety across all modes. At its core, the IDEA program seeks to:

- Improve travel time and travel time reliability along arterials for autos and transit vehicles;
- Improve safety of motorists, transit riders, and pedestrians;
- Decrease motor vehicle emissions and fuel consumption; and
- Improve knowledge and proficiency in the use of advanced technologies for arterial operations.

The IDEA program is divided into two categories:

1. Category 1 projects are focused on more mature, commercially-available advanced technologies; and
2. Category 2 projects are focused on advanced and less mature technologies such as connected and automated vehicle technologies.

2.2 Los Gatos Project Background

The Town of Los Gatos (Town) received a Category 2 grant to deploy an ATSPM system and an ATCS at 13 intersections along Los Gatos Boulevard and Blossom Hill Road. The grant also funds the deployment of a GPS-based virtual detection and potential signal priority system for bicyclists at nine intersections on Los Gatos Boulevard between Lark Avenue and Los Gatos – Saratoga Road. **Figure 1** shows the project study area.

The overall effort by the Town of Los Gatos can be described as a total of three projects with one funded locally by the Town and the other two funded through the IDEA program. The locally funded project, referred to going forward as Project 0, will provide traffic signal controller and auxiliary equipment upgrades at each of the town's 30 existing signalized intersections. Work on Project 0 has not commenced as of this writing.

Project 1 will deploy an ATCS in conjunction with an ATSPM solution. This project may include upgrades at 13 intersections to include cameras to detect vehicle, bicyclist and pedestrian movements, and other supporting features. These upgrades will enable staff to detect changes in operating conditions based on historic and real-time traffic data allowing for optimization of signal operations when needed.

Project 2 will pilot a smartphone-initiated bicyclist signal detection system, potentially with signal prioritization functionality, at nine intersections on Los Gatos Boulevard between Lark Avenue and Los Gatos – Saratoga Road. The smartphone-initiated applications would enable detection and potentially signal priority for bicyclists at intersections based on real-time demand.

Figure 1 – MTC IDEA - Los Gatos Project Area

2.3 Stakeholder Roles

The stakeholders and their roles in this project are listed in **Table 1**.

Table 1 – Project Stakeholders and Roles

STAKEHOLDER	ROLE(S)
MTC	Funding agency, program manager, systems engineering (SE) contract manager and overall project oversight.
Town of Los Gatos	Owns, operates and maintains 13 signalized intersections within the project area. Responsible for the procurement of all system elements, procurement of construction contractor, and construction administration and oversight of all system elements.
Los Gatos Safe Routes to School (LGSR2S)	Smartphone Activated VBD/BSP system public outreach and user training.
W-Trans	Consultant for the Town of Los Gatos to provide assistance and oversight of the project.
System Vendor(s)	Furnish, install and deploy the ATCS, ATSPM and VBD/BSP systems. This may require one or more vendor.
System Engineer (Iteris)	Perform SE tasks and provide support during ATSPM, ATCS and VBD/BSP system selection and deployment.
System Evaluation Consultant	Develop the validation and evaluation plan for the deployed ATSPM, ATCS, and VBD/BSP systems including performance of a before and after study.
Design Engineer	Perform PS&E for physical improvements in support of one or more project elements.
Construction Manager	Perform Construction Management for physical improvements in support of one or more project elements.
Construction Contractor	Construct and install field elements such as vehicle detection, communications infrastructure, controllers and performance monitoring devices.

2.4 Technical Challenges

There are no anticipated technical challenges as it relates to the ATSPM and ATCS system deployments. As with any traffic signal related deployment, the challenges will involve the system fine-tuning process which includes:

- The verification that all traffic controller hardware and firmware are capable of generating high-resolution data logs.
- The verification of detection for accurate data input into the ATSPM and ATCS systems;
- ATSPM and ATCS parameter configuration to provide optimum traffic measurement (ATSPM) and operations (ATCS); and
- Validation of the ATSPM and ATCS against the agency's needs.

The VBD/BSP system deployment does present some technical challenges. In addition to the configuration related challenges listed above, there are few vendors with off-the-shelf VBD/BSP solutions that could fit the Town's needs, goals and objectives. None of the VBD/BSP vendors currently known to be in the market have a significant number of deployments on record. In short, the VBD/BSP portion of this project is cutting edge technology. Another technical challenge will be integrating the VBD/BSP solution with traffic controller hardware that is part of the Town's Project 0 and therefore not identified as of this writing.

3 REFERENCED DOCUMENTS

The following documents have been used in the preparation of this ConOps document.

- "Systems Engineering Guidebook for ITS", California Department of Transportation, Division of Research & Innovation, Version 3.0, November 2009.
- "Model Systems Engineering Documents for Adaptive Signal Control Technology", United States Department of Transportation (US DOT) Federal Highway Administration (FHWA), FHWA-HOP-11-027, August 2012.
- "Bay Area ITS Architecture, 2017 Update", Metropolitan Transportation Commission, 2017.
- "Los Gatos Traffic Signal System Evaluation 2016", Traffic Patterns, January 23, 2017.
- "Los Gatos IDEA Systems Engineering Management Plan (SEMP)", November 1, 2018.

4 BACKGROUND

4.1 Existing Conditions

The Town of Los Gatos owns and operates 31 signalized intersections including the thirteen signalized intersections located in the project area. The rest of this subsection describes the field equipment and traffic signal operations at the project intersections. **Table 2** summarizes the Town of Los Gatos' existing traffic signal infrastructure for the thirteen intersections in the project area based on a review of the Town's documentation and field visits to each intersection conducted on November 6, 2018.

Table 2 – Existing Traffic Signal Infrastructure

INTERSECTION	TRAFFIC SIGNAL CONTROLLER	DETECTION	TRAFFIC SIGNAL CABINET	COMMUNICATIONS
Alberto Way/ Saratoga Rd	Econolite ASC/3-2100	Video - Iteris Vantage Edge 2	Type P TS-2 Type 1	None
Los Gatos Blvd/ Saratoga Rd	Econolite ASC/3-2100	Video - Iteris Vantage Edge 2	Type P TS-2 Type 1	12 pair SIC
Los Gatos Blvd/ Caldwell-Kennedy Rd	Econolite ASC/3-2100	Video - Iteris Vantage Edge 2	Type P TS-1	12 pair SIC
Los Gatos Blvd/ Nino Ave	Econolite ASC/3-2100	Video - Iteris Vantage Edge 2	Type P TS-1	12 pair SIC
Los Gatos Blvd/Roberts Rd-Shannon Rd	Econolite ASC/3-2100	Video - Iteris Vantage Edge 2	Type P TS-2 Type 1	12 pair SIC/SVITS/Fiber/ RuggedCom Ethernet Switch MOSA Ethernet switch
Blossom Hill Rd/ Roberts Rd	Econolite ASC/2S-2100	Video - Iteris Vantage Edge 2	Type P TS-1	12 pair SIC
Los Gatos Blvd/ Blossom Hill Rd	Econolite ASC/2S-2100	Video – Iteris Vantage Edge 2	Type P TS-1	12 pair SIC
Blossom Hill Rd/ Camella Terrace	Econolite ASC/3-2100	Inductive Loops	Type P TS-2 Type 1	12 pair SIC
Blossom Hill Rd/ Cherry Blossom Ln	Econolite ASC/2S-2100	Inductive Loops	Type P TS-1	12 pair SIC
Los Gatos Blvd/ LG Almaden Rd	Econolite ASC/2S-2100	Video - Iteris Vantage Edge 2	Type P TS-1	12 pair SIC

INTERSECTION	TRAFFIC SIGNAL CONTROLLER	DETECTION	TRAFFIC SIGNAL CABINET	COMMUNICATIONS
Los Gatos Blvd/ Village Square	Econolite ASC/2S-2100	Video - Iteris Vantage Edge 2	Type P TS-2 Type 1	12 pair SIC
Los Gatos Blvd/ Gateway-Garden Ln	Econolite ASC/2S-2100	Video - Iteris Vantage Edge 2	Type P TS-1	12 pair SIC
Los Gatos Blvd/ Lark Ave	Econolite ASC/2S-2100	Video Iteris Vantage Edge 2	Type P TS-1	12 pair SIC/SVITS/Fiber/ Optelecom Transceiver

4.1.1 Existing Signal System and Communications

The Town of Los Gatos uses Econolite traffic signal controllers. Three intersections utilize legacy Econolite ASC/2S controllers and the other ten intersections use more modern Econolite ASC/3 controllers which will support an ATSPM deployment. All the controllers utilize proprietary communications protocols to establish communications links to the Town's existing central system (Aries). Dial-up phone drops and modems are used at most intersections to establish communications links when monitoring or manipulation of traffic signal timing is required. As the current central signal system only allows for one dial-up modem to communicate at a time, the entire traffic signal network cannot be monitored in its entirety at any given time.

The Town of Los Gatos is a partner in the regional Silicon Valley Intelligent Transportation Systems (SV-ITS) program and that program provides a fiber optic links along several corridors in the Town. Installed in the early 2000's, this fiber has undergone a few changes over the years. The links listed below will remain in place going forward:

- 12 strand fiber optic cable along Lark Avenue from SR-17 to Los Gatos Boulevard.
- 24 strand fiber optic cable along Los Gatos Boulevard from Lark Avenue to Samaritan Drive-Burton Road.
- 96 strand fiber optic cable along Los Gatos Boulevard from Lark Avenue to the Town of Los Gatos Transportation Management Center.

In addition, the Town of Los Gatos installed a 72 strand fiber optic cable along Lark Avenue from Winchester Boulevard to Los Gatos Boulevard. In the near future the Town will install the following fiber links:

- 96 strand fiber optic cable along Los Gatos Boulevard from Lark Avenue to Samaritan Drive-Burton Road
- 12 strand branch cables at Walker Street/Los Gatos Boulevard, Lark Avenue/Los Gatos Boulevard and Lark Avenue/Oka Road.

Dial-up modem phone drops are used along Los Gatos Boulevard from Los Gatos-Saratoga Avenue to Roberts Road with a phone drop at Roberts Road. Along Los Gatos Boulevard between Blossom Hill Road and Lark Avenue, modems are used in conjuction with a fiber connection from the Master to City Hall. Overall, dial-up modem phone drops and SV-ITS fiber optic provide communications linkages to about two-thirds of the city's traffic signals (23 intersections). The remainder intersections have no communications linkages.

Seventy percent of the Town's intersections are currently equipped with twisted copper pair cables that link back to designated intersections with dial-up phone drops while the remaining traffic signals do not have any communications capabilities. When the Town is ready to check signal status, a field modem is accessed through a dial-up phone call. Four field modems provide access to dial-up locations..

Project 0 will upgrade all project intersections to support Ethernet communications protocols.

4.1.2 Traffic Signal Cabinets

The Town currently utilizes a combination of NEMA TS-1 and NEMA TS-2 cabinets. NEMA TS-1 cabinets are an original NEMA standard for traffic signal cabinets from the 1980's and use hard wire point-to-point connections within the cabinet. NEMA TS-1 cabinet environments offer limited maintenance and troubleshooting capabilities compared to the modern TS-2 cabinet environments. NEMA TS2 cabinets are considered the most modern traffic signal cabinets currently on the market and they make up about half of the Town's current inventory. These cabinets utilize Bus Interface Units (BIUs) to transfer data between different areas of the cabinet to the traffic signal controller, similar to how a modern computer transfers data between chipsets on a motherboard and add-on peripherals. The NEMA TS2 cabinets also maximize detection input opportunities (64-channels).

4.1.3 Detection

The Town of Los Gatos has inductive loop and video detection in place at 20 signalized intersections and has standardized on video detection exclusively. The Town's typical video detection setup has stop bar and advance detection zones for major streets. Minor side streets have stop bar detection zones only. Neither stop bar nor advance detection is broken out on a lane by lane basis. Bicycle detection is set up for bike lanes at the stop bar however City staff have received input that existing bike detection is not reliable.

4.1.4 Traffic Signal Operations

The Town has grouped the thirteen traffic signals into two groups. The first group contains the five signals from Alberto Way/Saratoga Road to Los Gatos Boulevard/Roberts Road – Shannon Road. The second group contains a total of eight signals. Four signals on Blossom Hill Road between Roberts Road and Cherry Blossom Laneand four signals on Los Gatos Boulevard between Los Gatos-Almaden Road and Lark Avenue. Each group operates in a coordinated manner during the weekday AM and PM peak periods with cycle lengths between 104 seconds and 120 seconds. The traffic signals operate freely at all other times.

According to Town staff, the project area has been severely affected by non-resident motorists utilizing the project area to avoid congestion on SR17. With several schools located in or near the project area, this traffic has impacted the safety of school children and the overall quality of life for residents in the area to the point where Town staff successfully lobbied Caltrans District 4 to close one freeway on ramp on occasion.

4.2 Proposed Development and Approach to Improving the System

4.2.1 Adaptive Traffic Control System and Automated Signal Performance Measure System

The Town of Los Gatos plans to improve its traffic signal system by applying advanced technologies to better manage vehicular, bicycle and pedestrian movements, with the goal of improving travel time, reliability and safety, ease traffic congestion and delays and reduce fuel consumptions and emissions. The proposed project seeks to install enhanced detection devices and communication that can provide a systematic and periodic signal timing accuracy check for improving traffic flow that will benefit all modes of traffic. The project will install centralized traffic signal management software and associated equipment that will receive high resolution traffic data and process commands to the traffic signal network through an automated process.

All intersections along Los Gatos Boulevard and Blossom Hill Road may be upgraded to modern advanced controllers and will be connected to a centralized advanced traffic management system (ATMS). All intersections are currently running Time-of-Day (TOD) coordination plans to manage the congestion experienced along Los Gatos Boulevard. Los Gatos Boulevard has varying traffic patterns throughout the day,

is near schools having different drop-off and pick-up schedules, and is the only north-south route with closely spaced intersections east of State Route 17. Additionally, Los Gatos Boulevard has experienced several vehicular, pedestrian and bicycle collisions from 2011-2016 along its stretch. With this project, the Town plans to upgrade its existing traffic signal system and develop a modern signal system with Automated Traffic Signal Performance Measures (ATSPM) and adaptive control. The new signal system will improve signal system performance, thereby reducing travel time, average delay and congestion. This in turn is expected to reduce driver frustration and aggressiveness as well as reduce merging and weaving issues through the corridor, resulting in safer traveling for all modes. Due to the several schools within the study area, the Town seeks to improve progression during periods of fluctuating traffic demand along the corridor and in-turn reduce the number of collisions.

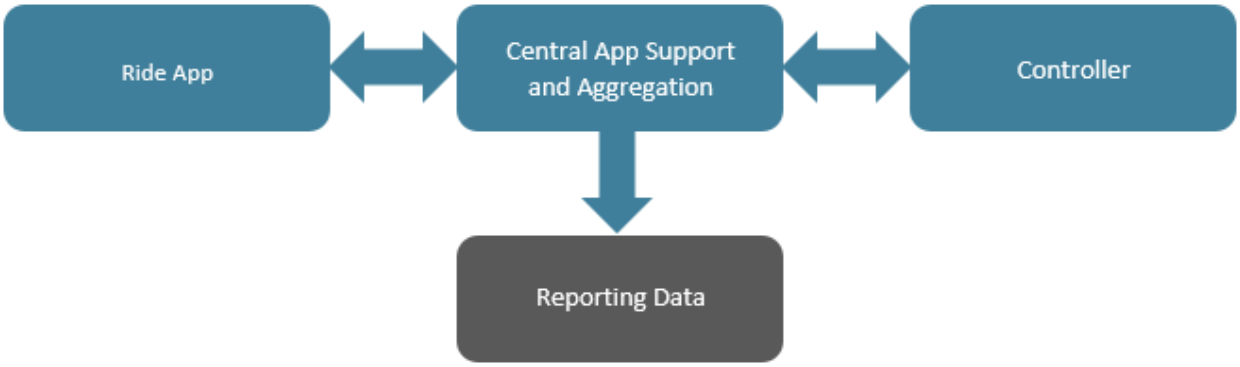
4.2.2 Virtual Bicycle Detection/Bicycle Signal Priority System

The Town is interested in improving bike detection and, potentially, a prioritization system that can identify and locate bicycle traffic within the corridor. The prioritization system would process the activity through a cloud-based central system which sends a detection message to the signal, thereby enhancing bike travel through the corridor.

This approach is a three-layer approach that starts with a smartphone-based app (see **Figure 2**). This app serves the function of providing telemetry information to the central system. This information includes location, speed and heading. This app would have a passive bicycle detection mode.

The central cloud-hosted component is the second layer. This layer includes the user interface and components that collects, aggregates, and analyzes the data. The central app can send that detector call to the signal to initiate the movement to the appropriate interval to support the bicycle movement. In the future, more complex operations could be supported such as priority requests, time-based prioritization (only grant prioritization during specified hours, otherwise place a simple call) or platoon-based prioritization (only grant prioritization when a specified number of bicycles are present close enough together to warrant such operations, otherwise place a simple call). The third layer is the local intersection controller. The controller should support remote detector call activation (for example, through an NTCIP 1202 OID set message or IP-based detector protocol).

Figure 2 – VBD/BSP High Level Conceptual Architecture



5 CONCEPT FOR THE PROPOSED SYSTEM

This section describes the concept exploration. It starts with a list and description of the alternative concepts examined. The evaluation and assessment of each alternative follows. This leads into the justification for the selected approach. The operational concept for that selected approach is described here. This is not a design, but a high-level, conceptual, operational description. It uses only as much detail as needed to be able to develop meaningful scenarios. In particular, if alternative approaches differ in terms of which agency does what, that will need to be resolved and described.

5.1 Potential System Concepts

5.1.1 Traffic Control Strategies

5.1.1.1 Proactively Operated Centralized Traffic Signal Management System

Description
This strategy involves deploying traffic signal timing plans for all intersections in the project area for AM peak and PM peak actively monitoring their effectiveness and making adjustments as needed. The active monitoring of the traffic signal system's performance would be done either manually or through the use of an ATSPM application. This will be discussed in more detail later in this section.

Evaluation and Assessment
A proactively operated centralized traffic signal system requires a significant amount of labor to come close to matching the performance of an adaptive traffic control system. This effort includes traffic engineering staff monitoring traffic operations on a consistent basis to identify issues as well as formulate and deploy signal timing plans aimed at mitigating the issues.

Conclusion
The Town of Los Gatos does not have the staff resources available to proactively operate a centralized traffic signal system at a level that approximates the performance of an adaptive traffic control system. It is therefore not considered further for inclusion in the project.

5.1.1.2 Adaptive Traffic Control System

Description
At a high level, adaptive signal control technology continually monitors and frequently adjusts the timing of traffic signals to accommodate changing traffic patterns and ease traffic congestion.

Evaluation and Assessment
The main benefits of adaptive signal control technology over conventional signal systems are that it can:

- Continuously distribute green light time equitably for all traffic movements
- Improve travel time reliability by progressively moving vehicles through a corridor
- Reduce congestion by creating smoother flow
- Prolong the effectiveness of traffic signal timing

- Adeptly adjust to sudden variations in traffic patterns

According to FHWA, many communities' traffic patterns change sufficiently within three years that the cost of completely reviewing the updating the timing plans is justified by the resulting efficiency improvements. Although you should not expect adaptive control to be "set and forget", less deterioration in efficiency between timing reviews is expected with adaptive traffic control. Generally speaking adaptive systems can go as long as ten years between signal timing updates compared to 3-5 years for a typical time of day system.

Most adaptive control systems operate on top of or in conjunction with many of the most basic foundational traffic control settings. Therefore these systems cannot overcome the impact of poorly selected basic timing settings and parameters. It is also particularly important to have up to date, good quality traffic signal control settings and appropriate plans programmed as backup plans that will be invoked if the adaptive control system fails or traffic would be better served by non-adaptive operation.

Conclusion
Adaptive traffic control systems allow the Town to provide traffic signal timings that adjust to the changing traffic volumes and patterns along the project corridor without substantially increasing the ongoing workload of the existing Town staff. It is recommended for inclusion in the project.

5.1.2 Traffic Signal Performance Measurement

5.1.2.1 Automated Traffic Signal Performance Measurement

Description
Automated Traffic Signal Performance Measurement (ATSPM or SPM) software analyzes data retrieved from traffic signal devices, visualizes it, and could provide notifications about inefficient traffic operations. This kind of software has only recently started replacing less detailed and infrequent information that are typically available on typical centralized traffic signal systems. Advancements in traffic controller technology and standardization of controller log messages have paved the way for the development of SPM tools.

Traffic signal controllers have improved significantly in the last several years. Faster processors and the Linux operating system on recent 2070, ATC and NEMA controllers have provided the ability to log many controller event at a high resolution (every tenth of a second). These events include inputs and outputs of the controller, and their definitions have been standardized across most manufacturers.

Each controller event is logged with the intersection number, a timestamp, an event code, and a parameter. The event code is a standardized number for the type of event that occurred, and the parameter provides detail on, for example, which phase or detector channel triggered an event, which timing plan is starting, or what the split time for a phase is.

Traffic signal controllers do not necessarily have a "big picture" view of an intersection. They are limited to knowing and reacting to the immediate and next requests. Perhaps a car ran over a sensor, an emergency vehicle preempted the normal program, or a pedestrian push button was activated. Collecting and storing traffic signal data in high resolution allows SPM software to show trends and visualize information in ways that help traffic engineers evaluate existing operations and develop efficient signal timing plans. For agencies with a central traffic control system such as the Town of Los Gatos, some basic detector reports and cycle/split reports have always been available. The value added by SPM software is the combination of

detector data with signal phase data, which tells a more complete story. Knowing that a vehicle arrived at the intersection on green or entered the intersection on red is much more valuable than just knowing that a vehicle was at the intersection.

Detector configuration and placement plays a large role in the different measures of effectiveness (MOE) that an SPM tool can generate. An optimal configuration that will allow for the most MOE's to be reported is to have each lane of an approach with a count detector just in front of the stop bar, a presence detector at the stop bar, and an advance detector past the end of the expected queue. Each of these detectors should be brought back to the controller on a separate channel.

Evaluation and Assessment
An ATSPM tool helps the engineer to easily identify problems so that they can quickly be addressed, and thus improve efficiency on the road and make traffic engineering staff more productive. SPM software allows an agency to retime signals when changes are needed due to traffic pattern changes and not according to a standard, fixed retiming schedule. When used in conjunction with an adaptive traffic control, the ATSPM system can be utilized to fine tune the adaptive system and evaluate the overall effectiveness of the adaptive system and supporting detection.

Conclusion
SPM software is a tool that allows traffic engineering staff to do their job more efficiently and identify issues in the traffic network that would be very difficult to do otherwise. It is recommended for inclusion in the project.

5.1.2.2 Manual Traffic Signal Performance Measurement

Description
In the absence of SPM software, manual traffic signal performance measurement would entail capturing and storing the high resolution controller data for manual review and analysis; traffic engineering staff would rely on the basic reports included in their central traffic control system and public input to identify and diagnose traffic signal operations or maintenance issues; and traffic signal timing would be updated based on the time since the last retiming.

Evaluation and Assessment
Manual measurement of traffic signal performance is an extremely time consuming process. Most, if not all, public agencies do not have the technical skills or the time to manually capture, store and analyze high resolution controller data. These same agencies also do not have the resources to conduct field visits to verify public complaints and diagnose traffic signal operational and maintenance issues in a timely manner.

Traffic signal timing updates would occur at set intervals, assuming sufficient budget is available. Traffic signal timing projects follow a strict and time consuming process that take months to complete. Having an ATSPM tool would allow many of the typical processes involved in a signal timing project to be performed more efficiently and accurately thus reducing the overall cost and time that it takes to re-time a typical corridor.

Conclusion
Collecting and analyzing SPM data without a software tool (i.e., manually) is not a viable alternative from a technical and resource standpoint. In all likelihood manual SPM would be a difficult and time consuming process in order to identify a significant number of operational and maintenance issues while at the same time diverting staff from completing some of their other duties. This strategy is not recommended for

inclusion in the project.

5.1.3 Bicyclist Enhancement

5.1.3.1 Traditional Detection Infrastructure

Description
This strategy focuses on enhancing the detection infrastructure along the corridor to support the detection of bicyclists for the purpose of improving safety and convenience for bicycles at signalized intersections. The purpose of this effort is for bicycles to both place a call to the traffic signal to request service (request a green light when the light is red) and also to maintain a request for service (keep the light green) so that the green phase will not end early or "gap out" when there are bicycles present but not automobiles. Specific detection enhancements include:

- Stop Bar Detection: The establishment of bicycle detection zones near the stop bar of each intersection approach that is used by bicyclists for the purpose of counting the number of bicyclists and alerting the central traffic control system of the presence of bicyclists at the approach.
- Advanced Detection: The establishment of bicycle detection zones placed a few hundred feet upstream of the intersection approach. This will be used to alert the traffic signal controller that bicyclists are en-route to the intersection.

There is video detection technology available in the market that distinguishes between automobiles and bicyclists within the same detection zone and provides traffic count data for each type.

Evaluation and Assessment
Increasing the detection infrastructure to initially support student bicyclists by placing calls and preventing "gap outs" is technically feasible using traditional methods such as pavement loops or video detection and later to expand to all bicylists. However the Town would need to incur significant capital costs up to $20,000 - $25,000 per intersection approach to deploy the advanced detection. It is assumed that a typical intersection will require advanced detection at two approaches to support bicycle travel. Elements impacting the advanced detection include:

- Distance between advance detector and the stop bar.
- Amount of conduit and cable.
- Pole and foundation.
- Number of pull boxes.
- Modifications needed in the traffic controller cabinet to accommodate advanced detection equipment.

In addition to the capital elements described above, deploying additional infrastructure will require additional on-going maintenance resources.

Conclusion
Increased detection infrastructure is not a viable alternative from a cost and resource standpoint for widespread deployment. This strategy is not recommended for inclusion in the project.

5.1.3.2 Virtual Bicycle Detection (VBD)

Description
With Virtual Bicycle Detection, instead of installing capital-intensive physical infrastructure, bicyclists ride with an application running on their smartphone. The smartphone app would run in the background and sense when the user is riding a bicycle. When the bicycle reaches a predetermined trigger point upstream of a traffic signal, the app sends a message to a server located in the cloud. The cloud server relays the detection information to the Town's central signal system which then issues a command to the traffic controller for the appropriate approach at the traffic signal to either place a call request or continue an existing request (hold request so the traffic signal does not "gap out"). This concept is illustrated below in **Figure 3**.

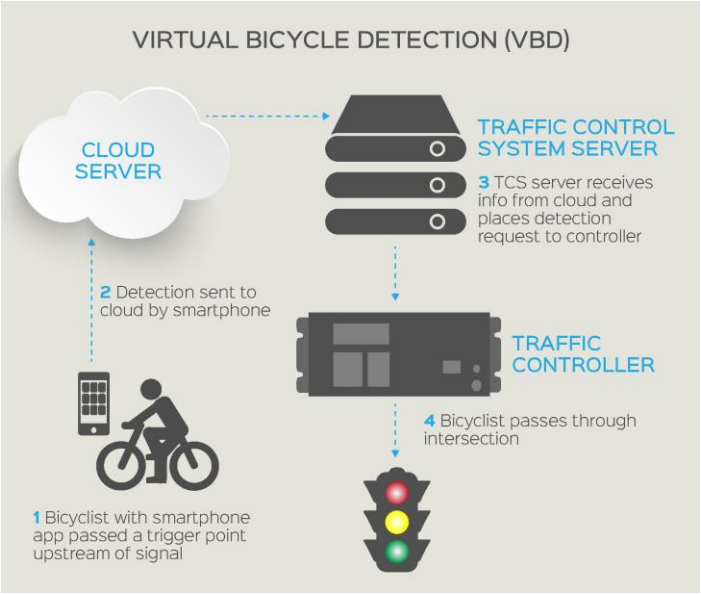


Figure 3 – Virtual Bicycle Detection (VBD)

Evaluation and Assessment
As the name suggests, VBD does not require additional detection infrastructure in the field. This saves significant time and budget that would be spent on construction and maintenance. There is a chance that not all bicylists will have the smartphone app activated on every trip which would reduce the overall completeness of the bicyclist data collected, however given the high volume of bicyclists observed traveling to and from school, this should have no impact on actual VBD operations. This strategy has the ability to quickly expand to the entire Town if desired by agency staff whereas deploying additional detection infrastructure does not.

Conclusion
Virtual Bicycle Detection is recommended for inclusion in the project.

5.2 Project Element Integration

Description
Another consideration regarding the recommended strategies is the level of integration that will exist between the ATCS, ATSPM and VBD/BSP technologies. How tightly linked will these three systems be to each other? There are pros and cons to different levels of integration. Generally speaking, a more integrated solution will most likely be easier to use and require less staff resources to operate and maintain. However, there may be fewer system vendors available to provide all three systems as a single solution given the somewhat unique combination of technologies. Conversely, a solution that includes little or no integration may require more staff resources to operate and maintain but provide the City with more options on the individual systems to select from.

Evaluation and Assessment
Below are considerations for each potential combination of system integration.

- **No integration between systems:** Relatively high level of staff resources needed to operate and maintain. Reduced risk of failure since each system will be self-contained.
- **Integrated ATCS and ATSPM, separate VBD/BSP:** Many traffic control system vendors offer ATCS and ATSPM functionality as add-on modules to the main central signal system so this will most likely not limit the number of systems available. Both of these technologies are well known and considered off-the-shelf thus reducing the overall project risk. The VBD/BSP application is newer and has not been widely deployed. An arrangement of this nature may attract vendors with VBD/BSP existing solutions as well as ATCS/ATSPM vendors willing to develop their own VBD/BSP solution for the Town of Los Gatos.
- **Integrated VBD/BSP with either ATCS or ATSPM:** Integrating VBD/BSP with an ATCS or ATSPM system and leaving the other separate would present a higher level of risk since the VBD/BSP system is relatively new and unproven, making that system the integration centerpiece presents a higher level of risk and may result in very fewer options for the City
- **Integrated ATCS, ATSPM and VBD/BSP:** Integrating all three technologies into a single solution will most likely provide Town staff with lightest operations and maintenance obligation however there very few vendors on the market that offer all three solutions. This significantly limit's the Town's options.

Conclusion
Given the Town's limited staffing resources, a certain level of integration between the three systems is important as is the federal requirement to encourage as many bidders as possible to submit a proposal. In an effort to balance these two needs while minimizing the overall risk to the project, the Town will issue a single RFP covering all three systems. Bidders will have the option to submit proposals on any and all systems. The bidders will be required to discuss their solution's integration capabilities. The level of integration between the systems will be one of the evaluation criteria. The exact weighting of this criterial relative to the others will be determined at a later date and included in the RFP.

6 USER-ORIENTED OPERATIONAL DESCRIPTION

6.1 Stakeholders

There are numerous stakeholders which will play key roles in the operation and maintenance of the ATCS, ATSPM and VBD/BSP systems. The stakeholders and their roles in this project are listed in Table 3.

Table 3 – Project Stakeholders and Current Roles

STAKEHOLDER	CURRENT ROLE(S)
MTC	Metropolitan Planning Organization (MPO) for the San Francisco Bay Area, maintains regional ITS architecture, administers various transportation funding programs.
Town of Los Gatos	Owns, operates and maintains 13 signalized intersections within the project area. Responsible for the procurement, operations and maintenance of all system elements.
Los Gatos Safe Routes to School (LGSR2S)	Smartphone Activated VBD/BSP system public outreach and user training.

STAKEHOLDER	CURRENT ROLE(S)
System Vendor(s)	Furnish, install and deploy the ATCS, ATSPM and VBD/BSP systems. This may require one or more vendor. Provide ongoing system support after deployment.
Town Maintenance Contractor	At the direction of Town staff, perform emergency and routine maintenance tasks for all transportation system infrastructure.

6.2 Current Method of Accomplishing Goals and Objectives

The Town currently operates the Econolite Aries central signal system and employs time-of-day traffic signal coordination that do not adjust to rapidly changing conditions in the project area resulting from school events and incidents on nearby freeways. The Town largely relies on the use of dial-up modems to operate and manage the traffic controllers in the field. This communications technology does not position the Town well for deploying advanced transportation technologies in the future. In addition there are several intersections that do not have any communications capabilities. These gaps in the communications infrastructure severely hampers the overall system's effectiveness. As a result, the entire traffic network cannot be monitored or controlled in its entirety at any given time from the Town's Engineering Office. In addition, the outdated traffic controller hardware at many intersections combined with the communications gaps and complete lack of more advanced communications technology (IP-based Ethernet communications) prevent the Town from utilizing state-of-the-art traffic signal performance and monitoring tools to improve traffic operations.

In short, the Town is not currently able to accomplish many of the project's goals and objectives. However the Town's Project 0 will close the communication gaps and establish an Ethernet-based communications network that will lay the foundation for accomplishing the project goals and objectives through the deployment of the ATCS, ATSPM and VBD/BSP systems.

7 OPERATIONAL NEEDS

This chapter describes the user needs identified by the stakeholders related to the operations of the ATCS, ATSPM and VBD/BSP systems. Each section below describes something that the system needs to be able to accomplish. Each of these needs, preceded with a Concept of Operations reference number as shown, will be satisfied by compliance to a set of system requirements that will be developed in a subsequent document.

7.1 Adaptive Traffic Control System (ATCS)

7.1.1 Operational Needs

[7.1.1-01] The system needs to be able to identify changing traffic conditions and automatically adjust operation based on the prevailing traffic conditions and Town traffic management policies at balancing throughput with local traffic patterns.

[7.1.1-02] The system needs to be able to implement preference for bi-directional corridor progression during certain periods of the day.

[7.1.1-03] During school hours, the system needs to provide operational preference focused on queue management and minimizing side street delay.

[7.1.1-04] The system needs to provide operational preference to minimize delay for side streets and protected left turns.

[7.1.1-05] The system needs to be able to provide cross-coordination along intersecting corridors, especially at the intersection of two major arterials.

[7.1.1-06] The system needs to be capable of eventually operating all city traffic signals.

[7.1.1-07] The system needs to provide controls that allow users to manually override system control to provide another form of operation including Free, TOD coordination, or a user-selected timing plan.

[7.1.1-08] The system needs to accommodate emergency vehicle preemption operation.

[7.1.1-09] The system needs to be flexible to accommodate various bicyclist operational goals including the ability to set a minimum and maximum cycle length and to operate early bicyclist/pedestrian start during different times of the day.

[7.1.1-10] The system needs to be flexible to allow changes in cycle length, splits, offsets, phase sequence, and signal groupings as part of the operation.

[7.1.1-11] The system needs to allow for user control to configure how responsive the system responds to fluctuations in traffic.

[7.1.1-12] The system needs to provide a user-friendly and intuitive graphical user interface.

[7.1.1-13] The system needs to be reliable with minimum maintenance required.

[7.1.1-14] The system needs to accommodate school arrival and departure patterns that change with staggered school bell schedules and early dismissals.

7.1.2 Monitoring Needs

[7.1.2-01] System monitoring needs to be provided via interface centrally (such as a central server), distributed to multiple client workstations on a local area network (LAN), and remote client workstation outside the LAN using Virtual Private Network (VPN) technology.

[7.1.2-02] System monitoring needs to be provided to multiple users on multiple client workstations simultaneously.

[7.1.2-03] System monitoring information provided to the user needs to be similar to or better than that provided by a modern day advanced traffic signal system. This generally includes information related to all pertinent system health information such as system status, communications status, detector status, intersection status, mode of operation, active phase and duration, etc.

[7.1.2-04] System monitoring needs to allow the user to access all local controller settings and parameters

from a central server, client workstation, or remote client workstation. Access includes the ability to upload (controller to system), download (system to controller), and compare (controller vs. system) a user-selected portion of the controller database or the entire controller database.

[7.1.2-05] System monitoring needs to allow the user to view, edit, and save changes to all systems level settings and configurations and all individual controller settings and parameters via the central server, client workstation, and remote client workstation.

7.1.3 Reporting and Documentation Needs

[7.1.3-01] The system needs to be able to provide and store real-time logs of all system status, events, and operation with user-editable setting for the length of storage before records are purged.

[7.1.3-02] As part of the system, the local controllers needs to be able to log and store real-time status, events, and alarms for the individual controller.

[7.1.3-03] The system needs to provide user manuals for system set-up, configuration, and maintenance.

7.1.4 Architecture Needs

[7.1.4-01] The system needs to work with existing traffic signal controller cabinets.

[7.1.4-02] The system needs to fully function in a computer network environment with various system devices and components potentially residing on different networks, different virtual local area networks (VLANs), and between network security devices (i.e., firewall).

[7.1.4-03] The system needs to be operated and monitored at the Town's TMC, at the workstation of Town staff, and on any mobile computing device connected to the Town's computer network.

[7.1.4-04] The system needs to allow monitoring access by authorized users via secured VPN.

[7.1.4-05] The system needs to use a relational database that allows access and assign rights to multiple levels of user access (i.e. admin, user).

[7.1.4-06] The system needs to be capable of being installed and fully functional in a virtual server environment.

7.1.5 Failure Needs

[7.1.5-01] When a system failure (i.e., central server failure) occurs, controllers under system control needs to revert to the local controller TOD operation that include Free operation, coordination plan, and any special functions.

[7.1.5-02] When a system wide communication failure occurs, controllers under system control needs to revert to the local TOD operation that include Free operation, coordination plan, and any special function.

[7.1.5-03] When a localized failure (controller and/or communications) occurs, the system needs to allow the user to determine the mode of operation at the failed location and at other non-failed intersections based upon a pre-defined set of conditions.

[7.1.5-04] When a localized detection failure occurs, the system needs to allow the user to determine the mode of operation based upon a pre-defined set of conditions.

[7.1.5-05] When a system failure occurs, Town staff shall be notified via email and text.

7.1.6 Maintenance Needs

[7.1.6-01] Comprehensive training needs to be provided to engineering staff and signal maintenance staff on local controller hardware and firmware programming, operation, and configuration.

[7.1.6-02] Comprehensive training needs to be provided to engineering staff on system (hardware and software) set-up, configuration, and maintenance.

[7.1.6-03] The ATCS vendor needs to conduct a bi-weekly review of system event logs, alarms, notifications, etc. on health of system and preparation of action items, if needed, to address any system deficiencies or component failures to return the system to a state of good operation.

7.2 Automated Traffic Signal Performance Measures (ATSPM)

7.2.1 Operational Needs

[7.2.1-01] The ATSPM system needs to be able to identify specific conditions at a traffic signal including phase failure, green utilization and arrivals on green.

[7.2.1-02] The ATSPM system needs to be able to identify changes in operational conditions over time at an individual signal and along corridors.

[7.2.1-03] The ATSPM system needs to be able to provide information that can be used to improve signal maintenance and operations practices.

[7.2.1-04] The ATSPM system needs to be capable of eventually monitoring the performance of all Town traffic signals.

7.2.2 Monitoring Needs

[7.2.2-01] ATSPM system monitoring needs to be provided via interface that is distributed to multiple client workstations on a local area network (LAN), and remote client workstation outside the LAN.

[7.2.2-02] The following information should be monitored and displayed for every traffic signal in the ATSPM system:

- Phases in max recall
- Phase failure by termination type
- Phase duration
- Causes and duration of coordination interruption
- Percent of vehicles that arrive on green, yellow and red
- Length of time the minor street waits while no one is on the major street

[7.2.2-03] The ATSPM system needs to provide a means of measuring the overall performance and effectiveness of the adaptive traffic control system deployed through this project.

7.2.3 Architecture Needs

[7.2.3-01] The ATSPM system needs to reside centrally and have same reliability (uptime, latency, etc.) as local communications and traffic control system servers.

[7.2.3-02] The ATSPM system needs to have Ethernet communications links to all traffic signals monitored.

[7.2.3-03] The ATSPM system needs to fully function in a computer network environment with various system devices and components potentially residing on different networks, different virtual local area networks (VLANs), and between network security devices (i.e., firewall).

[7.2.3-04] The ATSPM system needs to be operated and monitored at the workstation of Town staff, and on any mobile computing device connected to the Town's computer network.

[7.2.3-05] The ATSPM system needs to allow access by authorized users via secured VPN.

[7.2.3-06] The ATSPM system needs to use a standard database that allows access and assign rights to multiple levels of user access (i.e. admin, user).

[7.2.3-07] The ATSPM system needs to be capable of being installed and fully functional in a virtual server environment.

7.2.4 Reporting and Documentation Needs

[7.2.4-01] The ATSPM system needs to be able to provide and store real-time logs of all system status, events, and operation for a period of time that is programmable by the user.

[7.2.4-02] Comprehensive training needs to be provided to engineering staff and signal maintenance staff on local controller hardware and firmware programming, operation, and configuration.

[7.2.4-03] The ATSPM system needs to provide user manuals for system set-up, configuration, and maintenance.

7.2.5 Failure Response Needs

{7.2.5-01] When the ATSPM system failure occurs, Town staff shall be notified via email and/or text. Types of notifications need to be user editable.

7.2.6 Maintenance Needs

[7.2.6-01] Comprehensive training needs to be provided to engineering staff on ATSPM system (hardware and software) set-up, configuration, and maintenance.

[7.2.6-02] Comprehensive training needs to be provided to engineering staff and signal maintenance staff on local controller hardware and firmware programming, operation, and configuration.

[7.2.6-03] The ATSPM system needs to require minimal preventive maintenance tasks.

7.3 Virtual Bicycle Detection/Bicycle Signal Priority (VBD/BSP)

7.3.1 Operational Needs

[7.3.1-01] The VBD/BSP system needs to accommodate special features including early start and extended green in cooperation with the signal system.

[7.3.1-02] The VBD/BSP system needs to suggest bicycle routes.

[7.3.1-03] The VBD/BSP system needs to provide bicycle counts.

[7.3.1-04] The VBD/BSP system needs to be able to discriminate and respond differently to the presence of multiple bicyclists than from a single bicyclist.

[7.3.1-05] The VBD/BSP system needs the capability to adjust the detection range/distance from an intersection.

[7.3.1-06] The VBD/BSP system needs to provide reliable and accurate detection including location, direction, and time stamp.

[7.3.1-07] The VBD/BSP system needs to integrate with signal controllers and central signal system for providing real-time detection input to the signal system.

[7.3.1-08] The VBD/BSP system needs to allow operator-adjusted detection zones approaching signalized intersections, which could be such as half street, block, by lane, and/or by distance.

[7.3.1-09] The VBD/BSP system needs to provide analysis of bicycle experience by routes and by selected intersections.

[7.3.1-10] The VBD/BSP system needs to allow display or plots of bicycle paths crossing intersections on aerial photos by time and day.

[7.3.1-11] The VBD/BSP system needs to allow operator-defined bicycle user groups and routes.

[7.3.1-12] The VBD/BSP system needs to be designed so user personal information is never transmitted to the Town. The system should also not collect of store user personal information.

[7.3.1-13] The VBD/BSP system needs to be designed in a manner that is both appealing to school age children and provides and incentive for them to utilize the application. .

7.3.2 Monitoring Needs

[7.3.2-01] VBD/BSP system monitoring needs to be provided via interface centrally at a TMC, distributed to multiple client workstations on a local area network (LAN), and remote client workstation outside the LAN.

[7.3.2-02] The VBD/BSP system needs to provide a means of measuring the overall performance and effectiveness of the smartphone activated Virtual Bicycle Detection application.

[7.3.2-03] The VBD/BSP system needs to be capable of expanding to support all traffic signals in the Town.

[7.3.2-04] The VBD/BSP system needs to detect groups of bicyclists.

[7.3.2-05] The VBD/BSP system needs to display to the user the time of each activation and the system response.

7.3.3 Reporting and Documentation Needs

[7.3.3-01] The VBD/BSP system needs to provide volumes of requests/activations and volumes of adjustments in response.

7.3.4 Architecture Needs

[7.3.4-01] Virtual bicycle detection data collected and transmitted to a cloud-based server needs to relay the detection information to the Town's central signal system which then issues a command to the traffic controller.
[7.3.4-02] The VBD/BSP system needs to fully function in a computer network environment with various system devices and components potentially residing on different networks, different virtual local area networks (VLANs), and between network security devices (i.e., firewall).

[7.3.4-03] The VBD/BSP system needs to be operated and monitored at the workstation of Town staff, and on any mobile computing device connected to the Town's computer network.

[7.3.4-04] The VBD/BSP system needs to allow monitoring access by authorized users via secured VPN.

[7.3.4-05] The VBD/BSP system needs to use a standard database that allows access and assign rights to multiple levels of user access (i.e. admin, user).

[7.3.4-06] The VBD/BSP system needs to be capable of being installed and fully functional in a virtual server environment.

7.3.5 Failure Response Needs

[7.3.5-01] The VBD/BSP system needs to provide all system failures and alarms through an interface with the signal system.

7.3.6 Maintenance Needs

[7.3.6-01] Comprehensive training needs to be provided to engineering staff and signal maintenance staff on the system's hardware and firmware programming, operation, and configuration.

8 SYSTEM OVERVIEW

8.1 ATCS System Overview

This section describes the envisioned adaptive system to be deployed by the Town of Los Gatos. Key elements include system size and grouping, operational objective, fallback operation, crossing routes and adjacent systems, operation access, coordination and controller operation, and organizations involved will be discussed.

8.1.1 Sizing and Grouping

The Town of Los Gatos plans to implement adaptive control at thirteen signalized intersections as part of this project. This Concept of Operations defines the envisioned system for adaptive control operation at all traffic signals in the City. The system will allow the operator to define individual group(s) of signals for adaptive operation. . Groups of signals may range from a single signal up to any number of signals defined by the operator that may include all traffic signals in the Town. Under day-to-day operation, a typical group size would range from three to 20 signals. Group definitions will be flexible and allow for individual signals to belong to one or more groups. This will provide the operator with flexibility to define signal groups by either time-of-day or day-of-week to suit the varying traffic characteristics or conditions along any specific route or area.

8.1.2 Operational Objective

The first objective of the adaptive system will be to provide for smooth flow along an arterial, minimizing the number of stops and delay experienced by users along the coordinated route. This objective includes providing progression along both travel directions. Simply progressing traffic in the peak direction, at the expense of the opposite travel direction, would not be acceptable at all times. Part of this coordination objective will be to maximize the throughput along the coordinated route with a reasonable tradeoff of increasing delay for side streets and protected left turns, such that delays experienced by traffic on the coordinated route will be balanced with delays experienced by side-street and protected left turn traffic.

The second objective of the adaptive system will be to manage the lengths of queues at specific locations within the signal group, so that long queues do not block upstream intersections or otherwise reduce the capacity available to adjacent movements. During this objective, the goal of managing queues and clearing queues, especially for protected left-turn movements, may override the first objective of maximizing the throughput along the coordinated route. This may require controlling phase durations so that the size of platoons entering a downstream block does not exceed the storage length if the platoon will be stopped. This objective applies for specific situations, events, or areas of the town where queue management and minimizing the delay experienced by turning movements outweigh the need to provide progression along the main coordinate route. In particular, this objective would apply to signalized locations near schools during the school start/dismissal periods and in areas where there is a concentration of retail land use during peak shopping times.

The third objective of the adaptive system will be to manage the throughput of traffic volumes along an arterial, minimizing the impact of congestion for internal intersections along the arterial. This objective includes regulating the amount of traffic entering the arterial corridor at endpoint traffic signals with a tradeoff of increased delay and queuing at the endpoint traffic signals, but with reduced delay and queuing at internal traffic signals. Similar to the second objective, the goal of managing corridor throughput may override the first objective of maximizing the throughput along the coordinated route. This may require controlling phase durations at strategic signal locations so that the size of platoons entering the corridor does not exceed the traffic handling capacity of internal signals along the corridor. This objective applies for specific situations, events, or areas of the town where traffic volume management and minimizing the delay experienced by

internal intersections outweigh the need to provide progression along the main coordinated route.

The system or the operator will be able to select the appropriate objective depending on the current traffic conditions. For example, during commute peaks, the primary objective may be to maximize throughput and provide smooth flow on the coordinated route. Then during school start/dismissal periods or during weekends when there is significant cut through traffic bypassing the freeways to and from Santa Cruz, the objective may be to manage queues, prioritize pedestrian service, and balance delay for side-street and left turn traffic compared to the main street movements. The operator will be able to define the appropriate operational objective for each group of signals. For example, near a school or a concentrated retail area with heavy turning movements, the queue management strategy may be specified, while on an arterial with long signal spacing, the strategy to smooth flow and maximize throughput may be specified. Within these operational objectives, the adaptive system will change its operation to accommodate the rise and fall of traffic volumes throughout the day and the changing patterns of flow throughout the day and week.

8.1.3 Fallback Operation

The system will have a fallback state that allows coordination using a common cycle length for all signals within a coordinated group, similar to existing TOD coordinated operation when a complete system failure occurs, such as failure of the adaptive system server or a complete loss of communications between the adaptive server and all signals in a group.

In the event that failures are limited or isolated (i.e., detection failure for a specific movement at one or more location, communications failure at one particular location, etc.), the operator will have the option to continue running adaptive control based on historical data. If the isolated failure is at a location at the end or edge of a signal group, the system will have the option to remove (manually by the operator or automatically by the system) the isolated signal from the group and to operate in a backup mode (i.e., Free, TOD, etc.), while the remainder of the group continues to operate normally under adaptive control.

8.1.4 Crossing Routes and Adjacent Systems

The system will provide for coordination to occur on more than one coordinated route, such as two crossing arterials or a grid network of signals. At locations where coordination is to occur along two crossing arterials, the system will be able to maintain coordination along both routes in both directions by designating multiple phases (up to four) as the coordinated phase. There are no adjacent systems that the proposed adaptive system needs to interact with.

8.1.5 Operator Access

Town of Los Gatos transportation engineering and support staff will be assigned different levels of authority and access to equipment for which they are authorized, based on their roles and responsibilities. This will allow them to control, view, monitor, and analyze the operation of the system as appropriate.

8.1.6 Complex Coordination and Controller Operation

The City will use the following coordination and controller features:

- The ability to repeat a phase if needed, such as running a left turn phase before and after its opposing through movement;
- The ability to operate different phase sequences based on different traffic conditions or by time-of-day;
- The ability to omit a phase based on user input;
- The ability to operate flashing yellow for protected/permissive operation;
- The ability to allow the coordinated phase to terminate early if the coordinated phase gaps-out;

- The ability to display a pedestrian phase ahead of a corresponding signal phase (leading pedestrian interval) by a user-specified amount of time; and
- The ability to designate a phase split shorter than the minimum time required to serve a pedestrian movement (i.e. stop-in-walk).

8.1.7 Organizations Involved

The Town of Los Gatos will own, operate and maintain the adaptive system.

8.2 ATSPM System Overview

8.2.1 System Scope

The Automated Traffic Signal Performance Measures ATSPM system will be implemented to measure the performance of the thirteen signalized intersections in the project area listed below:

- Alberto Way & Los Gatos-Saratoga Road
- Los Gatos Boulevard & Los Gatos-Saratoga Road
- Los Gatos Boulevard & Caldwell-Kennedy Road
- Los Gatos Boulevard & Nino Avenue
- Los Gatos Boulevard & Roberts Road-Shannon Road
- Blossom Hill Road & Roberts Road
- Los Gatos Boulevard & Blossom Hill Road
- Blossom Hill Road & Camella Terrace
- Blossom Hill Road & Cherry Blossom Lane
- Los Gatos Boulevard & LG Almaden Road
- Los Gatos Boulevard & Village Square
- Los Gatos Boulevard & Gateway-Garden Lane
- Los Gatos Boulevard & Lark Avenue

The ATSPM system will be managed via a server located at the Town Engineering Office or located off-site. Primarily the system will be operating automatically without the requirement for user intervention. The ATSPM system will consist of hardware and software necessary to collect, store, and analyze the high-resolution controller data from the traffic controllers. The data analysis will be done for the purpose of measuring the performance of each signalized intersection individually and the corridor in general.

8.2.2 System Users

The ATSPM system will be used by three different groups of users: Operators, Managers and Users. Operators are those who are involved in the operation of the system such as the Town Traffic Engineer and Technicians. Managers are those responsible for the strategic direction of the system and include the Town Traffic Engineer and senior Town management. Users are those that receive the benefit from the system but do not actively operate the system.

8.2.3 System Interfaces

At a minimum, the ATSPM system must integrate with traffic controller firmware that generates high resolution data as well as the adaptive system.

8.2.4 System Capabilities

The ATSPM system will provide traffic signal performance monitoring function with the following capabilities:

- Collect, store, and present the data in visualizations that can be quickly and easily comprehended.
- Provide historical analysis of the data
- Provide analysis of the data based on user-specified date and time periods
- Provide data analysis on measures of effectiveness such as phase failure, green utilization, and arrivals on green.
- Identify changes in operational conditions over time at an individual signal and along corridors.
- Provide recommended signal timing updates based on monitoring of user-selected parameters.
- Provide alerts, summary dashboards, or other means of information dissemination that can be used to improve signal maintenance and operations practices.
- Monitor the performance of all Town traffic signals that are SPM-capable.

8.2.5 System Goals and Objectives

The goals and objectives of the ATSPM system are to improve traffic signal operations by applying advanced technologies to better measure and analyze vehicular, bicycle and pedestrian movements, with the goal of improving travel time, reliability and safety, ease traffic congestion and delays and reduce fuel consumption and emissions. The ATSPM project seeks to provide a systematic and periodic signal timing accuracy check for improving traffic flow that will benefit all modes of traffic.

The project will focus on addressing traffic around schools and improving multimodal safety and traffic operations. This system will help achieve the following goals:

- Improve travel time and travel time reliability not only for autos, but also for bicycles and pedestrians;
- Improved traffic operations by providing a tool that allows Town staff to address problems before they become citizen complaints;
- Improve safety of motorists, bicyclists, pedestrians and emergency vehicles;
- Reduce vehicle emissions and fuel consumption;
- Test new technology and develop the knowledge base on multimodal safety and operations improvements;
- Help address the traffic congestion issue on Los Gatos Boulevard.

8.2.6 System Architecture

From a physical perspective, connectivity between the ATSPM server and traffic controllers will be accomplished through an Ethernet network deployed during Project 0. Traffic controllers equipped with the appropriate hardware and software will generate high-resolution controller data that will be sent to the ATSPM server located at the Town Engineering Office or remote site. **Figure 4** illustrates the architecture at a high level. An application interface on a workstation will connect to the ATSPM server to retrieve, display, and analyze the data.

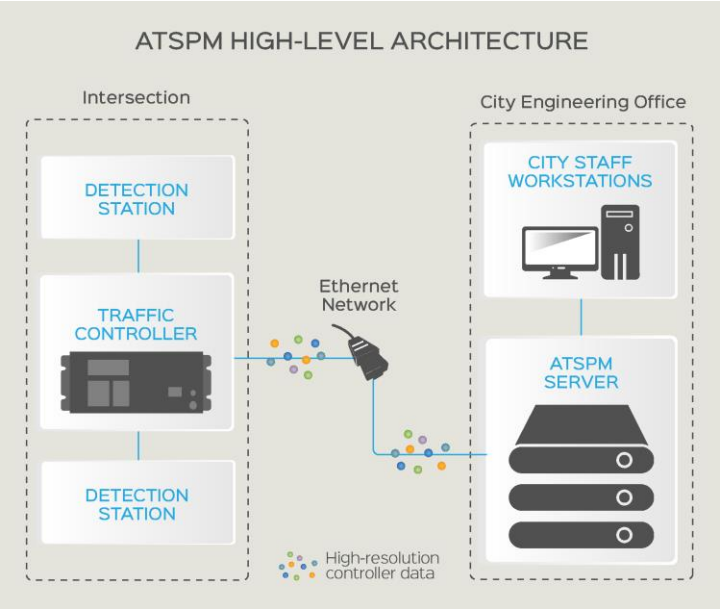


Figure 4 – Town of Los Gatos High-Level ATSPM System Architecture

8.3 VBD/BSP System Overview

With Virtual Bicycle Detection, instead of installing physical detection infrastructure, bicyclists are detected with an application running on their smartphone.

8.3.1 System Scope

The VBD/BSP system will outfit bicyclists with an app running on their smartphone. The smartphone app would run in the background and sense when the user is riding a bicycle. When the bicycle reaches a predetermined trigger point upstream of a traffic signal, the app sends a message to a server located in the cloud. The cloud server relays the detection information to the Town's central signal system which then places a detection call to the local controller to request a green or hold a green (to prevent the traffic signal from "gapping out") for a particular approach phase. The VBD/BSP system will operate at nine signalized intersections on Los Gatos Boulevard between Lark Avenue and Los Gatos-Saratoga Road including:

- Los Gatos Boulevard & Saratoga Road
- Los Gatos Boulevard & Caldwell-Kennedy Road
- Los Gatos Boulevard & Nino Avenue
- Los Gatos Boulevard & Roberts Road-Shannon Road
- Los Gatos Boulevard & Blossom Hill Road
- Los Gatos Boulevard & LG Almaden Road
- Los Gatos Boulevard & Village Square
- Los Gatos Boulevard & Gateway-Garden Lane
- Los Gatos Boulevard & Lark Avenue

8.3.2 System Users

The VBD/BSP system will be used by three different groups of users: Operators, Managers and Users.

Operators are those who are involved in the operation of the system such as the Town Traffic Engineer and Los Gatos Safe Routes to School staff who will work with the students using the smartphone app. Managers are those responsible for the strategic direction of the system and include the Town Traffic Engineer and senior Town management. Users are those that receive the benefit from the system but do not actively operate the system and include the public.

8.3.3 System Interfaces

At a minimum, the VBD/BSP system must integrate with central traffic control system managing the project intersections. In this case, all traffic signals will be operating the ATCS system.

8.3.4 System Capabilities

The VBD/BSP system will provide the following capabilities:

- Suggest bicycle routes to users.
- Automatically detecting, based on speed, whether or not a user is bicycling, driving or walking.
- Provide bicycle counts to Town staff for use in further analysis.
- Discriminate and respond differently to the presence of multiple bicyclists than from a single bicyclist.
- Adjust the detection range/distance from an intersection.
- Provide reliable and accurate detection including location, direction, speed and time stamp.
- Integrate with signal controllers and central signal system for providing real-time detection input to the signal system.
- Allow operator-adjusted detection zones approaching signalized intersections, which could be such as half street, block, by lane, and/or by distance.
- Provide analysis of bicycle experience by routes and by selected intersections.
- Display bicycle paths crossing intersections on aerial photos by time and day.
- Allow operator-defined bicycle user groups and routes.
- Remove user personal information.
- Send an alarm to the ATCS when no bicycles are detected on a school day.
- Transmit the detection data to the ATCS in a compatible format.

8.3.5 System Goals and Objectives

The project will focus on addressing traffic around schools and improving multimodal safety and traffic operations. This system will help achieve the following goals:

- Improve travel time and travel time reliability for bicycles;
- Improve safety of motorists and bicyclists;
- Test new technology and develop the knowledge base on multimodal safety and operations improvements

8.3.6 System Architecture

Figure 3 (shown in Section 5) of this document illustrates the VBD/BSP system architecture.

9 OPERATIONAL ENVIRONMENT

9.1 Adaptive Traffic Control System (ATCS)

The ATCS will be operated and monitored from workstations at the desks of transportation and support staff, on mobile computing devices in various Town buildings, in the field, and from remote locations. The central server equipment will be housed on an existing equipment rack in the Town's datacenter alongside other computing and networking devices. The central server will be a stand-alone commercial-off-the-shelf standard platform rack mount server and be able to be replaced independently from the adaptive software. Town transportation staff will have the ability to log in to the system from remote locations via secured VPN over the Internet and have full functionality consistent with their access rights.

The Town has a combination of Econolite ASC/2S-2100 and ASC/3-2100 controllers, however, Project 0 will upgrade these to a new controller platform capable of supporting Ethernet communications. The City also uses video detection as the standard detection technology and prefers to use this same technology for the adaptive system. However, the City will consider the use of other detection technology, to supplement the use of existing video, if appropriate.

The Town's transportation engineering staff are experienced in setting up, operating, and managing their existing central signal system, however, the Town's staff are limited and extremely busy and strongly desire an intuitive, easy to use interface and a system that is low maintenance. Day-to-day operations and management of the adaptive system will be the responsibility of the Town's transportation staff. They will require training specific to the adaptive system to set-up, fine-tune, and operate all aspects of the system. Maintenance of any field equipment deployed as part of the adaptive system, along with all other existing traffic signal infrastructure, will be performed by the Town's signal maintenance contractor.

The Town expects to operate the adaptive system with the latest software for a period of ten years assuming system performance continues to meet the Town's needs. The Town will seek technical support from the system vendor in using the adaptive software for three years in which the vendor will provide support via a combination of phone, on-site visits, and remote log-in to the adaptive server. The Town expects warranty and maintenance of any vendor-supplied software, parts, and equipment for a minimum of three years will be included in the purchase price. Software maintenance will include any updates (software patches, iterative revisions, and new versions) to be included in the purchase price for a minimum of three years.

9.2 Automated Traffic Signal Performance Measures (ATSPM)

The Town of Los Gatos intends to establish similar operational environments for the ATCS and ATSPM systems. The ATSPM will be operated and monitored from workstations at the desks of transportation and support staff, on mobile computing devices in various Town buildings, in the field, and from remote locations. The central server equipment will be housed on an existing equipment rack in the Town's datacenter alongside other computing and networking devices. The central server will be a stand-alone commercial-off-the-shelf standard platform rack mount server and be able to be replaced independently from the ATSPM software. If possible, the Town prefers the ATCS and ATSPM software to operate on the same server hardware. Town transportation staff will have the ability to log in to the system from remote locations via secured VPN over the Internet and have full functionality consistent with their access rights.

While the Town's transportation engineering staff is experienced in setting up, operating, and managing their existing central signal system, this is not the case with an ATSPM system. The Town's staff are extremely busy and strongly desire an intuitive, easy to use interface and a system that is low maintenance. Day-to-day operations and management of the ATSPM system will be the responsibility of the Town's transportation staff. They will require training specific to the ATSPM system to set-up, fine-tune, and operate all aspects of the system.

The Town expects to operate the ATSPM system with the latest software for a period of ten years assuming system performance continues to meet the Town's needs. The Town will seek technical support from the system vendor in using the adaptive software for three years in which the vendor will provide support via a combination of phone, on-site visits, and remote log-in to the adaptive server. The Town expects warranty and maintenance of any vendor-supplied software, parts, and equipment for a minimum of three years will be included in the purchase price. Software maintenance will include any updates (software patches, iterative revisions, and new versions) to be included in the purchase price for a minimum of three years.

9.3 Virtual Bicycle Detection/Bicycle Signal Priority (VBD/BSP)

The VBD/BSP system will be operated and monitored from workstations at the desks of transportation and support staff, on mobile computing devices in various Town buildings, in the field, and from remote locations. The central server equipment will be housed in the "cloud" and administered by the system vendor. Town transportation staff will have the ability to log in to the system from remote locations over the Internet and have full functionality consistent with their access rights.

The Town's transportation engineering staff will require training specific to the VBD/BSP system to operate all aspects of the system after initial set-up and fine-tuning by the system vendor. Maintenance of any field equipment deployed as part of the VBD/BSP system, along with all other existing traffic signal infrastructure, will be performed by the Town's signal maintenance contractor.

The Town expects to operate the VBD/BSP system with the latest software for a period of ten years assuming system performance continues to meet the Town's needs. The Town will seek technical support from the system vendor in using the VBD/BSP software for three years in which the vendor will provide support via a combination of phone, on-site visits, and remote log-in to the adaptive server. The Town expects warranty and maintenance of any vendor-supplied software, parts, and equipment for a minimum of three years will be included in the purchase price. Software maintenance will include any updates (software patches, iterative revisions, and new versions) to be included in the purchase price for a minimum of three years.

10 SUPPORT ENVIRONMENT

This chapter describes the support environment for the three systems. Key elements include identifying institutions and stakeholders, facilities, system architecture constraints, utilities, equipment, computing hardware and software, personnel, and other support needs will be discussed.

10.1 Adaptive Traffic Control System (ATCS)

Existing stakeholders of the systems includes the Town of Los Gatos and the Metropolitan Transportation Commission (MTC). The Town of Los Gatos will be the owner of the adaptive system to be deployed and will

be responsible for operation, management, and maintenance of the system. MTC is the funding agency and program manager of this initiative and is responsible for overall program oversight to ensure project delivery and success.

The Town of Los Gatos has an equipment room at the Town Engineering Office where transportation staff are located. This same building also houses the existing central signal system and is fully equipped with equipment racks and workstations. It is anticipated that Project 0 will provide networking equipment to support the ATCS.

The adaptive server will reside on a private network dedicated to transportation and be separated from the Town's IT network through the use of a firewall. This private network will support the other MTC IDEA Category #2 elements along with any Ethernet capable elements associated with the existing signal infrastructure. The Town's IT Department will provide support and system management of the firewall so that so Town staff operators and vendors will have VPN access to the servers. The communications media available for use by the adaptive system will be provided through Project 0 and include the introduction of Ethernet communications protocols.

The Town has all required equipment and resources to support the existing traffic signal system. Any additional test equipment required to support the adaptive system will be determined by the system vendor. The vendor will specify any needed hardware and software to support the adaptive system as well as any needed field modifications (i.e., detection). The vendor will be responsible for identifying and providing any hardware needed to support the adaptive system, such as servers and data storage subject to Town approval. Since the Town does not currently utilize Ethernet communications for transportation purposes, it is anticipated that new network switches, network routers and a firewall will be needed to support the adaptive system in conjunction with existing workstations, monitors, printers, equipment racks, and power supplies. Maintenance and repair of the computing equipment and adaptive software is the responsibility of transportation staff.

The adaptive system will be operated by existing transportation staff that currently operate the existing central signal system. There is one transportation engineer assigned to support the adaptive system however this staff member has a number of other responsibilities. The transportation engineer is available during normal business hours with after-hours support provided by the Town's signal maintenance contractor. Training of transportation engineering staff and staff from the Town's signal maintenance contractor will be required to be provided by the system vendor during and after the installation of the adaptive system. Backup of the adaptive system database will be incorporated into the work flow and follow the same existing routine of backing up the signal system database.

To ensure optimal operation of the system, the system vendor will provide transportation staff with bi-weekly confirmation noting system operations confirming all system components are properly functioning, including verification of two-way communications, system software and hardware, local controller, and detection health. The system vendor will also monitor system event logs, alarms, notifications, etc. on the health of system. The system vendor will prepare a list of action items, if needed, to address any system deficiencies or component failures to return the system to a state of good operation. This support shall be provided during the initial deployment and be included in the ongoing operations and maintenance support period.

10.2 Automated Traffic Signal Performance Measures (ATSPM)

Existing stakeholders of the systems includes the Town of Los Gatos and the Metropolitan Transportation Commission (MTC). The Town of Los Gatos will be the owner of the ATSPM system to be deployed and will be responsible for operation, management, and maintenance of the system. MTC is the funding agency and program manager of this initiative and is responsible for overall program oversight to ensure project delivery and success.

The Town of Los Gatos has an equipment room at the Town Engineering Office where transportation staff are located. This same building also houses the existing central signal system and is fully equipped with equipment racks and workstations. It is anticipated that Project 0 will provide networking equipment to support the ATSPM.

If a locally housed server solution is provided, then the ATSPM server will reside on a private network dedicated to ITS and be separated from the Town's IT network through the use of a firewall. This private network will support the other MTC IDEA Category #2 elements along with any Ethernet capable elements associated with the existing signal infrastructure. The Town's IT Department will provide support and system management of the firewall so that so Town staff operators and the selected vendor will have VPN access to the servers. The communications media available for use by the adaptive system will be provided through Project 0 and include the introduction of Ethernet communications protocols.

The Town has all required equipment and resources to support the existing traffic signal system. Any additional test equipment required to support the ATSPM system will be determined by the system vendor. The vendor will specify any needed hardware and software to support the ATSPM system as well as any needed field modifications (i.e., detection). The vendor will be responsible for identifying and providing any hardware needed to support the ATSPM system, such as servers and data storage. Since the Town does not currently utilize Ethernet communications for ITS purposes, it is anticipated that new network switches, network routers and a firewall will be needed to support the ATSPM system in conjunction with existing workstations, monitors, printers, equipment racks, and power supplies. Maintenance and repair of the computing equipment and ATSPM software is the responsibility of transportation staff.

The ATSPM system will be operated by existing transportation staff that currently operate the existing central signal system. There is one transportation engineer assigned to support the adaptive system however this staff member has a number of other responsibilities. The transportation engineer is available during normal business hours with after-hours support provided by the Town's signal maintenance contractor. Training of transportation engineering staff and staff from the Town's signal maintenance contractor will be required to be provided by the system vendor during and after the installation of the ATSPM system. Backup of the ATSPM system database will be incorporated into the work flow and follow the same existing routine of backing up the signal system database.

10.3 Virtual Bicycle Detection/Bicycle Signal Priority (VBD/BSP)

Existing stakeholders of the systems includes the Town of Los Gatos, Los Gatos Safe Routes to School (LGSR2S), and the Metropolitan Transportation Commission (MTC). The Town of Los Gatos will be the owner of the VBD/BSP system to be deployed and will be responsible for operation, management, and maintenance of the system. LGSR2S will be responsible for user outreach and training. MTC is the funding agency and program manager of this initiative and is responsible for overall program oversight to ensure project delivery and success.

The VBD/BSP system will be operated and monitored from workstations at the desks of transportation and support staff, on mobile computing devices in various Town buildings, in the field, and from remote locations. The central server equipment will be housed in the "cloud" and administered by the system vendor. As such the system vendor will be responsible for maintaining the VBD/BSP application's cloud infrastructure

The VBD/BSP system will be operated by existing transportation staff that currently operate the existing central signal system. There is one transportation engineer assigned to support the system however this staff member has a number of other responsibilities. The transportation engineer is available during normal business hours with after-hours support provided by the Town's signal maintenance contractor. Training of transportation engineering staff and staff from the Town's signal maintenance contractor will be required to be provided by the system vendor during and after the installation of the VBD/BSP system.

To ensure optimal operation of the system, the system vendor will provide transportation staff with bi-weekly confirmation noting system operations confirming all system components are properly functioning, including verification of two-way communications, system software and hardware. The system vendor will also monitor system event logs, alarms, notifications, etc. on the health of system. The system vendor will prepare a list of action items, if needed, to address any system deficiencies or component failures to return the system to a state of good operation.

11 OPERATIONAL SCENARIOS

11.1 ATCS Operational Scenarios

This section presents a number operational scenarios to describe how the adaptive system is expected to operate to meet user needs. The envisioned adaptive system is expected to be able to manage the following operational scenarios for both the current project corridor and potential future expansion of the system to other corridors in the Town of Los Gatos:

- Peak Period Operation
- Midday Operation
- School Start and Dismissal
- Fault Condition
- Unexpected surge or traffic spike

11.1.1 Peak Period Operation

During typical traffic conditions, the adaptive system will provide smooth flow and optimize the progression bandwidth in the peak direction, while at the same time provide progression for the non-peak direction, though the degree of progression provided may be to a lesser extent (i.e., smaller bandwidth, one or more stops) compared to the peak direction. The ATCS system will achieve this at the expense of increased delay for side-street and protected left turn traffic, but not to the extent that phase failures occur or an unreasonable delay is experienced. The adaptive system will operate at a cycle length optimized for the prevailing traffic conditions, and increase the cycle length as the peak period builds and decrease the cycle length as the peak period dissipates.

During non-typical traffic conditions, such as a traffic surge event, the adaptive system will regulate the

throughput of traffic along Los Gatos Boulevard. This will be achieved by managing the lengths of queues at specific locations (such as the end points) within the signal group, so that long queues do not form and block upstream intersections or otherwise reduce the capacity available to adjacent movements at intersections within the corridor. During this operation, the goal of managing throughput along the corridor may override the operational goal during typical traffic conditions of maximizing the throughput along the coordinated route. This may require controlling phase durations so that the size of platoons entering a downstream block does not exceed the storage length if the platoon will be stopped. This operation applies to specific situations or events, where queue management and minimizing the delay experienced by turning movements outweigh the need to provide progression along the main coordinated route.

The system would utilize the following signal timing strategies:

- At all intersections, select phase times that equitably serve all movements and eliminate phase failures;
- At critical intersections, select phase times that eliminates queue overflow in left turn pockets;
- For intersections where the left turn demand is high, the system will allow for the left turn phase to be served twice per cycle to avoid queue build up;
- At all intersections, provide green times on the coordinated phases to minimize stops for travel along Los Gatos Boulevard;
- Provide the ability to operate the entire corridor as one single group, or be broken up into two or more groups, based on prevailing traffic conditions and the required cycle lengths required on certain portions of the corridor compared to another; and
- Gateway management function to regulate the traffic volume in the corridor.

11.1.2 Midday Operation

During the midday period for typical traffic conditions, traffic volumes are much lighter compared to the peak periods with directional flow more balanced. During this time, the system will operate at the lowest cycle length possible, subject to prevailing traffic conditions, to ensure equitable distribution of green time to all phases while providing coordination. Unlike the peak periods, where the primary objective is to provide smooth flow and maximize throughput on Los Gatos Boulevard, the primary objective during the midday will be to ensure that all movements at all intersections have equitable distribution of green time, while still providing a reasonable progression along Los Gatos Boulevard in both directions. As a result, it would be acceptable to provide smaller progression bandwidths with potentially the need to stop once or twice when traveling through the project corridor.

During non-typical traffic conditions during the midday, such as a traffic surge event, the adaptive system will operate as described above for the peak period to regulate the throughput of traffic along Los Gatos Boulevard.

11.1.3 School Start and Dismissal

During the school start and dismissal periods, the system will manage queues and provide adequate phase times to individual movements that enters and exits the schools. In particular, left turns and side street traffic at signalized intersections adjacent to the schools experience a significant spike in activity associated with vehicle access to and from the schools. The system will provide adequate phase time for peak movements to minimize queuing and phase failures.

The morning school start period coincides with a portion of the morning peak commute period and results in a sharp spike in traffic volumes. The system will recognize the onset of this event and change the operational strategy from peak period (smooth flow and maximizing throughput) to queue management and minimizing phase failures. The system will then return to peak period operation when this event is over. The afternoon school dismissal period typically occurs during a portion of the midday period prior to the evening peak period. The system will recognize the onset of this event and change the operational strategy from midday operation to queue management and minimizing phase failures, and then return to midday operation when this event is over.

During the school start and dismissal periods, pedestrian volume and activity are high, especially at intersections directly adjacent to the schools. During this time, the Town could choose to operate longer pedestrian times (Walk and Flashing Don't Walk) compared to other periods of the day to accommodate the higher pedestrian activity. During this period, there are sufficient pedestrians present at a number of intersections that the cycle length will need to accommodate pedestrians on most phases in almost every cycle.

11.1.4 Fault Conditions

If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to a pre-defined mode of operation based on a time-of-day (TOD) table residing in each signal controller. This may include either time-based coordination or free operation depending on the time-of-day and/or day-of-week in which the communication failure occurs. However, if the communication failure occurs at the endpoint of a corridor or at the edge of a network, the system will allow the user to remove the failed intersection (either manually or automatically through a predefined set of parameters) from the adaptive control group and continue to operate the remainder of the group under adaptive control.

The system will recognize a detector failure and take appropriate action to accommodate the missing data. For a detector that influences adaptive operation, the system will use data from an alternate detector (such as an adjacent lane detector or another upstream/downstream detector) or use historical data from an archive of historical detector data. If the number of detector failures within an adaptive control group exceeds a user-specified threshold, the system will automatically cease adaptive operation and revert to a pre-defined mode of operation based on a TOD table similar to that described for a communications failure. Detector failures not only occur when a detector is broken and ceases to function, but it may also fail by reporting erroneous information (i.e., excessively high or low occupancy and count data), which would affect the operation of the adaptive system. The system will allow a user to set thresholds for individual detectors that will designate a detector as failed when erroneous data is reported by the detector.

In the event that the adaptive system fails (i.e., server fails), all signals under adaptive control will revert to a pre-defined mode of operation based on a TOD table similar to that described for a communications failure.

11.2 ATSPM Operational Scenarios

This section presents a number operational scenarios to describe how the ATSPM system is expected to operate to meet user needs. The envisioned ATSPM system is expected to be able to assist Town staff in analyzing the Town's traffic operations in a variety of ways including:

- Inoperative Push Button Detection

- Phase Left on Max Recall After Troubleshooting
- Signal Coordination Improved Because of a Timing Change
- Platoons of Vehicles Arrive Too Late
- Amount of Time Vehicles Wait on Side Street with No Traffic on the Main Street
- Frequency of Red-Light Runners
- Peak Period Operation

11.2.1 Inoperative Push Button Detection

False pedestrian calls degrade signal operations by unnecessarily allocating time to non-existent pedestrians. This affects the amount of time the vehicle phase will run. Phases that normally gap out in the absence of a pedestrian call would run for the entire allotted time. This problem can go unnoticed because visual observation is typically needed. High resolution controller data includes the time of every pedestrian call by phase. When Town Traffic Engineering staff receive complaints from the public about excessive delay at an intersection, the SPM tool can be utilized to check for constant pedestrian calls during the late evening and early morning hours would indicate a locked push button which is easily fixed once identified.

11.2.2 Phase Left on Max Recall after Troubleshooting

ATSPM software can alert you to problems inadvertently caused while working on a controller. A common practice when troubleshooting operational or mechanical problems at an intersection is to place a phase or several phases in recall in order to cycle the controller.

Recall makes the controller place a call to a phase regardless of any detector-actuated calls for the phase. There are four types of recall: vehicle recall, pedestrian recall, maximum recall, and soft recall. Forgetting that the controller is in recall after troubleshooting will not cause an alarm condition in a central signal system because the intersection is acting as programmed, just not as expected. Without ATSPM, this situation may be overlooked for quite some time.

Using high-resolution controller data, SPM software charts the phase durations and terminations and will show the resulting problems such as a phase maxing out consistently during off-peak hours. Once identified, this operational issue can easily be resolved.

11.2.3 Signal Coordination Improved Because of a Timing Change

Historically, a typical before-and-after study for traffic signal timing would be performed by a driver equipped with GPS, driving the timed corridor for several runs during the peak periods of a typical day. Success in retiming the corridor would be measured by seeing improvements in travel times during the same peak hours.

Collecting data in this manner is limited to a single driver and can be affected by things like roadway conditions and at what point in the system the driver enters the green band. On the other hand, using ATSPM software, traffic engineers can evaluate arrivals on green for different time periods over different days to determine how vehicles in the corridor are affected by timing changes. ATSPM software uses high-resolution data such as timing plan parameter change and phase state changes. Using advance detectors, traffic engineers can also obtain average speed/travel time data to evaluate before-and-after timing conditions.

11.2.4 Platoons of Vehicles Arrive Too Late

The important components in building a coordination plan include cycle length, splits, left-turn phasing, and offsets. The offset is what locks in the time, relative to the rest of the system, that the coordinated phase will

remain green. This is what allows for the ideal situation where people leaving from one intersection arrive at the next intersection while the traffic signal is still green. The two things normally taken into consideration when setting an offset are the distance between intersections and the speed of traffic.

This is simpler said than done. Because variables such as the traffic speed change and vehicles are driving in two directions along the arterial, the optimal offset can sometimes be difficult to determine. Vehicle arrivals at an intersection in a particular signal phase can be charted in a way that helps traffic engineers determine the best offset, allowing more vehicles to arrive at the intersection while the signal is still green. Using the SPM software, the engineer can consistently track when platoons of vehicle arrive at the traffic signal, and make adjustments to the offset to minimize vehicles arriving during the red.

11.3 VBD/BSP Operational Scenario

A 7th grade student living in a neighborhood off of Kennedy Road rides her bike to and from Raymond J. Fisher Middle School every day. Before leaving the house the student activates a VBD/BSP smartphone app and places it in her backpack. Sensing the single student or perhaps a user-selected minimum number of students are traveling at speeds commensurate with a bicycle, the smartphone app passes a trigger point a few hundred feet from the Los Gatos Boulevard/Caldwell Avenue-Kennedy Road traffic signal resulting in the smartphone app sending the trigger information to the cloud. The Traffic Control System (TCS) server receives the information from the cloud and places a detection request to the controller. The student passes through the intersection. This process plays out at every subsequent intersection along Los Gatos Boulevard until the student leaves the project area by turning left towards Raymond J. Fisher Middle School. In the afternoon, this process is reversed as the student travels to her home along the same route.

12 SUMMARY OF IMPACTS

This chapter provides an analysis of the proposed system and the impacts on each of the stakeholders. It is presented from the viewpoint of each, so that they can readily understand and validate how the proposed system will impact their operations.

12.1 Stakeholders

The stakeholders of the project must fully commit to active operation of the ATCS, ATSPM and VBD/BSP systems. The technologies that will be deployed will not achieve the goals of the project unless they are actively used and properly maintained. In order to have the system operate efficiently, stakeholders must collectively commit staff and budget to operate the system.

12.1.1 Town of Los Gatos

This project will provide the Town of Los Gatos with new equipment to operate and maintain. Equipment included that will be under Town control includes:

- Additional vehicle detection
- Additional server hardware located at the Town Engineering Office
- Upgraded traffic controller hardware
- Additional communications infrastructure

During construction the Town will need to approve and permit the construction activities to occur at a rate that will meet the project timetable. The Town must properly fund the Operation and Maintenance (O&M)

cost. Without the O&M funding none of the three systems will be able to operate properly.

12.1.2 Los Gatos Safe Routes to School

This project will provide students with a smartphone app that will function as part of the VBD/BSP system. Los Gatos Safe Routes to School staff must commit to educating students and parents alike on all aspects of the program in order for the VBD/BSP to operate in an efficient and safe manner.

12.1.3 Metropolitan Transportation Commission (MTC)

MTC will help promote the project to other public agencies within the region. In addition, MTC will assess the overall performance of the three systems and assist as needed with implementing institutional agreements.

12.1.4 Private Vehicle Operators and Bicyclists

Private auto and bicycle operators will experience an improved level of service for their travels through the project area.

12.2 System Constraints

The ATCS, ATSPM and VBD/BSP systems must be developed within the time and budget dictated by the terms and conditions of the IDEA program funds. The project should use existing infrastructure as much as feasible.

1999 Harrison Street. Suite 2125
Oakland, CA 94612-3520

iteris.com

© 2018 Iteris, Inc. All rights reserved.

Innovating Through Informatics™