9 | Monitoring Program Results and Next Steps

The improving economy, greater levels of employment and lower gas prices observed in 2016 have generally resulted in higher travel demands on the transportation network. This is apparent through declining speeds on the CMP network and increased ridership on BART; continuing the trends observed since 2010. The change in average speeds on freeways and arterials ranged from a - 3.3 mph speed decrease on freeways in the afternoon peak period, to a + 0.1 mph increase on Tier 1 Arterials in the afternoon peak period.

This section highlights the 2016 monitoring results in terms of conformity and summarizes upcoming improvements to the road network that may be encountered in the next monitoring cycle or beyond. Finally, innovative ideas that could further improve the effectiveness of monitoring studies have been identified for potential consideration. These include expanding the use of Big Data for transportation planning, ITS and connected vehicle implementations, and inclusion of countywide monitoring of alternative modes.

9.1 | 2016 CMP Conformity

CMP conformity is evaluated for the Tier 1 network in the afternoon peak period on segments that fail to meet the LOS E threshold and operate at LOS F. There were 61 segments operating at LOS F in 2016 in the afternoon peak period. Of these 61 segments, 26 were exempt from deficiency planning requirements because they were either grandfathered in the 1991-1992 LOS surveys or impacted by construction. The Alameda CTC model was utilized to conduct estimate LOS on the remaining 35 segments if trips originating from outside Alameda County were removed. Based on this analysis, no new deficient segments were identified.

9.2 | Construction during the 2016 Monitoring Cycle

In 2016, construction and maintenance activities have had an impact on road network performance, particularly on major corridors, although possibly not to the same extent as in 2014. Although it is not typical for construction to close lanes during peak hours, they often still unavoidably impact traffic flows either through the traffic friction caused by narrower lanes, presence of concrete barriers at close proximity, or rubbernecking by roadway users.

In Alameda County, major construction was present on State Route 84 in East County, I-880 in north, central and South County, and State Route 92 in Central County. The I-580 freeway in East County had operational changes with the new express lanes opening to traffic in February 2016, just before the start of the 2016 monitoring period; therefore, I-580 segments were not monitored as a part of the 2016 LOS Monitoring Report since the express lanes were in the ramp up period. Figure 9-1 maps the location of the morning and afternoon congested segments, and associated major construction.

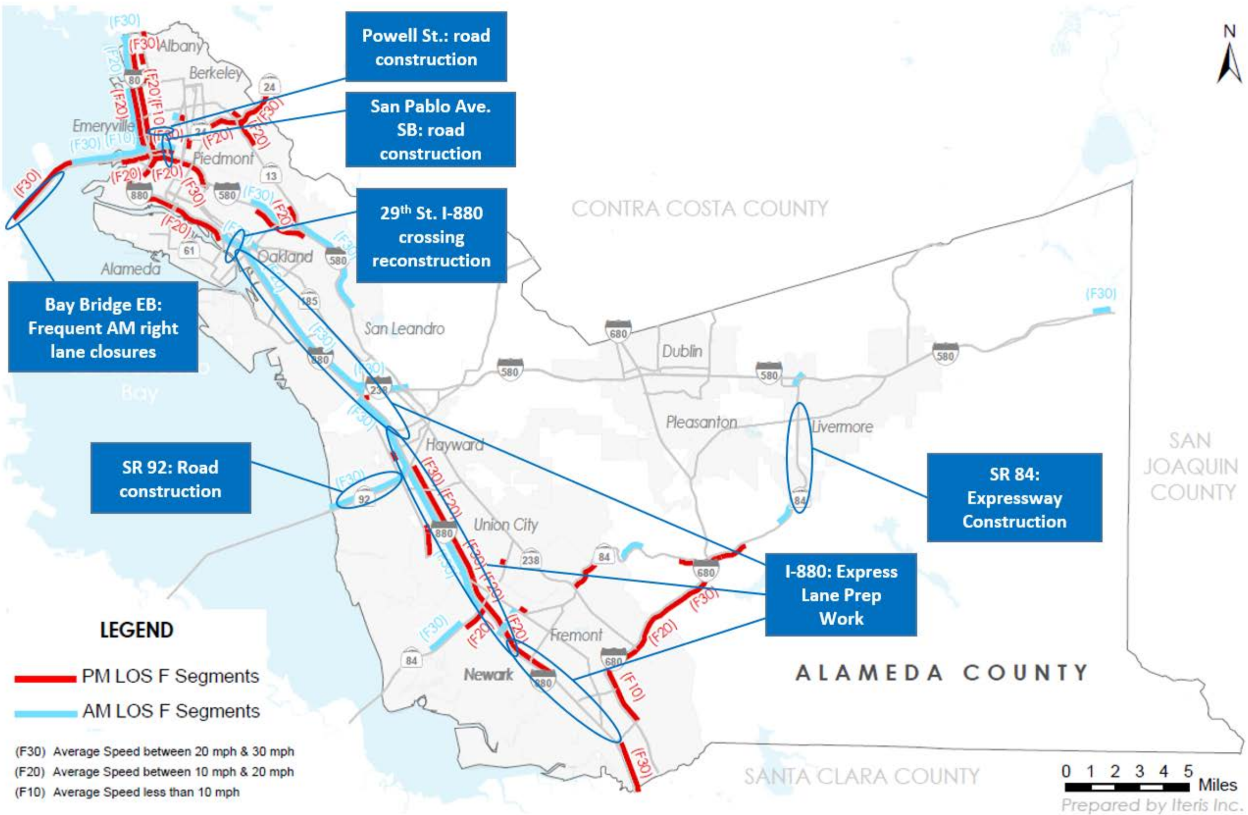

Figure 9-1: 2016 Congested Segments and Construction Activities on the CMP Network

Major construction during the 2016 monitoring period includes:

- **I-880 Improvements:** The 29th Avenue crossings in Oakland is being replaced as an operational and safety improvement. Work will begin on the 23rd Avenue crossing in 2017.
- **I-880 Express Lanes:** Early work on the I-880 express lanes consists of median barrier work in both directions between State Route 262 Mission Boulevard and 42nd Avenue.
- **I-580 Freeway Improvement:** I-580 Altamont Pass Eastbound Truck Climbing Lanes.
- **State Route 84 Expressway (South Segment):** Adding lanes and upgrading the roadway to a multi-lane expressway from Ruby Hills Drive north to South of Stanley Boulevard.
- **State Route 92:** State Route 92/ Clawiter-Whitesell Interchange and Reliever Route project.
- **International Boulevard BRT in Oakland:** A Bus Rapid Transit (BRT) system with station redesign is underway between San Leandro BART

and Downtown Oakland along International Boulevard. Service is planned to begin in November 2017.

- **Drainage Repair:** Tassajara Road in East County and Alvarado Boulevard in Fremont had sections closed for drainage repair.

9.3 | Future Planned Network Improvements

To realize future performance improvement, Alameda CTC has recently completed three plans that studied the county's multimodal transportation issues comprehensively:

1. **Goods Movement Plan** – Development of a long-range strategy for how to move goods efficiently, reliably, and sustainably within, to, from, and through Alameda County by roads, rail, air and water.

2. **Transit Plan** – Identification of near and long-term transit capital and operating priorities in the county to reduce travel times, and improve access and connectivity. The draft Countywide Transit Plan was approved by Alameda CTC in May 2016, and the final Countywide Transit Plan is scheduled for adoption in June 2016.[32]

3. **Multimodal Arterial Plan** - This plan studied the county's major arterials to identify strategies and solutions for improving multimodal connectivity, access, and mobility. The final report was approved by the Alameda CTC in June 2016.[33]

In March 2016, Alameda CTC approved the Measure BB Capital Project Delivery Plan (CPDP), which included 20 specific projects for delivery by Alameda CTC in the role of project manager.[34] This Plan is based on the 2014 Transportation Expenditure Plan (TEP), which was passed by voters for a potential funding of $8 billion.

There are also many other improvement projects in various project development, programming, or planning stages as shown in Table 9-1.

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[32] Countywide Transit Plan. Alameda CTC. 2016.
http://www.alamedactc.org/app_pages/view/13345
[33] Countywide Multimodal Arterial Plan. Alameda CTC. 2016.
http://www.alamedactc.org/app_pages/view/13346
[34] Capital Project Delivery Plan. Alameda CTC. 2016.
http://www.alamedactc.org/files/managed/Document/18558/CPDP_FINAL_20160328.pdf

Table 9-1: Future Improvements

Project	Scope	Current Performance
I-80 Integrated Corridor Management (ICM) Project	Install adaptive ramp meter control and dynamic signing between the Contra Costa County Line and the Bay Bridge Toll Plaza. The system is anticipated to begin in summer 2016. Operational performance will be assessed in the next CMP analysis cycle.	Congested segments present within the I-80 project boundaries between the Contra Costa County Line and the Bay Bridge Toll Plaza.
I-80 Gilman Interchange Reconstruction	The proposed project will reconfigure the I-80 / Gilman St. Interchange, located in northwest Berkeley. The project will improve traffic on the local street and frontage roads, and improve bicycle and pedestrian regional connectivity by completing a missing segment of the Bay Trail.	Congested segments present on I-80 around the Gilman Street Interchange.
I-880 North Safety & Operational Improvements at 23rd Ave.	This project proposes to construct operational and safety improvements on I-880 at the existing overcrossing of 23rd Avenue in the City of Oakland. Construction begins in early 2017.	Congested segments present on I-880 around the 23rd Ave. Interchange
I-880 Express Lanes	HOV to express lane conversion between Hegenberger Rd. / I-238 and the Santa Clara County Line.	Congested segments present on I-880 between Hegenberger Rd. and the Santa Clara County line.
I-680 NB Express Lanes	HOV/express lane implementation from SR 237 to north of SR 84 including additional auxiliary lanes and allowances for tolling infrastructure. This project is currently in the Environmental Phase.	PM Peak hour congested segments on I-680 NB between SR 238 and SR 84.
International Blvd. BRT	AC Transit's BRT will operate between downtown Oakland and San Leandro – primarily utilizing historic International Boulevard and East 14th Street. Construction of the 150 block transit service (that spans 9.5 miles) is slated to begin in May 2016 with service expected to begin in November 2017.	Congested segments present on International Blvd NB between 46th and 42nd in both peak periods.
I-880 to Mission Blvd. East-West Connector	This project will construct an improved east-west connection between I-880 and Route 238 (Mission Boulevard) and is a combination of new roadways, improvements to existing roadways and improvements to intersections along Decoto Road, Fremont Boulevard, Paseo Padre Parkway, Alvarado-Niles Road and Route 238 (Mission Boulevard). PSE completion is expected in 2017.	Congested segments present on Decoto Road (WB in PM), nearby Fremont Boulevard (WB between Peralta Blvd. and Thornton Ave.) and Thornton Ave.
I-580 Altamont Pass Eastbound Truck Climbing Lanes	Along with I-580 repaving, this project will add a truck climbing lane in the Eastbound direction on Altamont Pass.	Congested segments present on I-580 EB in the afternoon from Greenville Rd. to N. Flynn Rd.

9.4 | Recommendations for Future Monitoring Studies

The significant improvements which were made to the LOS monitoring methodology in the 2014 monitoring cycle such as the use of commercial data, inclusion of HOV/express lanes and bridges for monitoring, and developing arterial classification for Tier 2 network, were followed in the 2016 cycle. To continue further improvement and to expand the scope of the LOS monitoring for larger level applications, Alameda CTC could consider the following recommended enhancements.

9.4.1 | Expanding the Use of Big Data for CMP Monitoring

For the 2018 monitoring cycle, Alameda CTC may consider expanding the use of commercial speed data to survey all arterials and HOV/express lanes as well, if such suitable data becomes available.

Arterials (Tier 1): In 2014 and 2016, arterials (Tier 1) were monitored using floating car surveys as the 2013 and 2016 Validation Studies could not adequately validate the commercial speed data on arterials. [35] The 2016 Validation Study recommended that the use of commercial speed data on principal arterials with low signal density (i.e. less than or equal to 1 signal per mile).

However, in recent years, commercial speed data providers, including INRIX, have continued improving their algorithms and coverage on arterials. Given the significance that these results bear on the conformity of the CMP and associated deficiency plans, the application of commercial speed data for monitoring the Tier 1 arterials is worth further exploring with another validation study prior to the next monitoring cycle. More prevalent use of commercial speed data across the arterial network would represent a significant savings and redirect resources towards a more comprehensive focus on multimodal monitoring.

HOV and express lanes: These managed lanes were also monitored using a floating car methodology as exclusive managed lanes data was not available. These floating car surveys are more resource intensive than conventional floating car surveys due to the multiple passenger occupancy requirements.

Commercial speed data providers have continued to make progress in developing a data product which provides lane-based speeds. First generation products have been recently made available for purchase and these may be considered for next cycle. Alternatively, Alameda CTC can use the speed data collected from the express lanes operations itself, for further cost savings and data consistency.

Monitoring Alternative Modes: Monitoring of alternative modes has been undertaken since 1996 through ten OD surveys. The objective is to compare the time taken to travel between major employment centers and residential areas by various modes - auto, transit, bike and HOV. While these surveys provide a useful insight to understand the competiveness of different modes, results from only ten survey routes limit the capability to facilitate countywide improvement.

Alternatively, multimodal big datasets may be obtained for countywide monitoring. For transit, Automated Passenger Counter (APC) or Automatic

[35] Validating the use of Commercial Speed Data for Alameda CTC Level of Service Monitoring. Alameda CTC. 2016. Also completed in 2013. http://www.alamedactc.org/app_pages/view/8091

Vehicle Location (AVL) data may be processed to understand the speed of transit vehicles along the CMP network and their competitiveness with the auto mode. The processing task involves cleaning the data to remove faulty and outlier data samples, filtering to weekday peak periods only (as applicable), mapping onto the CMP segments and aggregating the records for both the morning and afternoon peak periods. This direct comparison of speeds for the entire CMP network would provide actionable information for agencies within Alameda County to help prioritize transit improvement projects such as BRT systems, dedicated bus lanes, transit signal priority or queue jump facilities. The analysis could also yield performance information along major transit lines, in off-peak periods or between specific ODs.

For bicycle and pedestrian data, Alameda CTC may explore newer data sources from providers such as Strava Metro that aggregate crowd sourced bicycle and pedestrian activity into commercial data products. The data can be filtered by commute or recreational purposes, and can be used to perform monitoring such as bicycle travel times and route choice, and to evaluate the success of new multimodal infrastructure. In both datasets, the sample size would significantly exceed that of the existing monitoring efforts for transit and bicycle.

Big Data Performance Metrics: In 2016, Alameda CTC expanded their monitoring to include calculation of reliability and the duration of congestion on freeways. In future monitoring cycles once the commercial speed data is adequately validated on arterials, this analysis may be expanded to include the arterial network also.

9.4.2 | Expanding the Visualizations Included in the Monitoring Report

For the 2018 Monitoring Report, Alameda CTC may consider including additional graphics and summary snapshots of the results. By providing visualization, it can better engage and inform the audience of stakeholders, policy makers, and the public, about monitoring traffic congestion. Additionally, these displays can provide added insights across data levels. Two examples are presented below.

Congestion Heat Map: For each roadway segment and for a 5-minute period, this heat map plots the average speed in terms of time (y-axis) and distance (x-axis). Stakeholders can view where and when congested conditions are forming. These contour maps when compared between different years, help to better visualize the patterns or trends in congestion or bottlenecks across each segment.

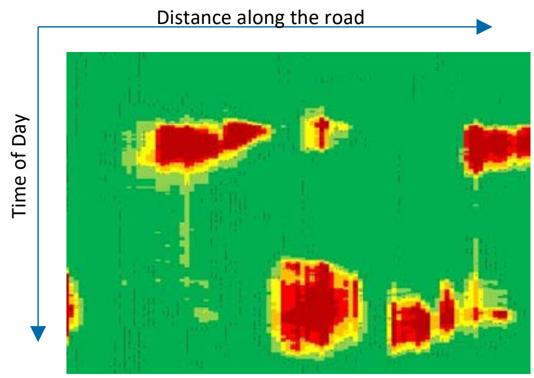
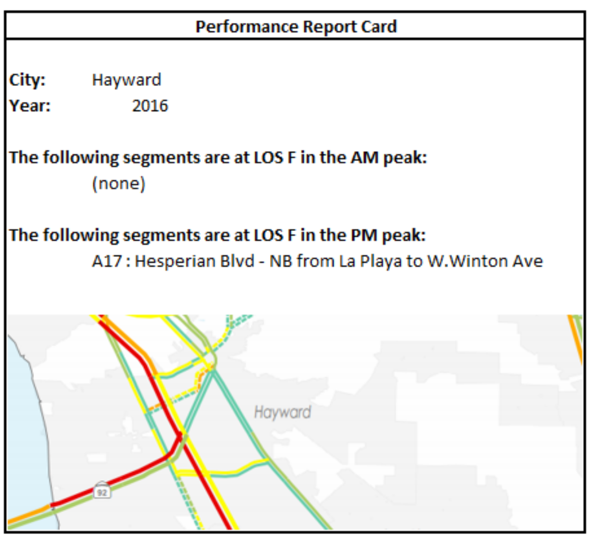


Figure 9-2. Example Congestion Space Time Map

Performance Report Card: In addition to the tabulated LOS results by network category, which are provided in the 2016 Monitoring Report, customized "report cards" for each city or planning area listing their congested (LOS F) segments could be generated by an automated script. An example report card is shown for the 2016 Monitoring Report for the City of Hayward in Figure 9-3. This can help individual cities track performance of their individual roadways and requirements for any applicable conformity studies.


Performance Report Card

City: Hayward
Year: 2016

The following segments are at LOS F in the AM peak:
(none)

The following segments are at LOS F in the PM peak:
A17 : Hesperian Blvd - NB from La Playa to W.Winton Ave

Figure 9-3. Performance Report Card

9.4.3 | Update CMP Database and GIS Segments

There were issues encountered with the existing CMP roadway segments (mostly Tier 1 Arterials) in compiling the 2016 monitoring results, such as the CMP roadway segment limits not matching surrounding land use transition points, or reflecting updates from traffic operational improvements e.g. conversion of a two way street to one-way, etc. It is recommended that a complete countywide inventory of CMP segments be conducted including the following efforts:

- Make corrections on the GIS segment geometries to more precisely match the intersection locations, especially on intersections involving freeway ramps;
- Update the segment descriptions in the GIS database, which are used when conducting field studies, as well as in reports based on the CMP segments analyzed; and
- Where land use changes have impacted traffic patterns significantly in recent years, it is recommended that the CMP segments be split into two or more segments as appropriate. A similar process was undertaken in 2007 on the I-580 in the east county.

Maintenance on the CMP roadway segment data in the GIS system is a task is that is needed periodically to ensure that the CMP segmentation is appropriate for the current CMP network.

9.4.4 | Performance Monitoring Tool

Currently, CMP speed measurements from floating car surveys and commercial speed data are recorded in spreadsheets. The floating car results are stored in separate spreadsheets according to the route and then summarized in higher level spreadsheets by the category of CMP segment (i.e. freeway, ramp, arterial, HOV). The commercial speed data is processed separately and then directly imported into the summary spreadsheets. For the next cycle, Alameda CTC could consider alternatives such as a database or online monitoring tool to process and store both the floating car and commercial speed data. Implementation of online tools would open up opportunities for Alameda CTC's stakeholders and the public to interact directly with the data; thereby increasing engagement with the LOS monitoring process.[36]

Prior to implementation of tools for the floating car survey portion, it is recommended that careful consideration be given to the role of floating car surveys in future monitoring cycles. It is anticipated that as the quality and coverage of commercial speed data improves over time (particularly on arterials) and as new data products such as lane-by-lane data become more readily available, that future LOS monitoring cycles could phase out floating car surveys (or minimize their use significantly).

Regarding other commercial speed data tools, an example is the iPeMS platform, a real-time data monitoring tool, which is being used by San Bernardino Associated Governments (SANBAG) in part to meet state CMP legislative requirements. The tool allows users to define each CMP segment which the tool then aggregates the commercial speed data for a user-defined time and date range. CMP performance reports (see Figure 9-4) can be generated as needed for the selected network category or city / planning area automatically. The performance

[36] Public viewing would be possible where data licensing agreements permit.

measures include average speed, delay, travel time, travel time index, reliability metrics and LOS. Additional features provide users reports on individual CMP segments with detailed reliability metrics or enhanced visualizations such as heat plots (see Figure 9-5). Such tools have uses beyond LOS monitoring studies which can include performance of signal synchronization projects and programs, ramp metering review, and monitoring construction impacts.

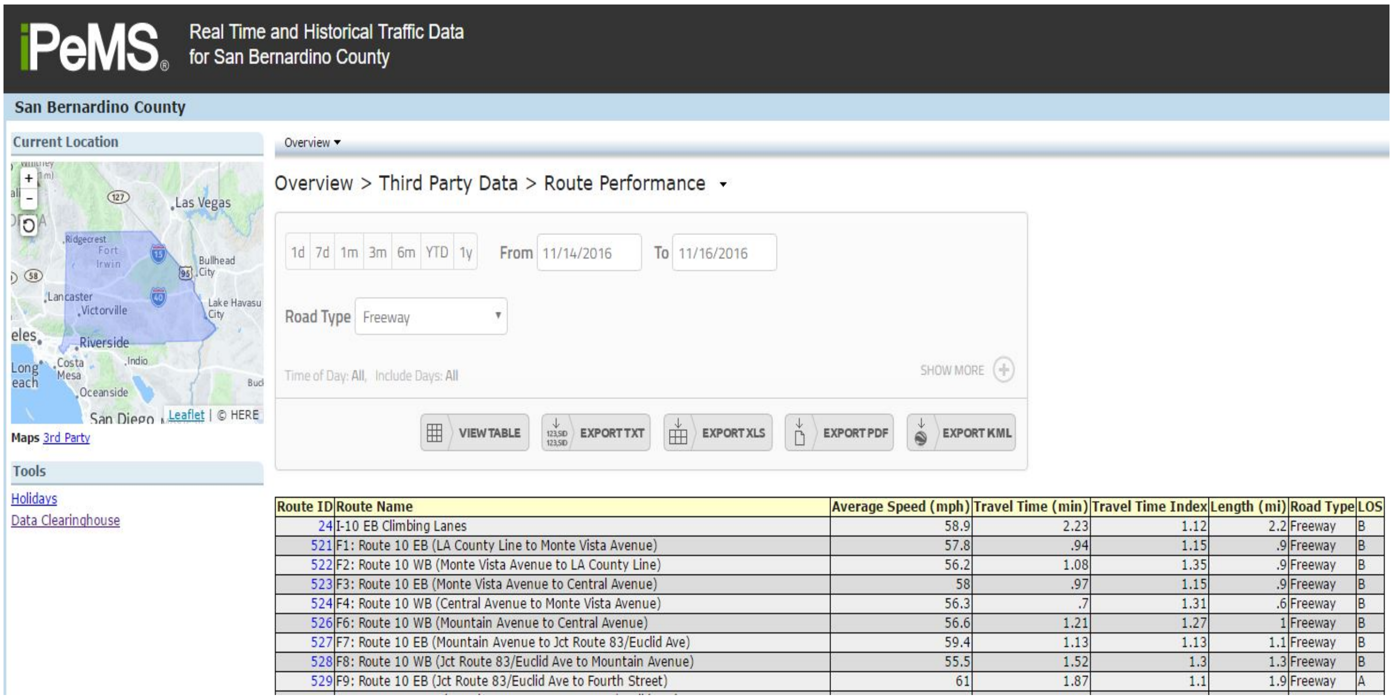


Figure 9-4. Example Web-based CMP Performance Report (Source: SANBAG)

Figure 9-5: iPeMS Performance Report: Time/Space Heat Map (Source: SANBAG)

Additional monitoring tools may be considered for multimodal performance monitoring such as high level countywide monitoring of transit. Some off the shelf tools to monitor transit Big Data exist and can be generally grouped into two categories:

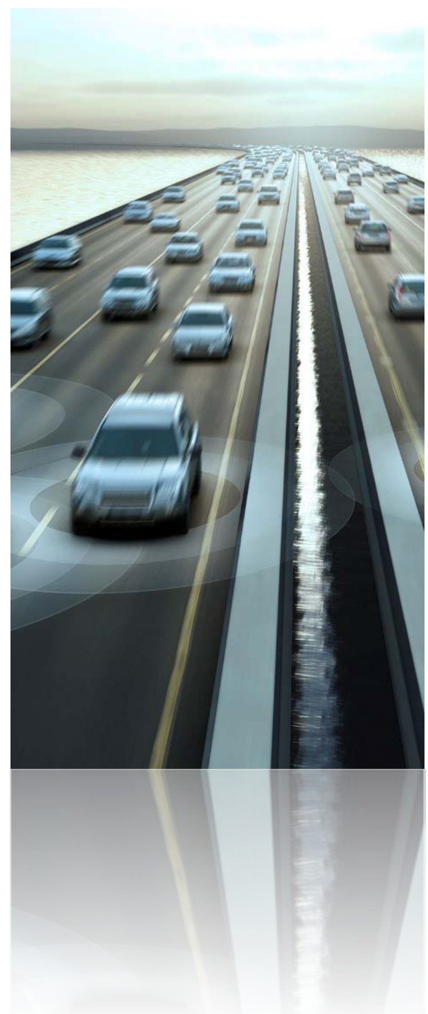
- Tools that review transit performance from an operational perspective, monitor the adherence to the schedule or predict arrival / departure times. While useful to transit agencies, this is likely to be less useful to a CMA like Alameda CTC.
- Tools that review the performance of transit from a planning perspective. These tools would help to monitor how well the transit mode meets the transportation needs of Alameda County residents, and perhaps compares transit travel times to other modes. It may identify locations within Alameda County with regular delays, slow travel speeds or poor reliability to help Alameda CTC and other local agencies plan for and program improvements to the transit system. This type of monitoring would be useful for future LOS Monitoring Reports.

The Caltrans PeMS deployment currently has a transit module which covers data for two specific agencies in San Diego: the Metropolitan Transit System (MTS) and the North County Transit District (NCTD). This was a module developed in 2011 as a prototype for a multimodal study by San Diego Association of Governments (SANDAG), the regional planning agency for San Diego. The module produces real-time and historical performance measures and visualizations using APC and AVL data. Caltrans is currently expanding the module's features and coverage to other transit agencies in California including AC Transit and BART where PeMS is ingesting schedule data in order to provide performance measures such as service frequency, capacity and schedule transit speed.

9.4.5 | Recommendations for Monitoring Connected & Autonomous Vehicle Deployments

Connected vehicles (CV) and autonomous vehicles (AV) are rapidly gaining attention in the transportation industry publicizing benefits in:

- **Safety** – Through the reduction of vehicle crashes and loss of life;
- **Mobility** – Through reduced travel times and more efficient travel on roadways;
- **Environment**: Through reduction of emissions and lower fuel usage; and
- **Economy**: Through more efficient goods movement.



In terms of CV, the associated communication deployments are categorized as vehicle to vehicle (V2V), vehicle to infrastructure (V2I), or the more generic term vehicle to everything (V2X). Public agencies such as Alameda CTC will have future opportunities to support the V2I aspect by installing CV infrastructure or integrating CV features into existing roadside infrastructure. This infrastructure would support applications such as driver advisories, driver warnings, and vehicle and/or infrastructure controls, by capturing real-time data from equipment located on-board vehicles and within the transportation infrastructure. The data is transmitted wirelessly and used by transportation agencies in a wide range of dynamic, multi-modal applications to manage the transportation system for optimal performance. There are close to 100 individual connected vehicle applications being tested or available in the market. For example, Multi-Modal Intelligent Traffic Signal System (MMITS) is a next-generation traffic signal system that seeks to provide a comprehensive traffic information framework to service all modes of transportation that is focused at the arterial roadway level. The MMITS application bundle seeks to improve mobility along signalized corridors using advanced communications and data to facilitate the efficient travel of passenger vehicles, pedestrians, transit, and freight and include applications such as with Intelligent Traffic Signal System (I-SIG), Freight Signal Priority (FSP), Mobile Accessible Pedestrian Signal System (PED-SIG), and Transit Signal Priority (TSP). An example operational environment of MMITSS is shown in Figure 9-6.

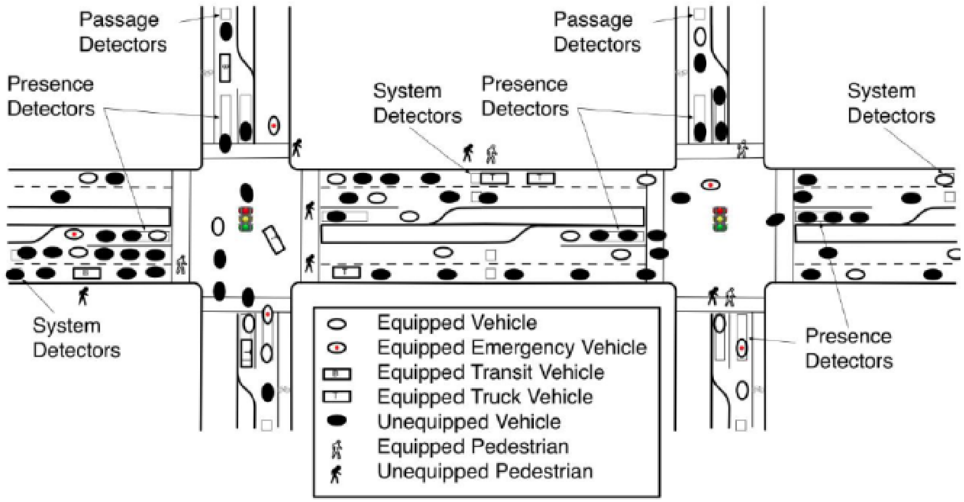


Figure 9-6: Illustration of the MMITSS Concept (Source: University of Arizona[37])

Transportation agencies, along with other public and private sector entities, must prepare for emerging technologies that will fundamentally change mobility. Vitally important for public agencies will be to direct investment in CV deployments towards applications that are expected to benefit their travelers, commuters and the community as a whole. In this respect, Alameda CTC could develop a CV Master Plan that:

- Considers uptake rates of (private) vehicle deployments which are needed in order to communicate with the infrastructure, and therefore the expected best timing for Alameda CTC to invest in CV infrastructure;
- Evaluates how existing Alameda CTC planning efforts can incorporate CV deployments (e.g. the Multimodal Arterial Plan, the Goods Movement Plan and the Countywide Transit Plan);
- Reviews current infrastructure within Alameda County, the needs of the county, and evaluates opportunities for integrating CV features into existing equipment or installing new roadside equipment. The corresponding maintenance approach would also need to be considered; and
- Proposes a monitoring approach that evaluates the performance of CV deployments after installation and the resulting benefit.

The last item is of particular relevance to this LOS monitoring study as periodic monitoring of CV features could be undertaken as a part of this effort.

[37] MMITSS Final ConOps. Chapter 9. University of Arizona. 2012. http://www.cts.virginia.edu/wp-content/uploads/2014/05/Task2.3._CONOPS_6_Final_Revised.pdf