Appendix E

TRANSIT SIGNAL TECHNOLOGY IMPLEMENTATION GUIDANCE

Fall 2020

ALAMEDA
County Transportation
Commission

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DRAFT MEMORANDUM

Date: August 24, 2020

Project #: 20921.9

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CC:

From: Laurence Lewis

Project: E. 14th St./ Mission Blvd. and Fremont Blvd. Multimodal Corridor Project

Subject: Implementation Guidance for Traffic Signal Technology Improvements

INTRODUCTION AND BACKGROUND

This memorandum describes implementation considerations for traffic signal system improvements recommended as part of the E. 14th St./Mission Blvd. and Fremont Blvd. Multimodal Corridor Project (Project). Traffic signal system improvements are included as part of the near-term recommendations to improve traffic signal progression along corridor and to improve the safety of pedestrians and bicyclists. Traffic signal system improvements are also included as part of the long-term recommendations for infrastructure to support connected vehicle technologies. (Transit-related signal improvements are discussed in a separate memorandum.)

The following discussion presents several traffic signal system technologies that were identified to specifically address the Project's goals and needs. These technologies are as follows:

- Advanced traffic controllers and advanced traffic management systems (ATMS)
- Signal communications systems
- Pedestrian detection systems
- Bicycle detection systems
- Next gen traffic operations and management
- Connected vehicle technology

For each technology, an overview discussion is provided along with a feasibility assessment describing how well the technology can meet the goals and gaps. For technology comparison purposes, the technology descriptions include planning level capital costs.

ADVANCED TRAFFIC CONTROLLERS AND ADVANCED TRAFFIC MANAGEMENT SYSTEMS

Technology Overview

The use of modern traffic signal controllers and central system software are two of the most important components of a robust and efficient traffic signal network. When interconnected, Advanced Traffic Controllers (ATC) and an Advanced Traffic Management System (ATMS) are the central nervous system for an agency to operate and manage various field devices. While the ATC controls the functions of a traffic signal, the ATMS provides the ability to monitor and control all traffic elements, including remote management of ATCs.

Advanced Traffic Controllers (ATC)

Advanced Traffic Controllers (ATCs) are based on national open architecture standards and provide flexibility for future software and hardware expandability as new technologies and applications emerge. ATCs have been designed for anticipated future transportation environments where data will be aggregated and processed from real-time detection systems, traffic signals, transit vehicles, dynamic message signs, freight, and freeway systems. Additionally, ATCs will prepare agencies for the integration of future connected vehicle applications, such as providing Signal Phase and Timing (SPaT) data to vehicles.

Advanced Traffic Management System (ATMS)

An ATMS is a central system solution that allows local agency transportation staff to operate and control field devices from a remote location. An ATMS can serve as the primary interface point for operations staff to manage and monitor traffic signals, communication devices, traffic monitoring stations (e.g., detection stations and closed-circuit television cameras), and traveler information devices.

Key features and capabilities of an ATMS that advance the Project's goals include the following:

- Implementation of corridor-wide operations (e.g., adaptive and traffic responsive signal timing)
- Collecting, processing, and analyzing traffic data (both real-time and historical)
- Automating alerts of traffic disruptions and equipment failures
- Disseminating traveler information via changeable message signs, emails/texts, and websites

Considerations and Feasibility

Advanced Traffic Controllers (ATC)

Per the baseline conditions assessment, only 15 of the over 120 signal controllers along the Project Corridor comply with national ATC standards. (Of these 15 signals, six are located along San Leandro Boulevard, six are located along Fremont Boulevard, and the remaining three are located along Mission

Boulevard in Hayward and Fremont.) It is recommended that all the remaining signalized intersections be converted to ATCs to "future-proof" signals and provide expansion capabilities.

ATCs are available for a variety of platform types and there are versions available for all the signal systems that exist along the Project Corridor. It should be noted that Caltrans' standard signal controllers and software are not compliant with ATC standards. However, Caltrans' controllers do provide most, if not all, the features and functionality of ATC. It is expected that Caltrans will utilize ATC standards in the future, but this has not been confirmed.

For most of the signal controller cabinets along the Project Corridor, ATCs would require minor or no modifications; this is because ATCs are available for multiple cabinet types. (Based on the baseline conditions signal inventory, most of the existing controller cabinets are either Type P or Type 332 cabinets.) However, some older cabinets may need to be replaced to accommodate new controllers and other traffic signal equipment as desired. A more thorough review of the existing controller cabinets will need to be conducted during the project development phase to identify specific improvements that are needed.

Advanced Traffic Management System (ATMS)

It is understood that each jurisdiction operating signals along the Project Corridor has an ATMS, except for the County of Alameda and Caltrans. Since the existing ATMSs were not reviewed to determine the level of functionality and capabilities, the following items should be reviewed and evaluated in future stages of project development:

- The potential capabilities of center-to-center integration to support joint operations and data sharing
- The age and version of the existing ATMS to identify upgrades/replacement required to provide desired corridor functionality (i.e., adaptive traffic signal control, TSP module, etc.)

Implementation Costs

Costs for ATCs and associated software vary depending on the manufacturer, type of controller, and software desired. Controllers typically cost around $4,000-$6,000 each, which includes furnishing and installing as well as software integration. Additional licensing fees may be required for the integration of a signalized intersection into an existing ATMS.

Typical capital costs for the procurement and implementation of an ATMS, assuming no traffic management center buildout, can range from $150,000 to $300,000 depending on the desired functionality and size of the traffic signal network.

SIGNAL COMMUNICATION SYSTEMS

Technology Overview

While ATCs and ATMSs discussed in the earlier section allow for advanced management of individual signals, additional infrastructure improvements are required for data sharing and communication between signals. The following are the three types of media commonly used by public agencies for traffic signal communication systems:

Fiber Optic Cables

Fiber optic cables utilize strands of glass fibers to transmit information using pulses of light. Due to their high bandwidth capabilities, fiber optic cables are the most desired standard communication medium by public agencies. Large-capacity backbone fiber cables will accommodate the deployment of equipment with high data demands (e.g., traffic monitoring video). Extra capacity also provides for alternate uses including, emergency services, connections to neighboring jurisdictions, and use by private telecom companies through a purchase or lease agreement. As an example, the City of Hayward is using its fiber optic cable deployments to expand local broadband infrastructure.

Ethernet-over-Copper (EoC)

The use of twisted-pair copper cables for signal interconnect was the industry standard for public agencies prior to the adoption of fiber optic cable. More recently, public agencies have been converting existing twisted-pair copper systems to Ethernet-over-Copper (EoC). This approach is a cost-effective solution for agencies who already have copper cables in place. EoC has lower bandwidth capabilities compared to fiber systems but is effective for systems with smaller data demands.

Wireless Communications

Wireless based interconnect allows for remote communications without the need for physical infrastructure improvements such as conduit and cabling. Two options for wireless interconnect include wireless radios and cellular modems.

Wireless Radios

Wireless radios operate on licensed or unlicensed bands on the UHF radio spectrum. Wireless radios depend on line-of-sight between antennas and the strength of the wireless connection is impacted by obstructions such as trees. For this reason, wireless radios are best suited for use on straight roadway segments.

Cellular Modems

Cellular modems provide wireless Ethernet communications through either 3G or 4G LTE cellular service. 3G modems are more appropriate for communication to field devices with lower bandwidth needs, such as detection stations and traffic signals without CCTV cameras. Where video streaming is required, 4G LTE modems are best suited to provide reliable service.

Considerations and Feasibility

As identified during the development of the Baseline Conditions Report, just over 60 percent of the signalized intersections along the Project Corridor have existing fiber or copper communications. However, over 50 intersections do not have existing communication. A recommended prioritized approach to establishing communication for the Project Corridor is as follows:

1. Establish signal communications to intersections without any existing communications
    a. Fiber-based communication is the preferred solution due to its robust data bandwidth and long-term expansion capabilities.
    b. Wireless communications (radios or cellular) to be used as an interim solution to interconnect signals until fiber can be established, or when a hardwire solution is not feasible
2. Upgrade existing communications to fiber or Ethernet-based communications
    a. Replacement of existing copper communications with fiber is preferred
    b. If there are funding limitations, establish EoC using existing communication

Additional considerations for signal communication systems include the following:

- **Existing network architecture** – Existing communication networks should be evaluated to determine the appropriate technology recommendations. Wireless and hardwired solutions depend on the size of existing fiber cables, connection points of existing systems, agency preferences, and existing field conditions.
- **Cross jurisdictional sharing** – Coordinated traffic operations across agency or jurisdiction boundaries is enabled through the sharing of communication/data between agencies and establishing connections between ATMS centers.
- **Concurrent corridor infrastructure projects**– Portions of the Project Corridor in Alameda County and Hayward have Complete Streets projects that will start within the next few years. A fiber- based communication network is an ideal candidate for these scenarios. Local jurisdictions can leverage the construction effort by installing conduit and fiber optic cables between individual intersections or along entire sections of the Project Corridor.

Implementation Costs

Typical costs for installing new fiber optic cables and underground infrastructure range from $500,000 to $750,000 per mile. Costs for furnishing and installing a wireless radio installation range from $2,500 to $6,000 per intersection. Typical capital costs for an industrial rated cellular modem are between $1,500 and $3,000 plus a monthly service charge of $50 per month.

PEDESTRIAN DETECTION SYSTEMS

Technology Overview

Passive or automated pedestrian sensors provide better detection of pedestrians at crossings, as they do not require pedestrians to push a button to activate the crosswalk signal. Passive detection systems can also be used to monitor pedestrians traversing a crosswalk and provide better conditions for those with mobility limitations. For example, if the crosswalk is still occupied during the normal end of the "Flashing Don't Walk" sequence, passive detection will sense the pedestrian(s) in the crosswalk, then extend the clearance time to allow the pedestrian to make it to the curb.

A well-designed pedestrian detection system addresses many of the Project's goals, including safety, optimized person trip throughput, and support of future connected vehicle technologies.

No existing passive pedestrian detection systems have been identified along the Project Corridor. Additionally, the baseline conditions assessment indicated that 49 of the 120 signalized intersections lack push button pedestrian detection systems.

Several types of passive pedestrian detection systems exist, as discussed in the following section. Each type has advantages and disadvantages depending on factors such the type of intersection and how the system is installed.

Microwave, Radar, and Infrared

Microwave or radar systems use an antenna to transmit radio waves plus a receiver that detects when pedestrians cause variations in the signal that is reflected. Infrared pedestrian detection systems are similar to microwave-radar systems but use infrared sensors to detect pedestrians. An advantage of these systems is they can be very precise in detecting movement; however, rigid equipment mounting locations and configurations can limit the detection area of some sensors.

Video Detection

Video detection systems have a camera to capture images and a computer that then interprets and processes this data. One advantage of video detection systems is that it is possible to provide detection of multiple transportation modes with a single fish-eye camera. Additionally, specialized software and video processing technologies can analyze the high-resolution data to provide useful metrics such as pedestrian classification and can generate pedestrian crash prediction models. However, additional equipment may be required to accommodate the transmission, storage, and analysis of the video that is collected, especially with higher resolution video footage.

Piezoelectric/Pressure Sensors

Piezoelectric or pressure sensors work by detecting when pressure is applied; they are placed under a mat or detectable surface and are activated when a pedestrian is standing on the surface. An advantage of piezoelectric sensors is that the detection zone can be customized by arranging the pressure plates into different configurations. However, once installed, modifying or moving the detection zone can be difficult.

RFID and Bluetooth Systems

Radio frequency identification (RFID) and Bluetooth® wireless detection systems both utilize devices carried by users. RFID systems consist of tags to label objects and readers that can read the labels. RFID tags are carried by users while a tag reader is positioned near the pedestrian crosswalk. When detected, the user's RFID tag identifies them as a user that needs additional time to cross safely. Passive RFID tags can be carried, retrofitted into canes used by the sight impaired, or incorporated into a guide dog's harnesses.

Bluetooth® wireless communications technology permits the intersection to sense a pedestrian’s cell phone or other Bluetooth® emitting device. Bluetooth® can also be used to transmit traffic signal status information to a pedestrian's device, such as when the walk phase will initiate. Like RFID, Bluetooth® can be used to request custom settings such as longer crossing times. An advantage of these systems is that they can generate and share useful data between its users and the infrastructure. However, these benefits of these systems are limited to those with the required devices.

Considerations and Feasibility

Passive pedestrian detection is recommended in areas with high pedestrian activity. In these areas, pedestrians generally do not expect to have to press a push button. The normalization of not needing the push buttons during peak periods may carry over to off-peak periods, which may result in people violating "Don't Walk" indications (because the pedestrian phase was not activated). The use of passive detectors would provide consistent pedestrian activation during all phases.

Passive detection is also recommended for areas where pedestrians are likely to require additional crossing time, such as near schools and senior centers. Instead of requiring every pedestrian phase to be based on a slower walking speed which may result in increased intersection delay, passive detection will only extend “Flashing Don’t Walk” and associated green phases when needed.

Passive pedestrian detection should also be considered in areas of the Project Corridor that have a high occurrence of pedestrian collisions. (As documented in the baseline conditions analysis, approximately 40 percent of the Project Corridor is part of the Countywide High-Injury Network for pedestrians.)

Due to the potentially high costs of some pedestrian detection systems, the following prioritized approach is recommended:

1. Ensure that all intersections have push-button pedestrian detection at a minimum.

2. Establish passive/automated pedestrian detection at intersections that are part of Countywide High-Injury Network for pedestrians
    a. Video-based detection is preferred solution due to its flexible zone configurations and multiple post-processing applications
    b. Radar, microwave, or infrared detection are alternatives when video-based detection is not feasible due to limited mounting options or other environmental conditions
3. Establish passive pedestrian detection at intersections with the highest pedestrian volumes adjacent to:
    a. School zones
    b. Senior centers
    c. Public transit facilities

Implementation Costs

Passive pedestrian detection systems typically require multiple sensors at each intersection corner to detect and monitor pedestrians. As such, eight or more sensors may be needed at an intersection with four approaches. Based on estimated costs of $1,500 to $3,000 per detector, the implementation of passive pedestrian detection could approach or exceed $30,000 per intersection.

ENHANCED BICYCLE DETECTION SYSTEMS

Technology Overview

Bicycle detection allows signals to increase minimum green times so that bicyclists can clear an intersection. Traditionally, inductive detector loops placed in the pavement have been the industry standard for bicycle detection. However, in-ground inductive loops are becoming less effective as bicycles are increasingly made with less metal and with lightweight materials such as carbon fiber. To address this issue, Video Image Detection System (VIDS) has become the preferred technology for bicycle detection at signalized intersections.

In addition to detecting bicycles, VIDSs can be used to detect vehicles' presence, occupancy, speed, classification by vehicle length, and traffic incidents. (For these reasons, VIDS is commonly used for detecting vehicles in conjunction with the ATC and ATMS technologies discussed earlier.) VIDSs are easy to modify and customize and a single camera can provide detection over multiple lanes, including separate detection zones in one lane (for example, bike boxes placed in front of a vehicle stop bar).

However, VIDS does have limitations that are associated with the use of cameras. Environmental conditions such rain, snow, fog, night, shadows, and dirt on the camera lens can decrease the performance of the system by degrading the video quality. Additionally, improperly placed cameras will limit the visibility and detection of bicycles and vehicles passing through the detection zone(s).

Per the baseline conditions analysis, approximately two thirds of the signalized intersections along the Project Corridor lack video detection. Of the intersections with existing video detection systems, six are located along San Leandro Boulevard and 22 are in Hayward; ten intersections in Fremont use a combination of video detection plus in-pavement loop detectors.

Considerations and Feasibility

Additional considerations for VIDS include the following:

- **Support for other traffic signal technologies** – VIDS upgrades can be leveraged for other signal technology deployments, including adaptive signal timing and signal performance measures.
- **Traffic monitoring benefits** – Video-based systems can provide traffic monitoring benefits at locations that do not have existing closed-circuit television cameras.
- **Post-processing data** – Specialized software and video processing technologies can analyze high-resolution video data to support automatic incident detection, crash prediction models, and prediction of future traffic flows (using a combination of real-time and historic data).

It is recommended that all signalized intersections along the Project Corridor be equipped with video-based detection systems to improve mobility for bicyclists and to provide data for optimized traffic signal operations. The recommended approach for prioritizing VIDS improvements is as follows:

1. Establish video detection at intersections with existing loop detection systems, prioritizing the following:
    a. Intersections with high bicyclist volumes
    b. Cross streets that are existing or proposed bike facilities
    c. Intersections that are part of the Countywide High-Injury Network for bicyclists
    d. Locations with poor pavement conditions where maintenance is needed
    e. Locations where higher-resolution data is beneficial (for example, for incident detection at congestion hot spots)
2. Establish video detection at intersections with mixed (video and loop) or older video detection systems

Implementation Costs

VIDS installations require the purchase and installation of cameras, video processors, and cables for power and communication. Typical costs are $4,000-$6,000 per intersection approach; these costs include equipment installation and software.

NEXT-GEN TRAFFIC OPERATIONS AND MANAGEMENT

Technology Overview

Next-gen traffic operations and management technologies leverage historical and real-time data sets to improve the performance of the transportation network. These technologies will play a critical role in supporting cost-effective investments that promote sustainability and efficiency.

In the Bay Area, next-gen technologies are promoted through MTC's Innovative Deployments to Enhance Arterials (IDEA) and Next Generation Arterial Operations Program (NextGen AOP).

The following discussion presents two next-generation technologies, Adaptive Traffic Signal Control and Automated Traffic Signal Performance Measures (ATSPM), that are applicable to the Project Corridor and are being piloted and deployed throughout the Bay Area.

Adaptive Traffic Signal Control

Adaptive Traffic Signal Control enables traffic signals to adjust signal timing to accommodate real-time variances in traffic demand. Along the Project Corridor, the City of Hayward has an adaptive signal control system on Mission Boulevard between A Street and the Union City boundary, as well as Foothill Boulevard between A Street and D Street. The City of Hayward's Mission Blvd. Phase 3 corridor project will install an adaptive signal control system for the remainder of the corridor within the City (from A St. to Rose St.)

Automated Traffic Signal Performance Measures (ATSPM)

Automated Traffic Signal Performance Measures (ATSPM) systems are software applications that process and analyze high-resolution traffic data to report performance metrics for an individual traffic signal, corridor, and/or across the traffic signal network. ATSPM enables agencies to proactively identify trouble areas, monitor and report corridor performance, share data among partner agencies, thereby facilitating efficient traffic management. Most ATSPM systems are cloud-based to accommodate the large amounts of data that are continuously collected and processed.

The City of Hayward has begun the deployment of an ATSPM system that includes Project Corridor intersections in downtown Hayward between A Street and Fletcher Lane. The system requirements developed by the City of Hayward and lessons learned from the deployment can serve as a roadmap for the development of ATSPM implementation along other segments of the Project Corridor.

Considerations and Feasibility

Adaptive traffic signal systems are best suited for corridors with the following characteristics:

- High traffic volumes
- LOS D, E, or F at intersections
- Closely-spaced signals (less than <0.5 mile)
- Unreliable travel times and unpredictable travel demand

If traffic patterns are consistent throughout the day and week, a standard time-of-day signal timing is likely to be the most efficient and effective approach to traffic management.

Based on the baseline conditions analysis, adaptive traffic signal systems should be evaluated for Project Corridor intersections in San Leandro and Alameda County (E. 14th St./Mission Blvd.), Union City (Decoto Rd.) and Fremont (Fremont Blvd.) As noted earlier, the adaptive signal systems for City of Hayward intersections are either completed or in progress.

Adaptive signal control and ATSPM systems build upon the traffic signal technologies described in earlier sections. Key considerations include the following:

- **Vehicle detection** – Adaptive traffic signal systems typically require detection systems that can collect vehicle volumes on all intersection approaches. ATSPM systems need detection systems that can collect vehicle volumes on a lane-by-lane detection basis.
- **Signal controllers** – Adaptive traffic signal systems will require that most of traffic signal controllers along the Project Corridor be upgraded. Most ATSPM systems can work with any signal controller that has high-resolution data collection capabilities; otherwise, a data aggregator would be used.
- **Signal communication** - Both adaptive traffic signal control systems and ATSPM require reliable communication between traffic signals. Adaptive traffic signal control requires that intersections must be interconnected. ATSPM communications must be robust enough to allow the transfer of intersection data to the central ATSPM server; this could be through a City's interconnect system or through broadband cellular service at each intersection.

Implementation Costs

Adaptive traffic signal system costs can vary greatly, ranging from $20,000 to $45,000 per intersection, with the upper range including costs to provide controllers and detection. If a central ATMS is already in place and intersections are already equipped with necessary signal controller and detection upgrades (described earlier), then implementation is limited to the additional adaptive traffic signal control software, with costs around $10,000 per intersection.

Approximate costs for ATSPM system installation at a signalized intersection will be between $10,000 and $15,000 and includes system licenses, warranty, and support for three to five years. These estimated costs do not include controller and detection upgrades that may be necessary to collect high-resolution data. As with adaptive traffic signal systems, if a centralized ATMS is already place and intersections are already equipped with up-to-date signal controllers and detection upgrades, then ATSPM may be deployed through an additional module to the existing central system.

CONNECTED VEHICLES

Technology Overview

Connected Vehicle (CV) technology will enable cars, trucks, buses, and other vehicles to communicate with each other, with roadway infrastructure (for example, traffic signals), and with other road users (for example, pedestrians and bicyclists with compatible smartphones). This is accomplished by utilizing built-in or add-on devices that share important safety and mobility information.

The categories of CV interactions are as follows:

- V2I – Vehicle-to-Infrastructure
- V2V – Vehicle-to-Vehicle
- V2C – Vehicle-to-Cloud
- V2P – Vehicle-to-Pedestrian
- V2X – Vehicle-to-Everything

CV infrastructure and operations along the Project Corridor can be used to provide the following benefits:

- Optimize vehicle and person trip throughput by conveying signal information to connected vehicles
- Improve safety through in-vehicle alerts of pedestrians, bicyclists, and other vehicles
- Provide a platform for other transportation technologies (for example, cloud-based transit signal priority)

Dedicated Short Range Communications (DSRC)

Safety-related systems for CV technology are likely to be based on dedicated short-range communications (DSRC) since DSRC is specifically allocated to CV applications by the Federal Communications Commission. (It should be noted that cellular networks Wireless 5G are also able to support CV operations.) DSRC is a technology that is similar to Wi-Fi but optimized to be high-speed, secure, reliable, and not vulnerable to interference.

The following sections discuss the components of DSRC that allow for V2I communications.

On-Board Equipment

On-board equipment is integrated into vehicles (including passenger vehicles, heavy vehicles and transit vehicles) and provides access to data that is pulled from the vehicle’s controller area network. The data transmitted through on-board equipment can support crash avoidance applications and optimized traffic signal timings.

Roadside Units

Roadside Units are DSRC devices that provide wireless communication between vehicles, existing traffic infrastructure, and other mobile devices. Roadside Units can be mounted on a traffic signal pole or installed in an adjacent traffic signal cabinet.

In addition to CV applications, Roadside Units can support ASTPM systems, as described earlier.

Considerations and Feasibility

CV technology is continually evolving, and specific implementation requirements are likely to change over time. Given this uncertainty, a recommended approach is to "future-proof" traffic signal systems by installing Roadside Units that can support future CV technology. Roadside Units require minimal upgrades within the existing controller cabinets and serve to expand data collection and transmission capabilities.

Implementation Costs

CV technology deployments that use V2I interactions require both Roadside Units and on-board equipment. Costs for installing a Roadside Unit with DSRC capabilities are approximately $3,000 to $5,000 per intersection. On-board equipment is assumed to be provided by private vehicle manufacturers.

RECOMMENDATIONS FOR PROJECT DEVELOPMENT

Recommended next steps for project development are as follows:

Signal Communications

- Implement fiber-based signal-to-signal communication for intersections without existing communication (approximately 50 of 120 intersections). Implement wireless communication as an interim solution if fiber-based communication is not feasible. (Near-term)
- Upgrade all existing signal-to-signal communications to fiber-based communications. (Mid-term)

Advanced Traffic Controllers and Advanced Traffic Management Systems

- Convert the remaining signalized intersections (approximately 105 of 120) to Advanced Traffic Controllers to "future-proof" signals and provide expansion capabilities. (Near term)
- Coordinate with Alameda County and Caltrans to establish Advanced Traffic Management Systems for Project Corridor traffic signals that are maintained by each agency. (Near term)

Pedestrian Detection Systems

- Ensure that all signalized intersections along the Project Corridor have push-button pedestrian detection at a minimum. (Near-term)
- Install video-based pedestrian detection at intersections that are part of Countywide High-Injury Network for pedestrians, and at intersections adjacent to school zones, senior centers, and public transit facilities (Near-term)

Bicycle Detection Systems

- Establish video detection at intersections with existing loop detection systems, prioritizing based on bicyclist volumes, bike facility designations, safety, and pavement conditions. (Near-term)
- Establish video detection at intersections with mixed (video and loop) or older video detection systems (Mid-term)

Next-Gen Traffic Operations and Management

- Evaluate the feasibility of adaptive traffic signal systems for Project Corridor intersections in San Leandro and Alameda County (E. 14th St./Mission Blvd.), Union City (Decoto Rd.) and Fremont (Fremont Blvd.) (As noted earlier, the adaptive signal systems for City of Hayward intersections are either completed or in progress.)
- Use the City of Hayward's planned Automated Traffic Signal Performance Measures (ATSPM) deployment to develop a strategy for ATSPM implementation along other segments of the Project Corridor. (Near-term)

Connected Vehicles

- Install Roadside Units to "future proof" signalized intersections along the Project Corridor that can support future CV technology (Mid-term)

Key data collection and inventory needs for project development are as follows:

- **Inventory of existing signal controllers** - A thorough review of the existing controller cabinets should be conducted during the project development phase to identify specific improvements that are needed. For most of the signal controller cabinets along the Project Corridor, ATCs would require minor or no modifications; this is because ATCs are available for multiple cabinet types. However, some older cabinets may need to be replaced to accommodate new controllers and other traffic signal equipment as desired.
- **Functionality and capabilities for existing ATMSs** - For the existing ATMSs along the Project Corridor, the following should be evaluated to determine their level of functionality:

   - The potential capabilities of center-to-center integration to support joint operations and data sharing
   - The age and version of the existing ATMS to identify upgrades/replacement required to provide desired corridor functionality (i.e., adaptive traffic signal control, TSP module, etc.)
- **Existing communication network architecture** – Existing communication networks should be evaluated to determine the appropriate technology recommendations. Wireless and hardwired solutions depend on the size of existing fiber cables, connection points of existing systems, agency preferences, and existing field conditions.
- **Signal equipment upgrades planned for concurrent corridor infrastructure projects**– Portions of the Project Corridor in Alameda County and Hayward have Complete Streets projects that will start within the next few years. These projects provide opportunities to implement traffic signal technology upgrades, including fiber-based communication.