Cover Page

Project Name	I-210 Multimodal Congestion Management and Operational Improvement Project (MCMOIP)
Eligible Entity Applying to Receive Federal Funding	California Department of Transportation (Caltrans) 100 S. Main St., Los Angeles, CA 90012
Total Project Cost (from all sources)	$47,996,766
ATCMTD Request	$5,466,691
Are matching funds restricted to a specific project component? If so, which one?	:Yes: Project Management; Outreach & Communications; AMS; Software Design, Development, Integration, Deployment; Infrastructure Design and Build; and System Operations
State in which the project is located	California
Is the project currently programmed in the: • ***Transportation Improvement Program (TIP)*** • ***Statewide Transportation Improvement Program (STIP)*** • ***MPO Long Range Transportation Plan*** • ***State Long Range Transportation Plan***	YES: 1. Transportation Improvement Program (TIP) 2. The Southern California Association of Governments (SCAG) 2012 – 2035 Regional Transportation Plan (RTP) 3. The State Highway Operations and Protection Program (SHOPP)
Technologies Proposed to be Deployed (briefly list)	• Dynamic traffic reroutes and lane management • Queue progressive warning • Innovative Safety applications • Predictive traveler information system • Transit signal priority • Mode shift to transit, biking, and walking • Surveillance and detection • Improved maintenance of ITS elements • Reusable statewide system components • V2I and V2V interfaces and innovations • Real-time multimodal decision support system (RTMDSS) • Accessible transportation improvements

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1. PROJECT DESCRIPTION

1.1. INTRODUCTION

This Technical Application describes the proposed I-210 Multimodal Congestion Management and Operational Improvement Project (MCMOIP) and outlines the services and solutions expected to be delivered utilizing the Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program fund request.

Figure 1: LA Metro Rail Gold Line and I-210 Freeway

The linkage between the California Connected Corridors program, the ongoing Interstate 210 (I-210) Integrated Corridor Management (ICM) Pilot and the proposed MCMOIP is also discussed.

The Connected Corridors program is led by the California Department of Transportation (Caltrans) to plan and deploy innovative solutions along the congested transportation corridors in the state. The program has facilitated the I-210 ICM Pilot in the San Gabriel Valley, northeast of the city of Los Angeles. The program is expected to expand to other congested urban corridors throughout California to improve safety, efficiency and system performance.

Figure 2 depicts the I-210 ICM Pilot's key subsystems, user services, planned communication networks and interfaces. When leveraged with the ATCMTD funding, the transition to MCMOIP will support the U.S. DOT's initiative and expand the I-210 ICM Pilot to deliver enhanced intermodal connectivity, accessibility, mobility, and congestion relief benefitting transportation users and the general public.

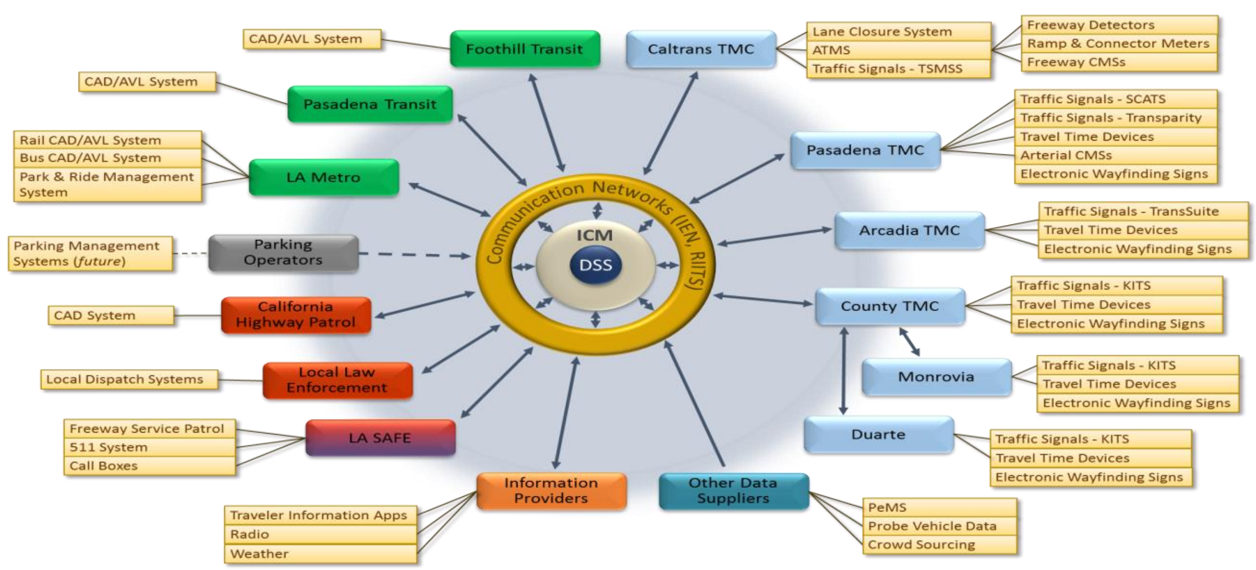

Figure 2: I-210 Pilot — Participants and Systems

While many of the foundational elements of I-210 ICM are currently in the systems engineering design process, the primary focus thus far has been on rerouting and rebalancing automobile traffic. ATCMTD Program resources will provide the opportunity to leverage existing State and local investments to further enhance the functionality by installing and operating scaled technologies to move people and goods in the most efficient and safest manner possible utilizing all available transportation modes and opportunities. This will be assisted by using a state-of-the-art Real-Time Multimodal Decision Support System (RTMDSS) to integrate ICM subsystems while featuring interfaces for Active Traffic Management (ATM) approaches and eventual vehicle-to-infrastructure (V2I), infrastructure-to-vehicle (I2V) and vehicle-to-vehicle (V2V) technology deployments.

Concurrent with the I-210 Pilot, Caltrans initiated an organizational shift to the Transportation Systems Management & Operations (TSM&O) business model, which is better suited for managing multimodal corridors. This realignment, the first of its kind in the nation for a state Department of Transportation, is significantly transforming how the agency manages integrated, multimodal transportation systems. This has also enabled Caltrans to develop and maintain a strong partnership among local agencies and jurisdictions supporting the I-210 Pilot implementation.

With the critical mass of the foundational elements already designed and programmed for deployment, together with the additional enhancements proposed under this ATCMTD proposal, the I-210 ICM coalition is uniquely positioned to achieve the USDOT's and Caltrans' common vision of achieving improved safety, mobility, sustainability, economic vitality, and air quality through deployment of advanced transportation technologies and strategies.

The proposed** I-210 Multimodal Congestion Management and Operational Improvement Project (MCMOIP) **builds upon the existing Connected Corridors program in California and deploys new data sources, technologies, and infrastructure to take ICM to the next level. It focuses on improving corridor performance through the balanced use of transit, autos, trucks, bicycles, and pedestrians. It will connect to transit opportunities, such as the recent Metro Gold Line Foothill extension, a light-rail system which opened six new stations in March 2016. Improved corridor operations will be achieved by utilizing a Real-Time Multimodal Decision Support System (RTMDSS) to fuse new third-party data sources, advanced technologies, new communications strategies, and traditional and Smart City performance metrics to measure, analyze, and manage corridor operations.

Figure 3 shows the relationship between the ongoing I-210 Pilot project, the proposed MCMOIP in California project, and their corresponding sources of funding. The I-210 Pilot, shown on the bottom, has already undergone a rigorous systems engineering process with initial deployment underway. The proposed project will build on this effort by designing and deploying additional Intelligent Transportation System (ITS) elements (shown here separately as matching contributions and ATCMTD contributions). These elements, and innovative data acquisition and communication strategies, will yield significant and measurable improvements compared to conventional traffic management practices that will enable a truly multimodal ICM system.

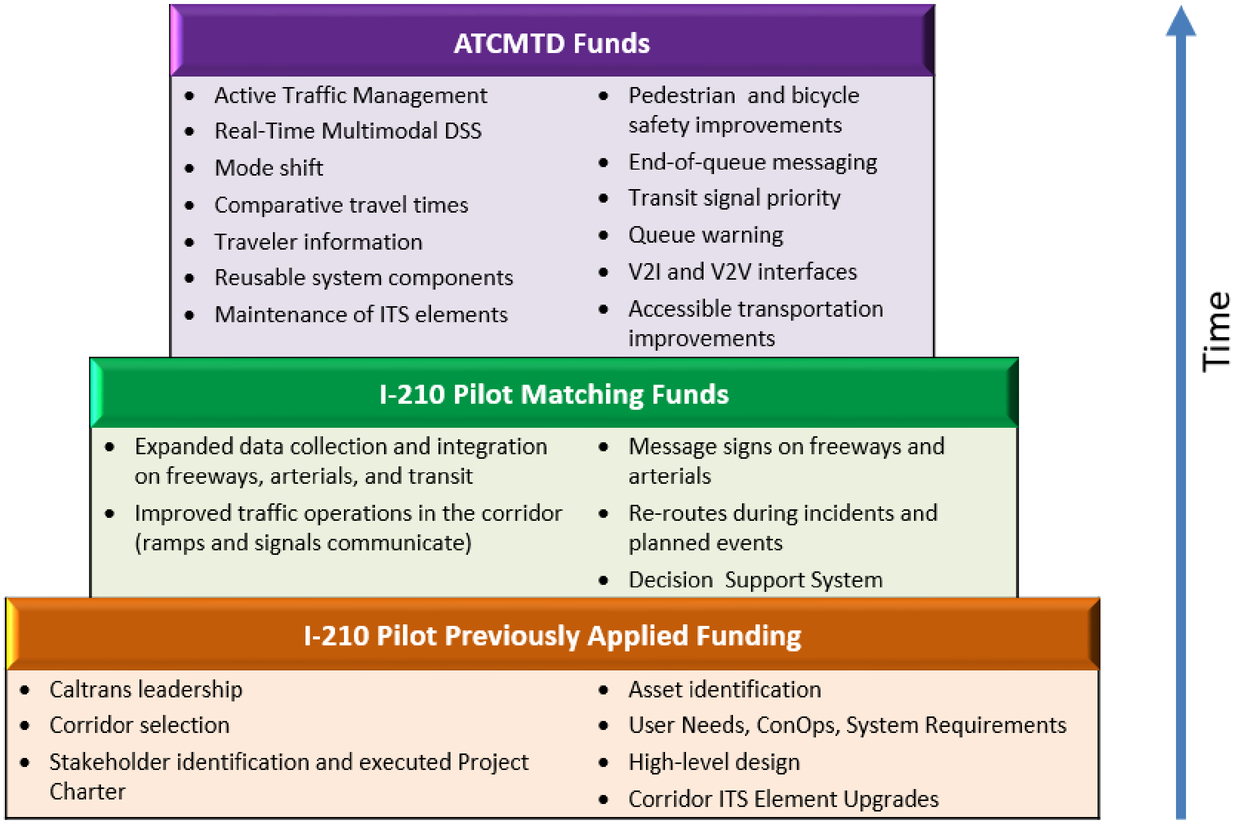

Figure 3: I-210 Pilot and ATCMTD Sources of Funding

1.2. APPLICANT

Caltrans is the applicant. The agency is responsible for managing California's state highway system, which includes more than 50,000 miles of highway and freeway lanes, in addition to providing inter-city rail services, and permits more than 400 public-use airports and special-use hospital heliports. Its mission is to ***provide a safe, sustainable, integrated, and efficient transportation system to enhance California's economy and livability.***

1.3. MULTIJURISDICTIONAL PARTNERSHIP

In 2012, Caltrans convened a team of stakeholders and industry experts to develop strategic initiatives for a statewide Connected Corridors program. Concurrently, the District began working with Caltrans Headquarters to implement cutting-edge technologies in one of the nation's most congested corridors. These efforts resulted in the establishment of the following multijurisdictional team:

- **California Department of Transportation (Caltrans)** – Both Caltrans District 7 (Los Angeles and Ventura Counties) and Caltrans Headquarters are partners in the project.
- **Los Angeles County Metropolitan Transportation Authority (LA Metro)** – Agency responsible for developing and overseeing transportation plans, policies, funding

programs, and both short- and long-term solutions to address Los Angeles County's mobility, accessibility, and environmental needs. LA Metro is also the third largest public transit operator in the country with a service area encompassing 1,433 square miles and more than 9.8 million people – nearly one-third of California's residents.

- **Los Angeles County –** Los Angeles County is one of the nation's largest counties, with 4,084 square miles and a population of 10.2 million. The partnership is primarily with the Public Works Department, which is responsible for the design, construction, operation, and maintenance of roads, traffic signals, bridges, airports, sewers, flood control, water supply, water quality, and water conservation facilities within county areas, including the unincorporated East Pasadena area along the I-210 freeway.
- **Cities of Pasadena, Arcadia, Monrovia, and Duarte** – These four San Gabriel Valley cities are situated along the section of I-210 where the project is located. With a population of 142,000 and 23.13 square miles, Pasadena is the ninth largest city in Los Angeles County. It is the home of the Rose Bowl, the Tournament of Roses Parade, the California Institute of Technology (Caltech), Pasadena City College, and the Norton Simon Museum of Art. Arcadia has a population of 57,000, covers 11.13 square miles, and is home of the Santa Anita Park racetrack and the Los Angeles County Arboretum and Botanic Garden. Monrovia has a population of 38,000 and covers 13.71 square miles, while Duarte has a population of 22,000 and covers 6.7 square miles.
- **Foothill Transit** - Primary transit service provider for the San Gabriel Valley area. The agency operates 39 bus lines within the area, primarily east of I-605, with some lines providing connecting service to downtown Pasadena and the El Monte Metrolink station along the I-10 freeway (a few miles south of the I-210 freeway).
- **San Gabriel Valley Council of Governments (SGVCOG)** – Joint Powers Authority made up of representatives of 31 cities, three Los Angeles County Supervisorial Districts, and the three Municipal Water Districts located in the San Gabriel Valley. The agency serves as a regional voice for its members and works to improve the quality of life of the more than 2 million residents of the San Gabriel Valley.
- **Southern California Association of Governments (SCAG)** – Metropolitan Planning Organization (MPO) for the Southern California metropolitan area. This is the nation's largest planning organization, representing six counties, 191 cities, and 18 million residents.
- **Partners for Advanced Transportation Technology (PATH) at the University of California, Berkeley –** Lead research institution on Intelligent Transportation Systems (ITS) at the University of California, Berkeley. At the beginning of 2017, PATH was designated as a Beyond Traffic Innovation Center and is coordinating with the Southern California Innovation Center (California State University, San Bernardino) to advance the initiatives outlined in the 2045 Beyond Traffic report.
- **Leonard Transportation Center –** The Leonard Transportation Center is the voice for integrated and sustainable transportation in the Southern California region located at California State University, San Bernardino. CSUSB and PATH are the "Beyond Traffic Innovation Centers" for Southern and Northern California, respectively.

The above agencies (with the exception of Cal State, San Bernardino) executed a Project Charter in June 2015 establishing a mutual understanding regarding the I-210 Pilot. The Charter (see Appendix A), defines stakeholders' roles and responsibilities for planning and working cooperatively on the I-210 project. The stakeholders agreed to a vision of a cooperative multimodal ICM framework that considers the entire transportation network and all opportunities to move people and goods in the most efficient manner possible including freeways, arterials, transit, parking, travel demand strategies, and agency collaboration to ensure the greatest potential gains in operational performance will be achieved. A Memorandum of Understanding (MOU) has been drafted that will take the Project Charter to the next level and identifies technical and operational responsibilities for the stakeholder agencies. The MOU includes details such as the governance structure, coordination on funding applications, technical requirements for the system assets (signals, detection, software, etc.), drafting and implementing the Transportation Management System (TMS) Strategic Plan, communication protocols, etc. Operations and Management/Maintenance of the I-210 Pilot will be covered in an O & M Agreement to follow the MOU.

1.4. PROGRAM AND FUNDING MANAGEMENT

Caltrans District 7 will manage the program and its funding (with oversight from the USDOT), since all of the proposed technology deployments are located within the District's jurisdiction. Caltrans District 7 will provide day-to-day ATCMTD project management in collaboration with the stakeholder agencies. The District will continue to coordinate with Caltrans Headquarters and PATH to ensure the I-201 Pilot and the ATCMTD components are delivered.

Caltrans District 7 is the lead agency for the I-210 Pilot and has been successfully managing this complex, multijurisdictional effort since 2012. District 7 Division of Traffic Operations has reorganized to effectively support corridor management. The new structure, currently being implemented, moves the Division from a function-based organization to a TSM&O business model that focuses on corridor and system management; addresses accountability for corridor performance; improves collaborative, multi-agency planning for operations; expands real-time active traffic management; and assigns specialized functional staff to each corridor.

The Statewide Connected Corridors Project Office at Caltrans Headquarters will continue to oversee the statewide Connected Corridors program in ensuring that decisions, staffing, and funding needs are supported as part of the statewide effort.

PATH will further assist Caltrans and the project stakeholders with project management, research, evaluations, outreach, and system integration technical assistance. In parallel, PATH will also continue the project management role that it has successfully played in the deployment and execution of the ICM Pilot.

Since matching funds are provided by both Caltrans State Highway Operation and Protection Program (SHOPP) funds as well as from LA Metro's 2015 Call for Projects, these organizations will continue to provide any assistance needed in ensuring that funding is distributed in a timely manner and applied appropriately.

1.5. GEOGRAPHIC AREA

The Corridor: The project location is a 12-mile corridor within the San Gabriel Valley, northeast of downtown Los Angeles. As illustrated in Figure 4, the corridor includes the cities of Pasadena, Arcadia, Monrovia, and Duarte, as well as unincorporated East Pasadena.

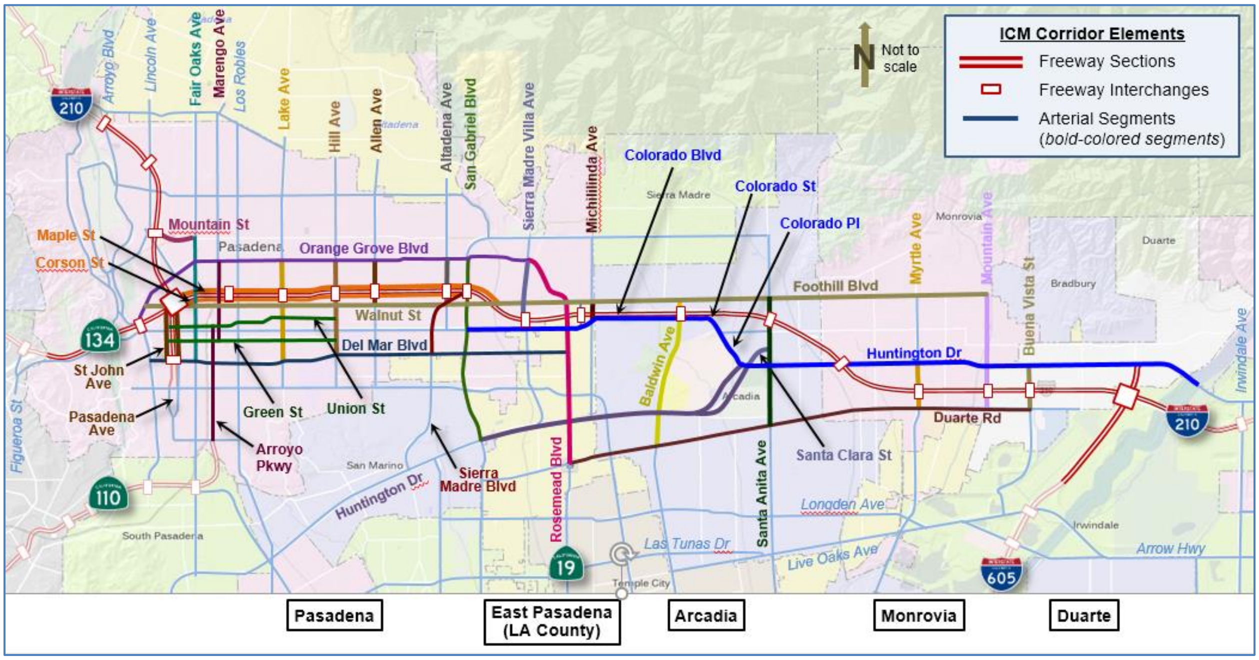

Figure 4: I-210 Corridor Freeway and Arterial Network

Freeway and Arterial Network: The corridor includes both the I-210 freeway and several parallel and crossing arterials. Many of these arterials, such as Walnut Street, Foothill Boulevard, and Huntington Drive, are already used by motorists to bypass incidents, particularly during peak hours. The network of parallel arterials provides many options for traffic rerouting. While this can be viewed as a benefit, these travel route options also create a very complex corridor to manage. This is due not only to the high number of possible route combinations, but also to the high number of freeway ramp and arterial traffic signals that may be affected by the traffic management strategies. Over 350 signals, operated in fixed-time, coordinated-actuated, or adaptive mode, are located along the potential detour routes. This is in addition to 30 metered freeway on-ramps and metered connectors at the I-210/I-605 interchange.

Light Rail and Transit: In addition to a dense roadway network, various transit services are operated within the corridor. Figure 5 illustrates the light-rail, rail, express bus, and commuter bus services provided by LA Metro, Metrolink, Foothill Transit, and the Los Angeles County Department of Transportation (LA DOT) in and around the corridor. Local bus and on-demand (dial-a-ride) transit services are also provided by the various cities along the corridor.

The transit services are further supported by parking facilities. Parking lots are operated by LA Metro at most light-rail stations, as well as other strategic locations. A few Park and Ride facilities are also operated by Caltrans and Los Angeles County. These are supplemented by several city-owned off-street parking lots and structures.

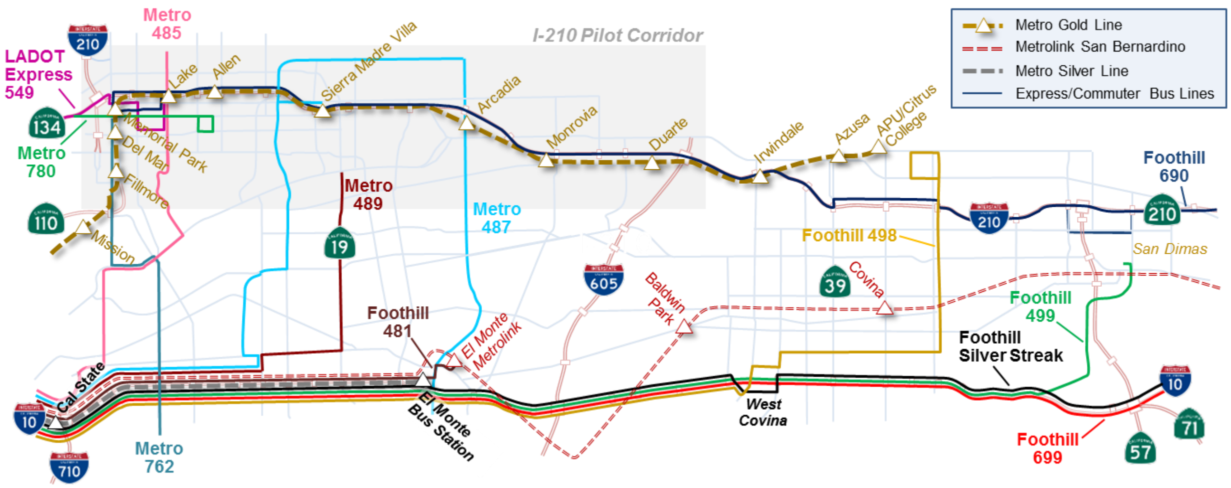

Figure 5: Light Rail and Express/Commuter Bus Services in I-210 Corridor

Bike Facilities: Bike paths within the corridor primarily consist of signed bike routes sharing the roadway with the general traffic (Class III paths), some on-street bike lanes (Class II paths), and a very limited number of fully-separated bike paths (Class I paths). As a result, cyclists generally share the road with the general traffic throughout the corridor.

Trip Generators: The corridor is served by a number of trip generators located in the vicinity. These include large event venues, such as the 90,000-seat Rose Bowl, the 25,000-seat Santa Anita Park, and the Pasadena Convention Center; a variety of public education institutions (Caltech, Pasadena City College, Mount Sierra College); and several major medical centers (Huntington Memorial Hospital, Methodist Hospital, City of Hope). These contribute to workforce development and community revitalization while providing essential services for the disadvantaged, people with disabilities, and elderly persons.

1.6. CHALLENGES AND ISSUES TO BE ADDRESSED

The following **key challenges** and issues are associated with the I-210 corridor:

- **Incidents and Events:** The I-210 corridor is one of the busiest and most incident-prone transportation corridors in California. It has very few days without incidents. Between 5 and 20 incidents are logged each weekday by the California Highway Patrol (CHP). In 83% of weekdays, the corridor experiences at least two collisions, while 40% of weekdays are affected by four incidents or more. Major incidents requiring the deployment of the Caltrans Traffic Management Team (TMT) occur once a month on average. Incidents and events affecting local arterials also periodically occur, including at large traffic-generating venues, such as sporting events at the Rose Bowl Stadium. The traffic congestion caused by incidents and events contributes significantly to increased greenhouse gas (GHG) emissions, reduced roadway safety, lost economic opportunity, and detrimental impacts on the quality of life in the corridor.

- **Safety:** Reduction of traffic-related fatalities and injuries together with implementation of countermeasures to mitigate the number and severity of traffic accidents is a priority for the USDOT and Caltrans. In 2013 alone, there were 7 fatal and 282 injury vehicle accidents on principal roadways within the corridor. The California Office of Traffic Safety collision information from 2012 shows 113 pedestrian and 170 cyclist fatalities and injuries. Approximately 40% of all roadway fatalities in Los Angeles County involve pedestrians or cycles. Without safety improvements, implementation of the proposed ATCMTD strategies (e.g., active lane management, queue warning) will likely not be as effective as desired. Also, dynamic routing of freeway traffic to local arterials could increase the number of interactions between vehicles, cyclists, and pedestrians. The newly opened Metro Gold Line light-rail extension is also already experiencing increased pedestrian and bicycle traffic within the corridor, thus raising the potential for conflicts. Preserving the safety and operation of the light-rail and I-210 roadway interfaces will also need to be considered.

- **Mode Shift:** Transit, bike, and pedestrian modes are traditionally underutilized in the region. Data from the 2008 to 2012 American Community Survey shows that pedestrians account for only 3.8% of trips within the San Gabriel Valley, while bikes account for 0.9%. Increasing the utilization of these modes can yield air quality benefits and help meet the goals of bicycle and pedestrian plans for the region, including the San Gabriel Regional Bicycle Master Plan and SCAG's 2040 Regional Transportation Plan.

  Promoting multimodal and active transportation within the corridor is challenging, as travelers are frequently unaware of alternatives, and often do not feel comfortable using the bike and pedestrian infrastructure.

- **Reusability of Solutions:** The implementation of ICM and ATM solutions relies on multijurisdictional agreements, new skill sets, and relatively complex computerized systems and applications. To effectively implement these solutions and to gain a return on investment across corridors, a reusable set of agreements, the development of new job descriptions for new skill sets, and the design of reusable software and application tools is needed. Without reusability, ICM development costs typically increase. There is also a greater risk of incompatibility between the proposed solution and existing/legacy systems, which may hinder cooperation, local smart city initiatives, and regional transportation management efforts.

Additional **related challenges** include:

- **Ensuring sufficient sensing infrastructure is in place and functioning**. The availability and maintenance of ITS elements, particularly those used for sensing, has traditionally been less than the level required for good decision-making. Ensuring that these elements are in place, working, and have good communication channels requires new approaches to maintenance.

- **Data Quality.** Current data, when available, is often of low quality, and this sometimes goes undetected. Using data of unknown quality reduces the accuracy of traffic management decisions and may worsen the performance and safety of transportation corridors.

- **Decision Support Tools**. Decision support tools are new to many transportation personnel and traditional industry partners. Most of these tools are still under development and not readily available from commercial vendors.
- **Traveler Behavior.** The industry requires a better understanding of how to influence traveler behavior, how to use new media to provide relevant information, and how to model and predict changes in traveler behavior.

Despite these challenges, the I-210 Pilot and the I-210 Multimodal Congestion Management and Operational Improvement Project (MCMOIP) will also benefit the Southern California economy by providing **pathways to job and economic opportunities** as a result of the proposed technology deployment. Some of these economic benefits include:

- Better access to the Metro Gold Line stations will improve access to job opportunities that were unavailable prior to the extension of the Gold Line.
- Improved bicycle and pedestrian access will give travelers more options for safely accessing jobs, commercial centers, medical facilities, and schools along the corridor.
- Improvement in corridor operations will make travel times more reliable, resulting in time savings for travelers and cost savings for goods movement.
- A small Medically Underserved Area (MUA) exists just south of the I-210 in Pasadena. There is also a Registered Nurse Shortage Area (RNSA) which overlaps the MUA and extends through most of the city of Pasadena and into the cities of Alhambra and San Gabriel. The proposed ATCMTD project work plan will evaluate this MUA and make recommendations for improved access to medical services where there are limited primary care offices. This will include multimodal accessibility via walking, bicycling, and/or transit to these areas.

1.7. TRANSPORTATION SYSTEMS AND SERVICES TO BE INCLUDED IN THE PROJECT

The proposed MCMOIP addresses the challenges described in section 1.6 through the deployment of ICM strategies and ATM technologies. These strategies and technologies include:

- Dynamic traffic rerouting harmonization around incidents and events
- Dynamic lane management
- Innovative safety improvements
- Effectively Informing Travelers and Operators
- Transit signal priority
- Promoting mode shift towards transit, biking, and walking
- Vehicle, bicycle, and pedestrian detection
- Improving maintenance of ITS elements
- Reusable system components
- Real-Time Multimodal Decision Support System (RTMDSS)

- Analysis, Modeling, and Simulation (AMS)
- Queue progressive warning
- V2I and V2V interfaces
- Connected vehicles
- Accessible transportation improvements

Table 1 indicates how the proposed ICM strategies and ATM technology solutions address the various goals listed in the ATCMTD Notice of Funding Opportunity. Each solution is described in more detail in the following sections.

Table 1: Link between ATCMTD Goals and MCMOIP Solutions

ATCMTD Goals	MCMOIP Solutions												
	Dynamic Reroute	Safety	Trav Info	TSP	Mode Shift	Detection	Maintenance	Reusability	RTMDSS	AMS	Queue Warning	V2I and V2V	Accessibility Improvements
Reduce costs and improve return on investments (via enhanced use of transportation capacity)	✓				✓								
Environmental benefits	✓		✓		✓				✓		✓	✓	
Measure and improve the operational performance of the transportation system		✓							✓	✓	✓		
Reduce number and severity of traffic crashes; increase safety		✓									✓		
Collect, disseminate, and use real-time transportation information to improve mobility, reduce congestion, and provide more efficient and accessible transportation	✓		✓						✓	✓	✓		
Monitor transportation assets to improve infrastructure management, reduce maintenance costs, prioritize investment decisions, and ensure a state of good repair						✓	✓					✓	
Economic benefits: reduced delays; improved system performance; efficient and reliable movement of people, goods, and services	✓	✓			✓				✓	✓	✓	✓	✓
Accelerate deployment of V2V, V2I, and automated vehicles				✓					✓			✓	
Integrate advanced technologies into TSM&O				✓					✓		✓	✓	
Demonstrate, quantify, and evaluate the impact of advanced technologies, strategies, and applications to improve safety, efficiency, and sustainable movement of people and goods	✓	✓	✓	✓		✓	✓			✓	✓	✓	
Reproducibility of successful systems and services for technology and knowledge transfer								✓		✓			

1.7.1. REROUTING OF AUTOS, TRUCKS, AND BUSES AROUND INCIDENTS AND EVENTS

As indicated earlier, the I-210 corridor frequently experiences significant disruptions due to incidents and events. During these incidents and events, congestion often develops on the freeway, particularly during peak hours. To help alleviate this congestion, the system will seek to use unused capacity on nearby roadways to reroute traffic around the incident or event. This will be achieved by first identifying suitable detours and subsequently modifying the operation of traffic signals and ramp meters along the identified detours to ensure that the selected routes can accommodate the expected influx of traffic. A more detailed operational scenario, albeit very detailed, is shown in Figure 6. While the typical perception is that freeway traffic will be routed along nearby arterials, the RTMDSS would also trigger redirection of arterial traffic onto I-210 when incidents or events are experienced within the corridor.

While the dynamic routing process may appear trivial, the extent to which it can reduce freeway congestion depends on several factors. For instance, while unused capacity along arterials may be sufficient to accommodate freeway traffic during off-peak periods, very limited capacity may be available during peak traffic times. Modifying signal operations along arterials may also significantly affect side-street traffic and result in local congestion. Reducing ramp metering flow rates could further create vehicle queues that spill onto nearby streets. The ability to modify signal operations further depends on centralized control capabilities and the specific capabilities of the local signal controllers. Additional factors, such as the desire to avoid sending too much traffic in active school zones or high-pedestrian areas may also affect decisions.

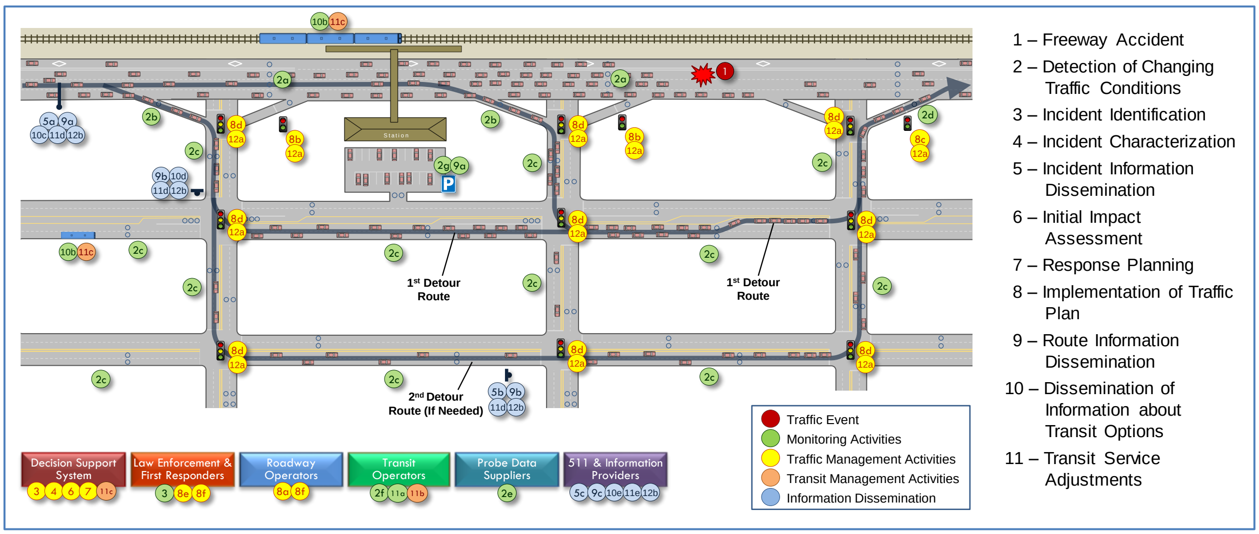

Figure 6: Example of Response to Major Freeway Incident

The key challenges for the proposed MCMOIP are thus not only to determine what detour route, or routes, to use around an incident, but also to determine how much traffic can realistically be sent along each selected route and how to effectively direct traffic within the corridor to optimize available capacity.

To make the appropriate routing decisions, data on traffic volumes and speeds along each roadway is needed to determine where congestion is occurring and how much capacity remains available. Turning counts at key intersections are also needed to assess routing patterns and determine appropriate signal phasing. This information will be obtained from traffic sensors and travel time measurement devices installed throughout the corridor, often in support of traffic signal operations. While over 95% of the 450 signalized intersections located within the corridor are already equipped with traffic detectors, only a minority currently forward traffic detection data to a central location, and few provide turning counts. This will require some upgrades in data communication, traffic surveillance, and detection capabilities throughout the corridor.

In addition to traffic data linked to signal operations, other data sources will be leveraged to assess corridor operations and support ICM decisions. Data sources and information will be integrated into the ICM system operations from the following existing or planned systems:

- Travel time data supplied from Bluetooth traffic monitoring systems operated by Pasadena, Arcadia, and Los Angeles County (existing systems to be expanded).
- Parking occupancy data from park-and-ride lots operated by LA Metro along the Gold Line (a new system is already in development and expected to be deployed by LA Metro next year).
- Speed and travel time data from probe vehicle tracking data supplied by Inrix or HERE
- Origin-destination and routing patterns extracted from cell-phone tracking data supplied by mobile phone service providers.

In addition to the data integration work, some equipment upgrades will be required to ensure that traffic signal controllers at key intersection are capable of implementing the desired control actions. While the use of advanced controllers, such as Type 2070 controllers, would be ideal, the system will be designed to also work with equipment frequently used by small cities, such as Type 170 controllers. The key is to have, at a minimum, local signal controllers that hold a number of predefined plans and that can receive remote instructions to change the active plan.

A final element will be the installation of arterial and freeway signage providing guidance to motorists. This will involve the use of static and electronic signs, as well as information dissemination to regional 511 systems and third-party navigation application providers such as Waze. The challenge is to deploy an information system flexible enough to address the variety of possible reroute assignments that may be used.

1.7.2. DYNAMIC LANE MANAGEMENT

A managed lane is an exclusive- or preferential-use lane that is managed proactively in response to changing conditions in order to achieve improved efficiency and performance. Managed lanes use operations strategies such as access control, vehicle eligibility, and tolling, or a combination thereof. These strategies are determined based on factors such as safety, regional and interregional consistency, impacts on freeway performance, enforcement needs, environmental considerations, and community support. Strategies may be adjusted to meet required performance standards or to address other managed lane or freeway performance issues. A managed lane is defined as one of the following: high-occupancy vehicle (HOV) lane, high-occupancy/toll (HOT) lane where tolled vehicles can also access the HOV lane, express toll lane (ETL) where all vehicles must pay a toll to access the lane, and dynamic shoulder lane. Focus group meetings and telephone surveys will be used to gauge public support of various alternatives. In Caltrans District 7, there are currently 556 lane miles of managed lanes and the technologies for the I-210 Pilot will be determined based upon safety, performance, environmental issues, etc. and will be real-time and actively managed. The following types of ITS and traffic control devices may be deployed:

- Static signs to notify drivers of eligibility to use a dedicated lane and times indicating when restrictions are in place.
- Overhead lane control signals and/or changeable message signs to accommodate highly directional demand.
- Access treatment and lane separation strategies to manage the speed differential often associated with managed lanes.
- Automated and on-site monitoring, enforcement, and incident response capability to help assure travel time reliability and safe operations.
- Variable pricing through electronic tags that vary tolls by time of day or by demand to more efficiently utilize lane capacity.

1.7.3. SAFETY IMPROVEMENTS

Improving safety along the I-210 corridor is an important project goal. As indicated previously, 113 pedestrians and 170 cyclists were killed or injured in the corridor in 2013. This is in addition to 7 fatal and 282 injury vehicle accidents occurring on the freeway, and 7 fatal and 13 severe injury vehicle accidents on principal corridor arterials near the freeway.

Many jurisdictions are concerned that rerouting traffic onto the arterials as a measure to manage incidents may increase the risk of collisions between vehicles and pedestrians or cyclists. Concerns were also expressed that a higher proportion of drivers unfamiliar with the roadway environment may present an additional challenge.

To help alleviate these risks, the following elements are proposed:

- Installation of speed advisory/queue warning information devices at strategic locations along the I-210, to reduce traffic speeds on the approach to congested areas and the likelihood of primary collisions along the freeway and impacts on Light Rail operation.
- Installation of bike and pedestrian sensors at key intersections within the corridor to ensure that pedestrian and cyclist needs are adequately considered and to reduce collisions at signalized intersections.
- Improvements to crosswalks in Duarte, where the opening of the Gold Line light rail has significantly increased conflicts between cars, cyclists, and pedestrians.
- Deployment of High-Intensity Activated Crosswalk Beacons (or similar technology) at existing crosswalks in the corridor (initially in Arcadia and Duarte) along arterials that may be used as freeway detours, to increase visibility for pedestrians.

The safety improvements considered were identified in consultation with the local jurisdictions, in accordance with their respective General Plans. They also aligned with the USDOT's "Safer People, Safer Streets" initiative, which aims to address non-motorized safety issues and help communities create safer, better connected bicycling and walking networks.

1.7.4. EFFECTIVELY INFORMING TRAVELERS AND OPERATORS

Implementing the proposed ICM strategies requires that accurate, timely, and readily available information be provided to travelers and system operators. To achieve this, the RTMDSS will generate real-time messages indicating recommended alternate routes and modes available during an incident and provide comparative car/transit travel time estimates. End-of-queue warnings will be displayed on the freeway to reduce collision risks. These messages will be displayed on freeway changeable message signs, arterial message signs, and the regional 511 information service, as well as through new media (Twitter, etc.), and third-party navigation providers (Waze, etc.). Depending on the capabilities of each distribution platform, these messages could potentially be personalized for individuals. Trip-planning information, focused on motivating and encouraging mode shift, will also be available on a central website and will be communicated through outreach meetings with stakeholder personnel.

1.7.5. TRANSIT SIGNAL PRIORITY

Transit Signal Priority technology will be deployed at key intersections to provide priority to buses at signalized intersections for express, commuter, and local lines operated by Metro and Foothill Transit. This includes equipping strategic intersections along Huntington Drive in Arcadia to support priority for the Arcadia Gold Line Shuttle.

In keeping with other priority systems deployed by Metro within the region, the transit signal priority technology along the I-210 corridor will be integrated into existing traffic signal coordination schemes to allow for backwards compatibility with existing systems and future connected vehicle applications. Transit signal priority strategies include:

- Extending the green light for up to ten seconds past the normal green time to avoid being stopped at a red light
- Shortening the existing red light by up to ten seconds to reduce delays or avoid a stop

Results from previous deployments in the region indicate that these improvements can reduce bus delays at signalized intersections by approximately 35% and total bus travel time by about 33% without significantly impacting cross-street traffic. A significant reduction in travel time variability, and thus an increase in reliability, was also obtained. Additional anticipated benefits include increased attractiveness of transit, and economic benefits through improved person-based system throughput.

1.7.6. PROMOTING MODE SHIFT TOWARDS TRANSIT, BIKING, AND WALKING

One of the goals of the Multimodal ICM is to increase the attractiveness of transit, biking, and walking travel modes and encourage a growing number of travelers to use them. The potential for mode shift along the I-210 corridor is evidenced by the recent opening of the Gold Line extension, which extended the line east by 11 miles, to the city of Azusa. The six new stations all have parking facilities and bike lockers and/or bike racks. Two months after its opening, the new line is already carrying 4,000 to 5,000 riders per day, with projections that ridership could reach 65% of the planned 2035 level within the next two months. About 66% of these riders previously drove to work, according to a four-week survey conducted by LA Metro, and with improved traveler information, this percentage will be even higher.

For travelers to seriously consider shifting modes, they require information, access, and a sense of safety. Mode shift occurs when travelers understand their various travel choices; thus, information must be provided to allow them to compare the benefits of each mode. Travelers must also have adequate access to the alternate modes, including parking opportunities at transit stations, bike racks or lockers, and walkways to the transit facilities. Travelers must also feel safe using the alternate mode, whether it is riding a bus or biking along a designated path on a given street.

Supplementing the travel time comparisons from existing trip planning tools (such as Google Maps), the proposed project will post real-time comparative car/transit travel times on select freeway and arterial changeable message signs. This real-time information will be extracted from collected traffic data and transit operational data. Transit signal priority technology will be deployed at several intersections to improve bus travel time reduction and reliability on arterials. Planned crosswalk improvements at key arterials will encourage walking and bicycling to transit stations, bus stops, medical facilities, schools, and employment sites. Parking counts and parking space availability information will be coordinated with a project that LA Metro is implementing.

1.7.7. VEHICLE, BICYCLE, AND PEDESTRIAN DETECTION

Detection is an essential component of ICM and ATM strategies. The RTMDSS will utilize accurate and timely data to suggest traffic management strategies and incentivize mode choice. Local city intersections will detect pedestrians and ensure traffic signal timings allow for sufficient time for safe crossings. Bicycle detection will be used to ensure actuated signals are aware of bicycles. Detection will also be used to determine where bicycle and pedestrian demand is highest so that simulation and real-time models can accurately suggest response plans.

1.7.8. IMPROVING MAINTENANCE OF ITS ELEMENTS

Responding to incidents, rerouting vehicles, recognizing safety concerns, providing useful messages to travelers, and ensuring that quality data is available all require reliable ITS elements, communication lines, and back-end software. As part of this proposal, the project team will set reliability and availability goals for ITS devices and communication and software elements. The stakeholder agencies will also develop and implement new procedures for meeting those goals. Periodic reports will be generated to determine how the established goals are met.

These efforts will occur in parallel to an effort underway at Caltrans aimed at ensuring that institutions and organizations are properly staffed and working at reliable levels. Stakeholder agencies recognize that appropriate levels of maintenance are needed for both equipment and organizations, particularly when managing ICM efforts.

1.7.9. REUSABILITY

Successful reusability requires both technical and organizational support. Technical support ensures that software components are carefully designed and have well-documented interfaces. The Connected Corridors architecture shown in Figure 7 was developed to ensure easy integration of the ICM system with regional subsystems. Organizational support is supplied by the connected corridors statewide program. Since its inception, this program has been working to set standards, provide implementation funding, design statewide organizational structures, and ensure that tools and processes are reusable. Information and documentation are available on the connected corridors website (http://connected-corridors.berkeley.edu/). Finally, institutional motivation has been supplied by Caltrans by making the adoption of ICM systems statewide a strategic priority. The California legislature recently passed a roads bill (SB-1) that secures additional funding for congested corridors programming throughout the state. Over the next ten years, $2,500,000,000 is available for congested corridors projects “designed to achieve a balanced set of transportation, environmental, and community access improvements within highly congested travel corridors throughout the state.” [SB-1 Bill Text, May 1, 2017] California has five or six of the nation’s most congested travel corridors, which are in Los Angeles, the San Francisco Bay Area, the Inland Empire, San Diego, and increasingly, the central valley. Reusable components of the I-210 Pilot will help alleviate congestion in these corridors.

1.7.10. UTILIZING A REAL-TIME MULTIMODAL DECISION SUPPORT SYSTEM

The Real-Time Multimodal Decision Support System (RTMDSS) is the heart of the ICM and ATM implementation. This system will determine the best multimodal response plans to address the congestion developing around incidents in real time, assess the savings that can be achieved by travelers considering a travel mode shift, identify safety risks, and issue appropriate messaging and traffic control responses to promote the efficient use of existing transportation systems. When used for planning, the system will permit analyzing “what-if” scenarios supporting response planning activities, safety improvements, and mode shift educational programs.

The RTMDSS will be primarily used to respond to incidents and events. This system will accept real-time and historical data from sensors, traffic control equipment, and third-party providers. It will also assess the quality of the data by filtering it and tracking sensor health status. The data will then be used to estimate the state of the corridor and to determine, using a set of predefined rules, possible network control and traveler management strategies (response plans) to address active incidents or events. The system will use evaluation models (traffic, environmental, and energy) to assess how the various response plans might affect corridor performance. The system then selects, using agreed-upon performance goals, a response plan to implement to address the active incident or event.

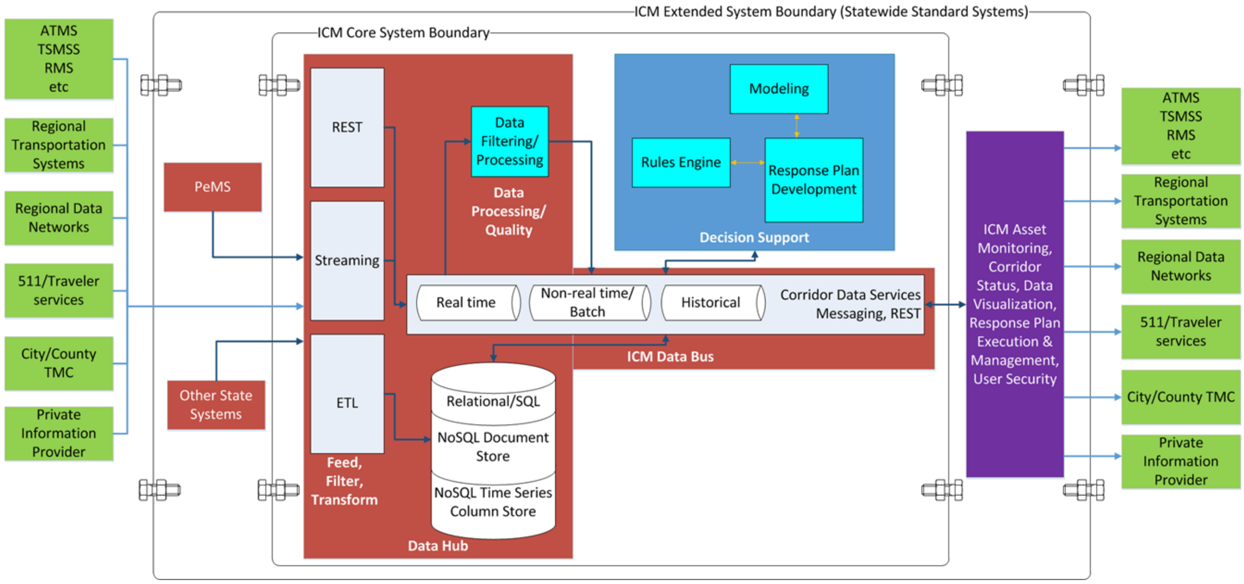

Figure 7: RTMDSS Architecture

Figure 7 shows the overall architecture within which the decision support system will operate. It will be a cloud-based software system, developed using innovative algorithms and technology. This proposal supports enhancing and upgrading the items shown in turquoise, i.e., the Modeling, Rules Engine, Response Plan Development, and Data Filtering and Processing components necessary to accommodate new data interfaces enumerated under Section 1.7. Caltrans is providing the remainder of the system components as depicted in the red and purple areas through a separate procurement contract.

1.7.11. ANALYSIS, MODELING, AND SIMULATION (AMS)

Over the last year, the team has made considerable progress on the development of a model of the I-210 corridor. The model is one of the largest models presently available in the U.S. with over 400 intersections, transit and bus stops, and even school zone locations and hours. The model will be used extensively throughout the life of the project. Its five primary purposes are:

- Pre-planning to inform and validate the process of building incident response plans
- Real-time to score a response plan for use by the Decision Support System when the Pilot is deployed
- Retrospective to improve response plans and prediction capabilities and post-incident evaluations
- Special planning to inform other special planning needs
- Outreach and stakeholder support to visually demonstrate progress and build confidence

The response plans are currently in development and will be expanded to include additional technologies funded through this grant. Existing data sources are being regularly reviewed for accuracy and new data sources will continue to be added as available. As a part of the review of the response plans with stakeholders, the model will be used to simulate how a response plan would impact conditions in the corridor. Once deployed, the DSS will regularly simulate response plans to determine the best course of action. Additionally, the model will be updated following incidents to ensure it is matching what is actually occurring in the corridor.

In support of the model, a PeMS sensor monitor tool has been developed and is analyzed weekly to improve and maintain the health of the traffic sensors in the corridor. Currently, only Caltrans data is updated automatically, however, the team is actively working to include sensor data from all four cities and LA County.

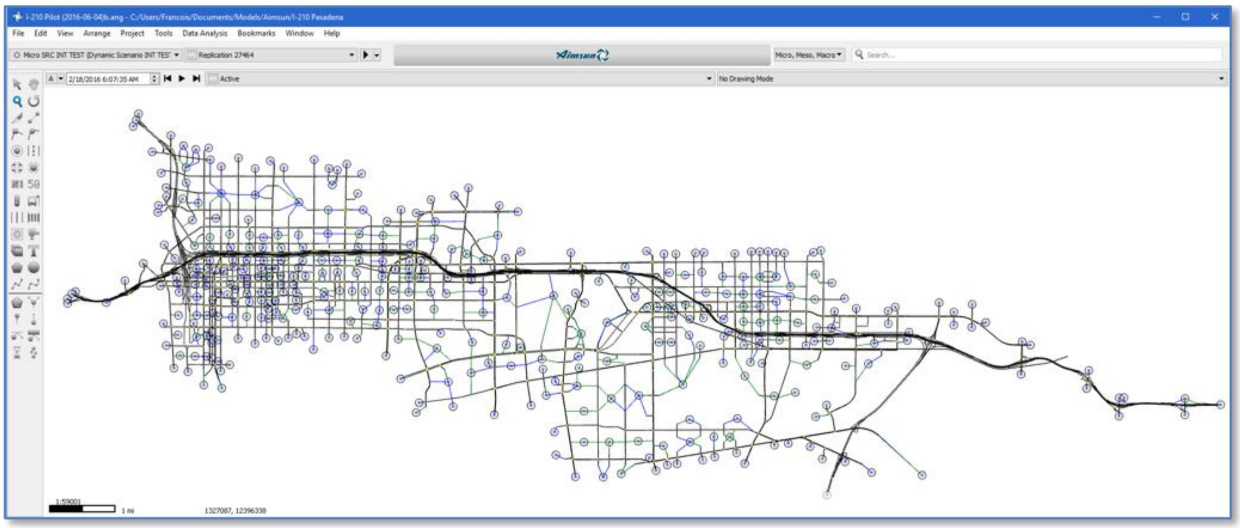

Figure 8: Screenshot of Developed Model of the I-210 Corridor

1.7.12. QUEUE PROGRESSIVE WARNING

Queue warnings inform travelers of the presence of downstream stop-and-go traffic (based on real-time traffic detection) using warning signs and flashing lights. Drivers can anticipate an upcoming situation of emergency braking and slow down, avoid erratic behavior, and reduce queuing-related collisions. Dynamic message signs show a symbol or word when stop-and-go traffic is near. Speed harmonization and lane control signals that provide incident management capabilities can be combined with queue warning. The system can be automated or controlled by a traffic management center operator. Work zones also benefit from queue warning with portable dynamic message signs units placed upstream of expected queue points. Benefits include: Reduced primary and secondary crashes by alerting drivers to congested conditions; delayed onset of congestion improving smooth and efficient traffic flow and trip reliability; and environmental benefits through decreased emissions, noise, and fuel consumption.

1.7.13. V2I AND V2V

Numerous V2I technologies are currently under development. The plan is to have the I-210 be a test bed for a number of V2I and V2V communication systems. For example, an app could provide spoken information to the driver about incidents and/or congestion and/or drivers could receive information about signal timing and phases. UC Berkeley/PATH and Caltrans have been working on a number of projects that may be tested (or further tested) on the I-210 corridor including:

- Intelligent traffic signal systems
- Transit signal priority
- Mobile accessible pedestrian signal system
- Emergency vehicle preemption
- Truck platooning

Additional studies are underway with Nissan and BMW.

1.7.14. CONNECTED VEHICLES

Connected Vehicle technology provides driver assistance functions by using wireless communications with other vehicles and infrastructure to gather information about the environment. The I-210 MCMOIP will integrate the findings from another PATH project whereby new traffic signal control strategies using data from connected vehicles will improve mobility and safety. Caltrans and UC Berkeley PATH updated California's connected vehicle test bed in Palo Alto (SR-82) in 2014. The upgraded test bed provides up-to-date equipment and infrastructure for government agencies and the private sector to test connected vehicle applications and perform certification activities. The test bed supports cutting-edge research for connected vehicle safety, mobility, and infrastructure-related applications, services, and components. It serves as a real-world platform for regional industries and research labs. The technology can be deployed and tested in the I-210 corridor.

1.7.15. ACCESSIBLE TRANSPORTATION

The City of LA, LA Metro, Pasadena, and Arcadia have accessible transportation services (for example, Dial-A-Ride), departments, and/or vehicles. To address accessibility to medical services, educational institutions, and services in the I-210 Corridor, an I-210 Accessibility Committee will be set up to advance technologies and information to the disabled, seniors, disadvantaged groups, and persons who do not drive, to ensure that they have continued and improved access. As a starting point, existing agencies and community groups will be contacted to participate on the Committee, and new technologies in the areas of wayfinding focusing specifically on those with visual impairments, mobility on-demand travel services with reduced fares, and advances in V2I infrastructure (particularly for pedestrians at major intersections) may be prioritized.

1.8. DEPLOYMENT AND OPERATIONS & MAINTENANCE PLANS

1.8.1. DEPLOYMENT PLAN

In addition to capital project development and delivery, deployment of a complex Multimodal ICM system consists of several efforts, including the equipment procurement, hardware and communications, new software and data management/storage functions, systems integration, and new processes and training. Each of these steps is described in more detail below.

1) **Deployment of hardware and communications**. Caltrans, working with both in-house and contracted personnel, will install hardware and communication lines required to implement the proposed technology deployments. The agency and its contractors are experienced at the installation of complex ITS elements.
2) **Deployment of new software (RTMDSS and system interfaces), data management, and data storage functions**. Caltrans, working with in-house IT personnel, PATH, and contracted personnel, will deploy software and data functions. A cloud-based computing platform will be utilized to provide this functionality. This ensures a simple deployment, removes the need to purchase and install equipment, and ensures simple scaling of computing and storage resources.
3) **Deployment of new processes and newly trained personnel**. Caltrans and corridor stakeholders will deploy, through training and awareness seminars, the new processes required to operate and maintain a multimodal ICM system. As previously indicated, Caltrans has realigned to focus on performance management. This will provide a solid base of trained personnel to carry out ICM. Lengthy roles and responsibilities are being included in the system requirements to ensure the correct job duties are identified and new personnel assigned to these positions as needed.
4) **Systems integration**. The bringing together the hardware, communications, software, processes, infrastructure, and personnel will occur as part of a one-year deployment and operations period during which problems will be identified and resolved.

1.8.2. OPERATIONS AND MAINTENANCE PLAN

Caltrans is committed to operating, maintaining, and supporting the overall ICM and ATM system. This includes the hardware and communications lines on state-owned right-of-way, the RTMDSS software and data management functions, and the overall processes and personnel.

The cities of Pasadena, Arcadia, Monrovia, and Duarte, and the Los Angeles County Department of Public Works are responsible for and committed to operating and maintaining the equipment and infrastructure deployed within their agency boundaries. Through existing agreements, Los Angeles County also provides centralized traffic signal control services for the cities of Monrovia and Duarte. Detailed responsibilities for operating and maintaining the system will be in the MOU and the O & M Agreement outlined previously.

1.9. DEPLOYMENT CHALLENGES AND OBSTACLES

Implementation of ICM systems is a complex effort carrying inherent risks and challenges. While there are some small regulatory or legislative challenges (for example, what is allowed on a CMS sign, or regulations governing what equipment Caltrans can provide to cities), none of these are considered to be serious risks to the program.

The larger risks lie in the institutional and cultural challenges. Multimodal, multijurisdictional transportation system management requires a focus on communication and agreement among stakeholders. Caltrans understands this risk and, through organizational realignment, is placing importance and focus on corridor operations. While the probability is low, a new City Council or Board of Supervisors member who may not be as supportive of integrated corridor management technologies could question the investments. Since all of the corridor stakeholders have signed a Project Charter and agreed on a concept of operations and requirements, the overall risks have been significantly reduced.

Another challenge is to successfully deploy a complex system requiring a large number of items (hardware, communication, software, databases, processes, and personnel) to be developed or hired in a timely manner and subsequently integrated to work as a unified whole. Caltrans has a mature capital project development process and proven track record in project delivery. The program is following the systems engineering process and working with experienced consultants as a way to mitigate these risks.

1.10. QUANTIFIABLE SYSTEM PERFORMANCE IMPROVEMENTS

The proposed MCMOIP is expected to have the following measurable impacts on corridor operations:

Table 2: Expected Performance Improvements

Improvement	Impact
Mobility Improvements	• Reducing the total number of vehicle/people hours of delay incurred in the corridor during incidents and events • Improving multimodal (person-based) throughput during incidents and events • Reducing travel time variability • Improving bus transit travel times • Increasing the utilization of existing transportation infrastructure
Safety Enhancements	• Reducing the rate of primary collisions that occur as a result of unusual congestion or traffic patterns • Reducing the rate of secondary collisions • Reducing pedestrian and bike accidents
Environmental Improvements and Use of Alternative Transportation Modes	• Raising the share of transit trips taken during major incidents • Raising the share of transit trips taken during normal operations • Raising the share of trips involving bicycle and walking segments • Reducing greenhouse gas emissions

1.11. QUANTIFIABLE SAFETY, MOBILITY, AND ENVIRONMENTAL BENEFIT PROJECTIONS

A before-after evaluation (or support for a third-party evaluation) will be conducted to measure the project's impact on mobility, safety, and the environment. System performance data for this evaluation will be collected using both the existing and new detection devices that will be installed as part of the project. Existing databases such as California Highway Patrol's (CHP) Computer-Aided Dispatch (CAD) system and the Statewide Integrated Traffic Records System (SWITRS) will further be used to track collision data. Air quality sensor data will be used to monitor greenhouse gas emissions.

The following performance targets have been established for the project:

Table 3: Performance Targets

Benefit	Target
Mobility Benefits	• 5% reduction in the total number of vehicle/people hours of delay incurred in the corridor during incidents and events • 5% increase in multimodal throughput during incidents and events • 20% reduction in travel time variability • 5% reduction in bus transit travel times
Safety Benefits	• 10% reduction in the rate of primary collisions that occur as a result of unusual congestion or traffic patterns • 20% reduction in the rate of secondary collisions • 10% reduction in pedestrian and bike accidents
Environmental Benefits and Use of Alternative Transportation Modes	• 5% increase in the share of transit trips taken during major incidents • 2% increase in the share of transit trips taken during normal operations • 5% increase in the share of trips involving bicycle and walking segments • 5% reduction in greenhouse gas emissions

1.12. VISION, GOALS, AND OBJECTIVES FOR THE TECHNOLOGY DEPLOYMENT

The Connected Corridor's overall vision is to unify vehicles, infrastructure, and people into one effective decision-making system operating across transportation networks. It assumes that every device, person, and organization on the transportation network will be intelligent, connected to the Internet, and interested in both providing information for and being provided information to help with global and individual decision making using all modes of travel. The decision making would integrate with higher-order Smart City and Smart Region priorities.

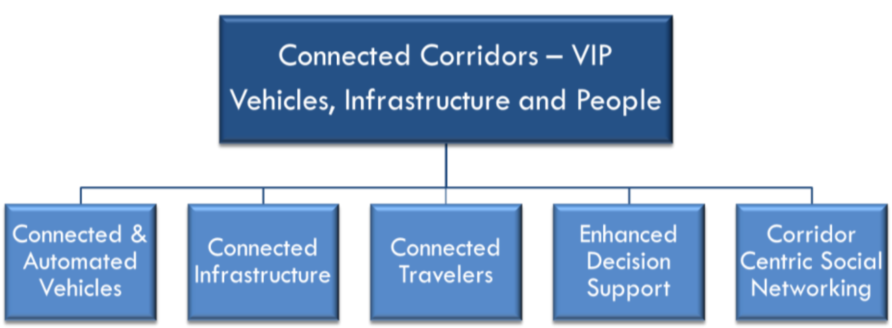

Figure 9: Connected Corridors Vision

To achieve this vision, the following goals and objectives have been established for Connected Corridors:

Table 4: Connected Corridors Goals and Objectives

Goal	Objectives
System-wide Performance Improvements	• Improve multimodal throughput, reliability, and travel time • Manage overall system demand through improved trip planning and better use of multi-passenger vehicles • Improve safety through reduced collisions for autos, trucks, bicycles, and pedestrians
Promote Active Transportation	• Raise the share of transit trips taken • Raise the share of trips involving bicycle and walking segments
Empower Travelers and Operators to Make Better Decisions	• Utilize enhanced data sources to provide real-time information to travelers • Improve decision support capabilities • Improve information availability through new media • Use information and social networking tools for real-time incentivization • Grow our understanding of human behavior in complex systems
Prepare for V2I and V2V	• Plan for and install V2I Components • Improve models and decision support systems to include vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) systems
Integrate and Enable Smart Cities and Regions	• Enable next generation urban ecosystems • Grow decision support to include more variables, performance metrics, and the ability to work with unpredictable human behavior

1.13. PARTNERING PLAN

Government, academic, consulting, and commercial organizations are already working together to bring the I-210 Pilot and statewide efforts to fruition. Figure 10 illustrates the existing partnerships, which are the result of four years of committed work to promote the ideals of ICM systems, develop shared funding, and ensure agency participation in eventual system operations.

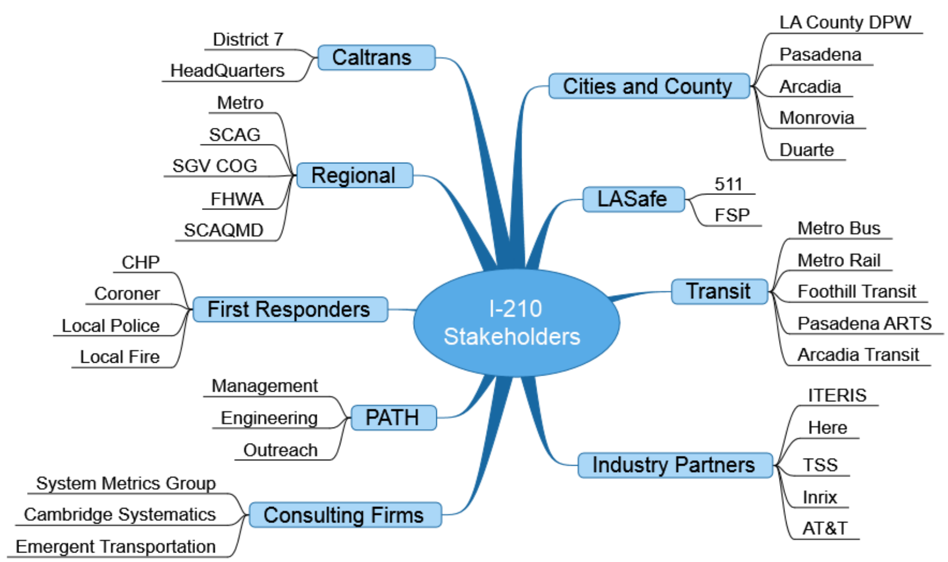

Figure 10: I-210 Pilot Existing Partnerships

As stated, I-210 corridor agencies have already signed a Project Charter. A Memorandum of Understanding (MOU) for use during deployment and operations is under development.

1.14. TRANSPORTATION TECHNOLOGY INVESTMENT LEVERAGING PLAN

Key existing transportation technology assets will be leveraged to deploy the proposed MCMOIP and support its operation. This will significantly reduce the overall cost of the proposed deployment. Some of the major assets to be leveraged are summarized below.

To the extent possible, existing centralized data collection and control capabilities at Transportation Management Centers (TMCs) will be utilized. Interfaces are being developed to enable the ICM system to communicate with the Los Angeles Regional TMC (operated by Caltrans and the CHP) on a 24-hour/ 7-day-a-week basis, the Los Angeles County TMC, the Pasadena TMC, and Arcadia's traffic signal control system. While the cities of Monrovia and Duarte do not have a TMC, a hosting agreement with the Los Angeles County Department of Public Works allows their signals to be operated from the County's TMC.

The cities of Pasadena and Arcadia, as well as Los Angeles County, have invested significant amounts of money developing centralized traffic signal control capabilities. These capabilities will be taken into consideration in the development of the RTMDSS. Project funds will also be used to connect additional signals within Monrovia and Duarte to the County's centralized traffic signal control system and expand the number of intersections that are controlled centrally.

Extensive detection capabilities covering the I-210 mainline and most on-ramps and off-ramps already exist. This includes the ability to retrieve, visualize, and analyze up to 10 years of freeway data using Caltrans' Freeway Performance Measurement System (PeMS). This deployment will enhance the PeMS interfaces so that this existing system (currently in its 15th version) can continue to be utilized for data visualization and analyses.

While most of the corridor arterials are already equipped with traffic detectors, generally to support actuated signal operations, the data generated by these devices are in most cases not collected. An exception is the City of Arcadia, which keeps a 6-month traffic data archive. The proposed deployment will establish appropriate data communication channels with key corridor intersections and establish necessary data storage and processing capabilities.

Bluetooth travel time monitoring systems have already been deployed within the corridor. This includes a 13-device system covering the City of Arcadia and a small system around the Rose Bowl in the City of Pasadena. Los Angeles County has also started a deployment in unincorporated county areas, although not within the I-210 corridor. The ATCMTD funds will allow for an expansion of these systems. This will potentially include an expansion of the I-210 and County system to provide travel time coverage across the cities of Monrovia and Duarte.

Major transit agencies within the corridor have already implemented Automated Vehicle Location (AVL) and Automated Passenger Counting (APC) systems, as well as real-time arrival information tracking through either a NextTrip or Connexionz application. The proposed technology deployment will facilitate the transfer of real-time data generated by these systems to the regional 511 system and to system managers and operators.

Various near-term system deployments or upgrades currently being planned will further support ICM system operations. This includes LA Metro's planned installation of parking occupancy monitoring systems at all park-and-ride facilities along the Gold Line light rail system, which will provide an opportunity to share real-time parking occupancy information. Arcadia was also recently awarded a $1.5 million grant from LA Metro to construct pedestrian improvements around the Arcadia Gold Line Station and better connect the station with downtown. These improvements will facilitate improved transit access and intermodal transfers along the corridor.

In addition to the above technology deployments, stakeholder agency staff time is already being leveraged. At least $300,000 of staff time has been incurred over the past three years on the I-210 Pilot. This includes participation in meetings and workshops; reviewing and commenting on project and partnering documents; and communicating with team members on data collection needs, traffic signal operations, communication needs with field devices, etc. Such involvement is expected to continue through the proposed deployment.

1.15. SCHEDULE

Figure 11 shows the project schedule with major tasks and subtasks. The required deliverables from the ATCMTD Notice of Funding Opportunity are shown in the schedule as well. Each of the project tasks and subtasks are summarized below.

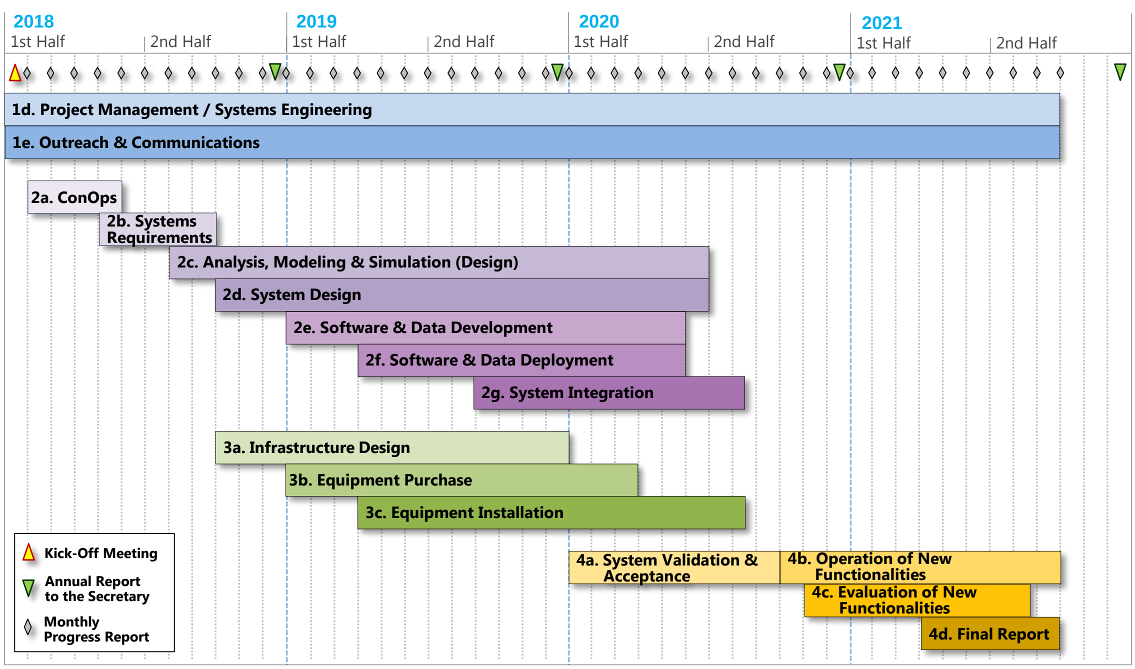

Figure 11: Project Schedule

Task 1: Project Management and Outreach

a. Kick Off Meeting

b. Monthly Progress Report

c. Annual Report to the Secretary

d. Project Management – Management of personnel, schedules, budgets, and risks; review of deliverables to ensure completeness and quality; progress reports

e. Outreach and Communications – An ICM program is often said to be comprised of 70% people working together and 30% technology. The outreach function is responsible for supporting agreements between stakeholders, presenting to city councils and other governmental bodies, maintaining web and print presence, and providing educational material and outreach meetings related to specific deliverables (mode shift, for example). This function also assists Caltrans and the stakeholder agencies in ensuring appropriate human processes are in place for the use of the developed or acquired hardware and software components.

Task 2: Software and Data Design and Build – This is the systems engineering process of designing, building, integrating, and deploying the software and data stack. This task also includes overall system integration (adding hardware and communication).

a. Update Concept of Operations – The existing I-210 Concept of Operations will be updated to include additional focus on transit, bicycles, and pedestrians.

b. Update System Requirements – The existing I-210 System Requirements will be updated to cover the new items added to the Concept of Operations.

c. Analysis, Modeling, and Simulation – A large model of the I-210 corridor (1,000 lane miles of road, 5,000 traffic detectors, 459 signalized intersections and control plans, 45 freeway ramp meters, Metro Gold Line light-rail and all bus routes) will be developed and calibrated. It will be used in the development of response plans for incidents, to simulate the effects of existing and proposed active traffic management strategies, to predict performance improvements, and to review observed traffic patterns against predicted patterns.

d. System Design – Hardware, communication, software, and data functions will be required to work together to implement MCMOIP. This task addresses the design of these components, the identification of the built/purchased/existing components, the definition of interfaces between these components, and the functional requirements of the subcomponents.

e. Software and Data Component Development – This is the standard development of software components to be built as part of this project. At a minimum, this task will include parts of the decision support system, schemas for the databases, and upgrades to city, county, and regional software stacks.

f. Software and Data Component Deployment – Core ICM system software and data components will be deployed in the cloud to ensure resource availability and scalability.

g. System Integration – This includes integration of hardware, communication, software, and data components in preparation for system validation, acceptance, and operation.

Task 3: Infrastructure Design and Build – In addition to the design and delivery of construction documents, there is significant hardware to be installed as part of the ICM effort. This includes sensors, controllers, communication, and signage.

a. Infrastructure Design and Construction – Development of plans, specifications, and estimates (PS&E) for safety enhancements, equipment, communication, and requisite infrastructure work. This includes choosing the exact equipment, understanding where it will be installed, planning the installation steps, and preparing bid documents.

b. Equipment Purchase – Detailed specification of equipment, communication, and infrastructure needs; finalization of bid packages; execution of the procurement process resulting in the purchase of required items.

c. Equipment Installation – Preparing the ground and existing infrastructure for the installation of equipment; equipment installation; and establishment of communication lines.

Task 4: System Operations

a. System Validation and Acceptance – Creation and execution of appropriate system validation and acceptance tests and related documentation. This will involve the creation of "mock" incidents and a review of suggested response plans.

b. System Operations – The system will operate in a preliminary mode for a year in order to permit response plan refinement and the resolution of bugs in the system.

c. Evaluation – The system's actual performance will be compared with the performance predicted by modeling.

d. Final Report and Lessons Learned – Generation of a report describing the final performance results of the project, discussing what went right or wrong, and providing recommendations for future projects.

2. STAFFING DESCRIPTION

As the recent ICM domestic scan notes (NCHRP Project 20-68A, Scan 12-02) and experience confirms, the success of an ICM effort is deeply tied to the ability of stakeholders to work together in the design of corridor management strategies, in the upgrading of the corridor to support data gathering and real-time control, and in the ongoing management of the corridor.

Figure 12 illustrates the general organization of the project team. This team is composed of practiced, experienced, dedicated personnel who have worked on or in support of the Connected Corridors program for over four years. They encompass government, industry, and academia, ensuring the right skills are in place and the correct management, oversight, and advice are available when needed.

Key responsibilities within the project team are divided as follows:

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- [redacted]
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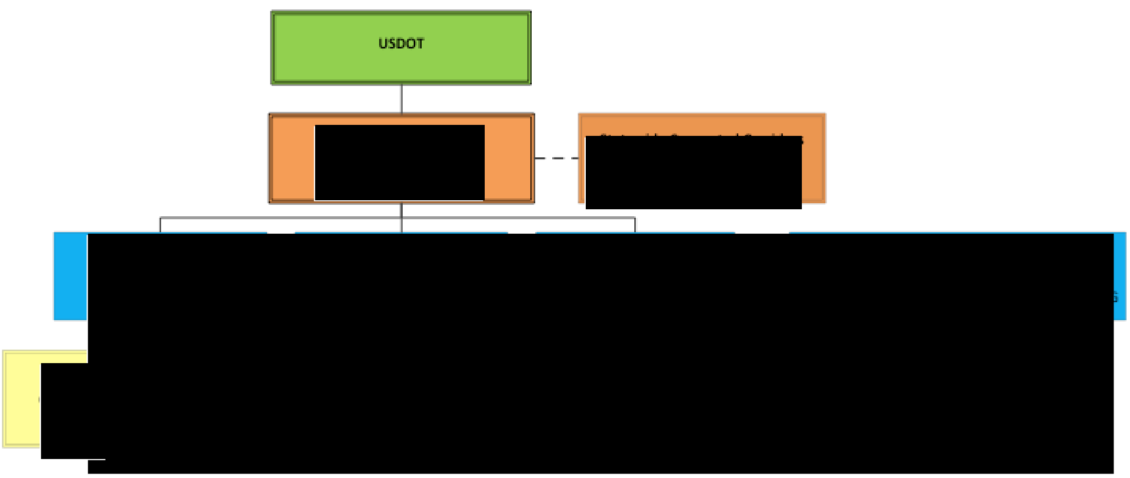

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]

- Developing decision support capabilities
- Identifying and developing data sources and quality metrics
- Managing communications and outreach activities

Consultants and industry partners are also key members of the project team. After competitive bid, the consulting partners will be identified. It is anticipated that consultants will be used for work on system evaluation, system integration, modeling support, and outreach and communication.

3. FUNDING DESCRIPTION

		Matching	ATCMTD
Task 1:	**Management**		
a.	Kick Off Meeting		4,000
b.	Monthly Progress Report		16,000
c.	Annual Report to the Secretary		8,000
d.	Project Management	312,000	148,000
e.	Outreach and Communications	202,000	140,000
Task 2:	**Design and Build**		
a.	Update Concept of Operations		44,800
b.	Update System Requirements		48,188
c.	Analysis, Modeling, and Simulation	489,425	200,532
d.	Software Design	385,210	80,100
e.	Software Development	988,315	405,600
f.	System Integration	622,250	401,777
g.	Software Deployment	102,825	80,451
Task 3:	**Infrastructure Design and Build**		
a.	Infrastructure Design & Construction	107,332	576,500
b.	Equipment Purchase	1,694,450	1,566,680
c.	Equipment Installation	505,840	1,006,063
Task 4:	**System Operations (1 Year):**		
a.	System Validation and Acceptance		80,000
b.	System Operations	125,000	400,000
c.	System Evaluation		200,000
d.	Final Report and Lessons Learned		60,000
		5,534,647	5,466,691