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INSTITUTE OF TRANSPORTATION STUDIES
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Connected Corridors: I-210 Pilot Integrated Corridor Management System

System Validation Plan

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1. INTRODUCTION

The I-210 Pilot Integrated Corridor Management (ICM) system is a monitoring, assessment, decision support, and operational control tool to be deployed along an urban corridor in the San Gabriel Valley of Los Angeles County. Its deployment will be centered on a 12-mile section of I-210 traversing the cities of Pasadena, Arcadia, Monrovia, and Duarte. The system aims to help corridor traffic managers determine the best course of action for responding to incidents and events and to facilitate more efficient, coordinated responses using cross-jurisdictional, multi-modal traffic and demand management strategies.

This document presents the validation strategy that project stakeholders will use to assess whether the delivered ICM system satisfies the user needs that prompted its development. This introductory section includes:

- Purpose of document
- Relation of validation plan to the systems engineering process
- Intended audience
- Document organization

1.1. PURPOSE OF DOCUMENT

The purpose of this Validation Plan is to define how system validation will be performed at the end of the project—the strategy that will be used to assess whether the developed system accomplishes what it was designed to do. This essentially implies assessing whether the system meets the goals, objectives, and user needs stated in the Concept of Operations (ConOps) at the beginning of the project. Specific questions that this document seeks to answer include:

- How will the developed system will be evaluated?
- Where will the assessment take place?
- When will the assessment be conducted?
- What types of tests will be conducted?
- What data will need to be collected?
- Who will conduct the assessments?
- Who will participate in the assessments?

1.2. RELATION TO SYSTEMS ENGINEERING PROCESS

The development of a system validation plan is part of the systems engineering process that the Federal Highway Administration (FHWA) requires be followed for developing Intelligent Transportation System (ITS) projects when federal funds are involved. While not required for projects only using state or local funds, use of the systems engineering process is also encouraged in such cases.

As shown in Figure 1-1, which illustrates the overall systems engineering process, an initial system validation plan is typically developed early in the engineering process, often after completion of the Concept of Operations. The purpose of this plan is to outline an agreed-upon strategy that will be used at the end of the project by system stakeholders to determine whether the user needs identified as part of the ConOps development are adequately satisfied in the final product. Depending on the project, this

initial plan may be periodically updated as the project progresses. Specific validation procedures may also be developed in the initial plan or developed closer to the start of the validation effort when a clearer understanding of system functionalities is available. The end result of the validation effort is the production of a validation report detailing the outcomes of the validation tests.

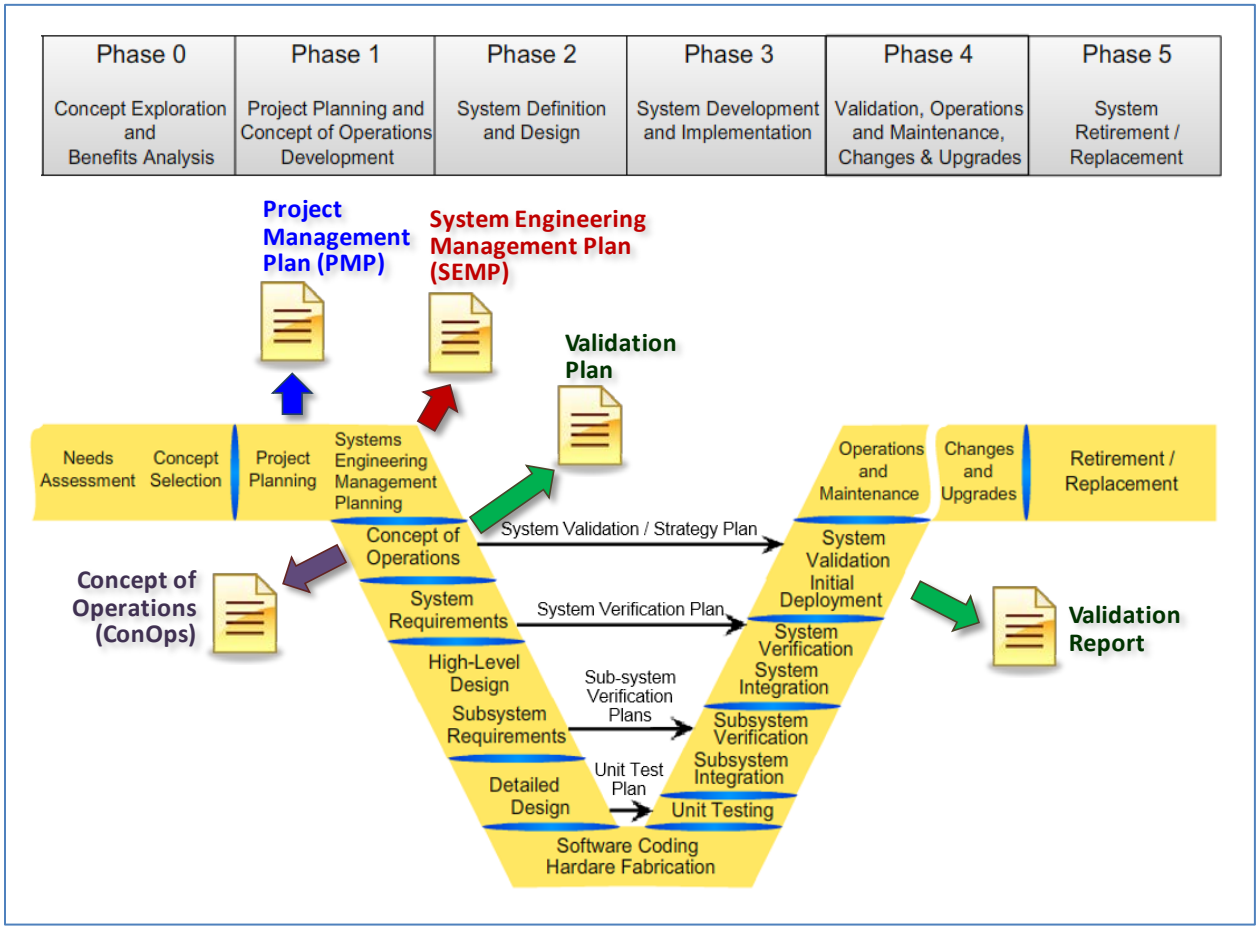

Figure 1-1 – Validation Plan within Systems Engineering Process

Validation activities must not be confused with verification activities. Both activities assess how a system has been built. The difference is on the focus of the assessment:

- **Verification—*Was the system built right*?** Verification is the confirmation, through objective evidence, that the specified requirements have been fulfilled. The question being asked here is whether the design of the system correctly and completely embodies the requirements, i.e., whether the system was built right.
- **Validation—*Was the right system built*?** Validation is the confirmation, again through objective evidence, that a developed system effectively achieves its intended purpose and meets the user needs it was developed to address. In other words, validation attempts to determine whether the right system has been built.

The majority of system verification can be performed before a system is deployed. Validation, however, really cannot be completed until a system is in its operational environment and is being used by its

intended users. For instance, validation of a new traffic signal control system cannot be completed until the new system is in place and observations can be made on how effectively it controls traffic.

1.3. INTENDED AUDIENCE

The general audience for this validation plan is the same as for the ConOps. Key audience groups include personnel from each agency who will be tasked with operating the system, as well as individuals from each agency who will be responsible for accepting delivery of the system.

1.4. DOCUMENT ORGANIZATION

The remainder of this document is organized as follows:

- **Section 2** presents a general description of the I-210 Pilot ICM system that will be the subject of the validation effort.
- **Section 3** lists the documents that were used in the preparation of this validation plan.
- **Section 4** provides a broad outline of how the validation is to be accomplished. It defines who will do the validation; when and where it is to be done; the deployed hardware and software configuration to be used for the validation; the responsibilities of each participant before, during, and after the validation; and the documents to be prepared as a record of the validation activity. This section also defines how anomalies are to be handled, i.e., what to do when an unexpected situation or a failure occurs during validation.
- **Section 5** identifies the specific validation cases to be performed, i.e., scenarios that will be used to test system operations.

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2. SCOPE OF PROJECT

This section provides a brief description of the system that is to be validated. Elements presented include:

- Deployment location
- Project goals and objectives
- Traffic management situations of interest
- Problems to be addressed
- Technical capabilities sought
- System stakeholders
- Identified user needs
- Description of system to be deployed

2.1. DEPLOYMENT LOCATION

Phase I of the I-210 Pilot seeks to reduce congestion and improve mobility along an urban corridor centered on a 12-mile section of I-210 traversing the cities of Pasadena, Arcadia, Monrovia, and Duarte in the northern area of Los Angeles County. Figure 2-1 shows the key freeway and arterial segments that are to be managed by the deployed system. Future deployments will expand the deployment area 9 miles eastward along the I-210 up through the I-605 freeway interchange in San Dimas.

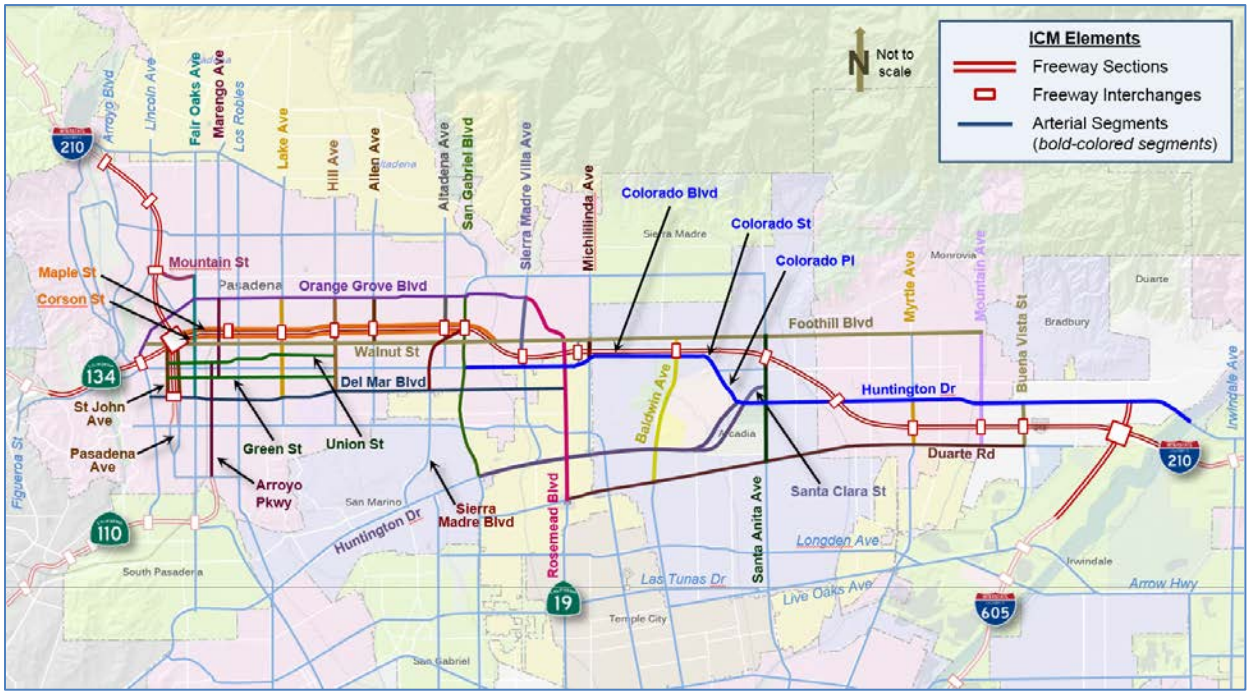

Figure 2-1 – System Deployment Area

2.2. PROJECT GOALS AND OBJECTIVES

Table 2-1 identifies the goals and objectives behind the development and deployment of the I-210 Pilot ICM system. The overall goal is to improve mobility within the corridor during incidents and events by enabling all corridor actors and systems to work together in an efficient and coordinated way. This overall goal translates into the following nine specific goals:

1. Improve operational situational awareness
2. Promote collaboration among corridor stakeholders
3. Improve response to incidents and events
4. Improve travel reliability
5. Improve overall corridor mobility
6. Empower travelers to make informed travel decisions
7. Facilitate multi-modal movements across the region
8. Promote transportation sustainability by reducing impacts on the environment
9. Improve corridor safety

Many of the objectives that are associated with the above goals are similar to those associated with traditional transportation improvement projects. However, several differ from traditional projects in their focus on implementing more comprehensive travel and system status monitoring systems, enhancing data-sharing capabilities among agencies, implementing novel demand management approaches, improving operational forecasting, improving collaboration among transportation system operators, and improving information dissemination to travelers.

Table 2-1 – ICM System Goals and Objectives

Goals	Objectives
1. Improve situational awareness	• Establish minimum requirements for data collection to support system management • Increase data collection opportunities from arterials and local roads • Improve the collection of real-time operational data from non-traditional sources, such as probe vehicles • Develop a comprehensive corridor informational database covering all relevant travel modes within the corridor • Improve the quality, accuracy, and validation process of collected data • Increase the ability to estimate travel demand patterns in a multi-modal environment • Improve the ability to forecast near-future travel conditions based on known incidents, road conditions, weather, and local events • Develop performance metrics considering all available travel modes
2. Promote collaboration among corridor stakeholders	• Strengthen existing communication channels among the corridor's institutional stakeholders • Explore opportunities for new communication links between corridor stakeholders • Improve cooperation and collaboration among corridor stakeholders • Develop regional/joint operations concepts • Identify new methods of collaboration • Extend corridor performance metrics to the network level • Investigate new types of agreements between participating agencies

Table 2-1 – ICM System Goals and Objectives

Goals	Objectives
3. Improve response to incidents and unexpected events	• Reduce the time needed to identify the existence of an incident or unexpected situation • Reduce the time needed to respond to incidents or unscheduled events • Enhance the coordination of activities among first responders, traffic management agencies, and transit agencies to minimize impacts on system operations • Reduce the time needed to implement control actions to address congestion resulting from an incident or event • Reduce the time needed to disseminate recommended detours around an incident or event
4. Improve travel reliability	• Improve travel time predictability along the corridor • Reduce the impacts of incidents and events on network operations • Improve incident/event notification for first responders and network operators • Improve incident/event notification to travelers and fleet operators • Provide travelers and commercial vehicle operators affected by an incident or event an enhanced ability to seek alternate routes or mode of transportation
5. Improve overall corridor mobility	• Reduce delays incurred by travelers • Reduce the impacts of incidents and events on network operations • Efficiently use spare capacity along corridor roadways to plan necessary detours around incidents or events • Promote strategies to induce desirable travel demand patterns • Coordinate the management of freeway and arterial bottlenecks • Promote increases in vehicle occupancy • Promote increases in transit ridership
6. Empower system users to make informed travel decisions	• Improve the dissemination of real-time, multi-modal travel information • Enhance the use of infrastructure-based informational devices (freeway CMS, arterial trailblazer signs, kiosks, etc.) to provide en-route information to travelers • Enable individuals to receive travel information on connected mobile devices • Make archived historical data available to 511 services and information service providers • Support the dissemination of travel information by 511 services and third-party providers
7. Facilitate regional multi-modal movements	• Promote the integration of commuter rail and bus services with corridor operations • Facilitate transfers across modes during incidents and events • Provide relevant regional travel information to travelers • Direct travelers to park-and-ride facilities with available spaces
8. Promote transportation sustainability	• Reduce fuel consumption • Reduce vehicle emissions • Identify financially sustainable solutions for long-term system operations and maintenance • Encourage the use of transit, walking, and bicycling where appropriate • Support locally preferred alternatives compatible with corridor objectives • Develop and implement performance metrics reflecting environmental goals
9. Improve corridor safety	• Reduce collision rates • Reduce the severity of collisions • Reduce the number of fatalities • Reduce the impacts of primary and secondary incidents on network operations through improved incident management • Improve safety for bicycles, pedestrians, and transit

2.3. TRAFFIC MANAGEMENT SITUATIONS OF INTEREST

The ICM system will provide decision support and recommend courses of action for situations involving incidents and planned events. This includes providing decision support for the following situations:

- Non-recurrent congestion due to incidents and unplanned events:
    - Unexpected road closures
    - Minor roadway incidents
    - Major roadway incidents
    - Transit incidents
    - Unexpected adverse weather events, such as fog or flooding
    - Fire events near roadways
    - Natural disasters
    - Terror threats
- Non-recurrent congestion due to planned events:
    - Maintenance and construction activities
    - Special events, such as concerts and sports activities
    - Forecasted weather events, such as predicted rain storms

2.4. KEY PROBLEMS TO BE ADDRESSED

The intent of the I-210 Pilot is to coordinate the various transportation networks and control systems currently in use in the deployment corridor so they can operate in a cohesive and integrated manner. This presents a unique set of technical, procedural, and organizational challenges, as it leads to the need to investigate and/or develop tools, technologies, and processes that will help the various corridor agencies improve their real-time collaborative decision-making capabilities.

Figure 2-2 identifies the various operational issues to be addressed by the project. These issues are grouped into the following six categories:

- **Enhancement of situational and operational awareness for system operators and managers.** Up-to-date measurements of corridor performance and travel demand are essential for any system aiming to provide real-time decision support capabilities. This creates a need for the availability of comprehensive traffic and equipment monitoring systems, as well as data processes for determining corridor performance.
- **Management of congestion spanning freeways and arterials.** Prior to the start of the project, Caltrans typically tried to resolve congestion issues along freeways, while cities typically only focused on what happens on surface streets. This approach ignored the fact that congestion often spreads across networks and can effectively be addressed only by considering solutions spanning multiple types of roadway networks.
- **Management of corridor-based response plans.** Prior to the start of the project, transportation systems managed by different entities were typically managed as independent entities, with occasional considerations given to cross-jurisdictional issues. This prevented the implementation of synergistic strategies. Agencies operating transportation networks within a corridor need to be able to define, select, communicate, and implement jointly developed

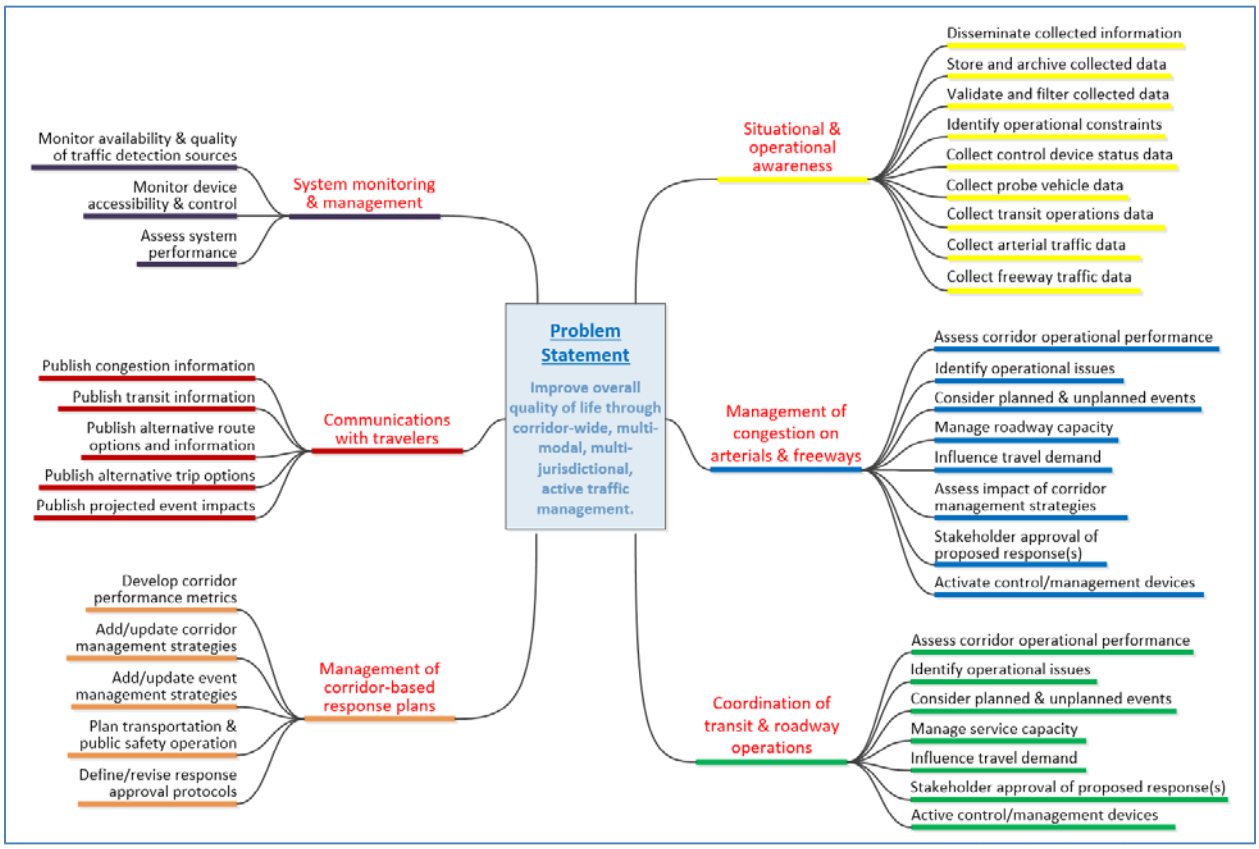

Figure 2-2 – Mapping of User Issues to General Corridor Management Needs

response plans and strategies that address operational issues from a corridor-based perspective. This requires the establishment of processes and corridor performance metrics based on common operational philosophies and corridor management objectives.

- **Coordination of transit and roadway operations.** While transit operators were already devoting significant effort to providing efficient services, further improvements could be achieved by coordinating transit and roadway operations, particularly during incidents and events when unexpected congestion significantly affects corridor travel. To help alleviate congestion, transit agencies could, for instance, offer additional rides. Temporary schedule or routing changes could also be implemented to reduce delays and improve service reliability.
- **Enhancement of communication with system users.** To enable travelers to make informed travel decisions, an effective mechanism must exist to disseminate relevant travel information to them. This includes the ability to disseminate real-time travel condition information to travelers both before they start a trip and during a trip.
- **Monitoring and management of the deployed ICM system.** Field equipment deployed for information gathering and traffic management can degrade over time due to exposure to weather, traffic, construction activities, vandalism, or other causes. To maintain an appropriate level of operations, the health of deployed equipment must be continuously monitored. This requires developing methods and metrics for assessing equipment and overall system health based on data that can be gathered from them.

2.5. TECHNICAL CAPABILITIES SOUGHT

To help manage travel activities within the corridor during incidents, unscheduled events, and planned events, the project is seeking the following technical capabilities to support the goals and objectives identified in Section 2.2:

- Gather and archive information characterizing traffic operations, transit operations, and the operational status of relevant control devices within the I-210 corridor.
- Identify unusual travel conditions on the I-210 freeway or nearby arterials based on monitoring data provided by various traffic, transit, and travel monitoring systems.
- Identify situations in which an incident on roadways or transit facilities significantly affects travel conditions within the corridor.
- Provide corridor-wide operational evaluations to traffic managers, transit dispatchers, and other relevant system managers, including projected assessments of near-future system operations under current and alternate control scenarios.
- Identify recommended detours around incidents or routes leading to the site of an event, considering observed travel conditions within the corridor. Depending on the need, and final system capabilities, specific detours may be recommended for motorists and for transit vehicles.
- Identify recommended timing plans to use at signalized intersections to accommodate the influx of traffic expected to occur during incidents and events and improve overall corridor mobility.
- Identify recommended ramp metering rates to use on individual I-210 freeway on-ramps and connectors to maintain overall corridor mobility.
- Identify messages to post on available freeway and arterial CMSs to inform motorists of incidents and events.
- Provide guidance to motorists on the I-210 freeway and surrounding arterials using available freeway CMSs, arterial CMSs, and arterial dynamic trailblazer signs regarding which detour to take around an incident or which route to follow to the site of an event.
- Provide information to motorists about the availability of parking and transit services to help travelers make alternate mode-choice decisions.
- Provide uniform traffic management strategies across jurisdictional boundaries during incidents and events.
- Provide information to motorists through third-party outlets, such as 511 services, navigation application providers, etc.

2.6. SYSTEM STAKEHOLDERS

Table 2-2 lists the agencies and roles having a direct interest in the operation of the I-210 Pilot ICM system and in how the proposed system might affect travel conditions in the corridor. For each stakeholder, the table further identifies the key roles the entity plays in the management and operations of the corridor according to the following definitions:

- **Freeway operators** – Entities managing freeway traffic
- **Roadway operators** – Entities managing local arterials and regional highways
- **Rail transit operators** – Entities providing commuter rail and light-rail transit services
- **Bus transit operators** – Entities providing fixed-route transit services
- **Paratransit operators** – Entities providing on-demand transit services
- **Parking operators** – Entities managing parking garages and parking lots within the corridor
- **Motorist aid services** – Entities responsible for providing aid to stranded motorists
- **Emergency responders** – Entities tasked with responding to incidents and emergency situations
- **511/Information providers** – Entities using information produced by the ICM system to generate and distribute value-added travel information to corridor travelers
- **Information consumers** – Entities using information produced by the ICM system to help plan their movements within the corridor
- **Local transportation planning** – Agencies planning transportation system development at a local level (e.g., city transportation planning department)
- **Regional planning** – Agencies forecasting regional travel demand patterns and developing long-range transportation improvement plans
- **Technical/policy advisor –** Entities developing and applying regional standards and policies
- **Application developer and system integrators** – Entities responsible for developing, and possibly operating, devices and systems used within the corridor

Table 2-2 – Roles of I-210 Pilot Stakeholders

Stakeholders	Roles													
	Freeway Operator	Roadway Operator	Rail Transit Operator	Bus Transit Operator	Paratransit Operator	Parking Operator	Motorist Aid Services	Emergency Responder	511/Information Provider	Information Consumer	Local Transportation Planning	Regional Planning	Technical/Policy Advisor	Application Developer/Integrator
Caltrans – District 7	●	●				●			●	●	●	●	●	
Caltrans – Headquarters													●	
Los Angeles County Metropolitan Transportation Authority			●	●		●			●	●		●	●	
Los Angeles County		●			●	●		●	●	●	●	●	●	
City of Pasadena		●		●	●	●		●	●	●	●			
City of Arcadia		●			●	●		●	●	●	●			
City of Monrovia		●			●	●		●	●	●	●			
City of Duarte		●		●		●			●	●	●			
Foothill Transit				●					●	●				
Pasadena Transit				●					●	●				
LA County Service Authority for Freeway Emergencies (LA SAFE)							●	●	●	●				
California Highway Patrol (CHP)	●	●					●	●	●	●				
Southern California Association of Governments (SCAG)												●	●	
San Gabriel Valley Council of Governments (SGVCOG)												●	●	
University of California, Berkeley – PATH Program													●	●
US Department of Transportation (USDOT)													●	

2.7. IDENTIFIED USER NEEDS

Table 2-3 describes the user needs governing the development of the I-210 Pilot ICM system. These needs were identified following discussions with corridor stakeholders and a review of current operational processes. Verification that these needs are adequately satisfied is the central objective of the validation efforts outlined in this document.

Table 2-3 – System User Needs

ID	Title	Description
System Monitoring		
1	Collect and Process Multi-modal Data Characterizing Corridor Operational Performance	The ICM system needs to collect, on a real-time or near real-time basis, data characterizing the operational performance of roadways, transit systems, parking facilities, and any other relevant transportation elements. This information will be used to identify whether incidents or events are impacting corridor operations and warrant the evaluation of alternate management strategies. This implies not only identifying which data to collect, but also determining how to validate and filter data from each potential source and developing suitable processing algorithms to reliably derive the information sought.
2	Collect and Process Multi-modal Corridor Travel Demand Data	The ICM system needs to collect data characterizing the demand for travel along the I-210 corridor. This includes collecting data characterizing the movement of automobiles, buses, trucks, and possibly individuals, along the freeways and key arterials. Information about freight movement, as well as cyclist and pedestrian flows, should also be collected if deemed relevant.
3	Monitor Asset Availability	Agency operators need to monitor the status of all devices and facilities that may be used to manage traffic or disseminate information to travelers. This means monitoring which devices may be down for maintenance or unavailable because of operational constraints, as well as monitoring available roadway and parking capacity.
Decision Support		
4	Decision-making Assistance	The ICM system should indicate when an operational change is recommended, which systems/control devices should be modified to implement the desired change, and how these systems or devices should be modified. This includes considering both available capacity and desired demand management strategies, where feasible.
5	Operational Forecast Capability	To assist with the development of efficient response plans to incidents and events, the ICM system needs to be able to forecast over near-term intervals the effects of proposed actions, including a “no action” option, on traffic performance, transit system performance, and/or travel demand.
6	Strategy Effectiveness Assessment	Before implementing a recommended response plan, system operators should be able to assess its potential impacts on corridor operations. System operators must also be able to determine if an implemented strategy is having the intended effect. This implies identifying key performance metrics to use, developing processes to track changes in system performance over time, and providing suitable reporting capabilities. It also implies identifying a recommended course of action based on the results of the assessments conducted.
Control Capabilities		
7	Multi-Agency Coordination Support	Participating agencies need to coordinate how they respond to incidents or events to avoid implementing incompatible local strategies. This means establishing appropriate communication capabilities, as well as a joint operational framework among them.

Table 2-3 – System User Needs (cont'd)

ID	Title	Description
Control Capabilities		
8	Automated Incident Response Capability	To the extent possible and allowed, the ICM system should be able to operate in a fully automated mode during agreed-upon periods or when specific circumstances are met.
9	Manual Control Capability	Under specific circumstances, system users should have the ability to manually change one or more components of a response plan to address corridor operational issues not adequately captured by the ICM system. This includes an ability to alter traffic control directives and messages disseminated by information devices.
10	Preferred Control Setup Options	System users should have the capability to identify preferred control actions to be considered when developing responses to specific types of incidents, unscheduled events, or planned events. An example would be the ability to define as a first response strategy specific detours or traffic signal control plans to consider.
11	Device Modification and Addition Capability	System users should be able incorporate additional locations and devices into the control environment, as well as to modify or update existing control locations and/or devices.
12	Information Visualization	To facilitate decision-making, information characterizing system operations should be provided to system operators in a format that is easy to read and interpret, such as through the use of maps, tables, color-coded displays, etc.
Information Dissemination		
13	Provision of Real-Time, Multi-modal Information to System Operators	System users should receive, to the extent of their availability, real-time data enabling them to manage the transportation network(s) under their management. This may include observed link speeds, estimated queue sizes, projected flows, and other data considered relevant. This means not only operating a suitable information exchange network, but also managing restrictions on certain access, features, and/or system controls that may be imposed on data feeds. This also includes adding, when needed, new information or data to the system associated with new systems or services.
14	Provision of Real-Time, Multi-modal Information to End Users	To help travelers make informed decisions, the ICM system should provide travelers with real-time or near real-time information about travel conditions within the corridor. This can be done through existing 511 and roadside information systems, third-party information providers, or the development of new mobile applications.
Data Management		
15	Historical Data Archiving	The data collected and information generated by the ICM system needs to be stored to support future off-line analyses and modeling activities. This implies setting up one or more databases, determining how data will be stored and for how long, and defining protocols for archiving data and accessing and managing databases. Data output from the system should further be in a format consistent with the regional ITS architecture and be able to be utilized by other mainstream software systems.
System Management and Maintenance		
16	ICM System Management	Administrative functions need to be developed to enable authorized users to support the management of user accounts, system configurations, and system security.
17	System Maintenance	The ICM system should provide system diagnostics and alerts about malfunctioning devices. Users should also be able to identify and locate devices needing maintenance. The ICM system should further be able to perform self-diagnostic checks to assess maintenance needs and recommend maintenance actions.
18	Training Support	Adequate documentation must be available to support system operations and maintenance. Adequate training must also be provided when needed.

2.8. DESCRIPTION OF SYSTEM TO BE DEPLOYED

This section provides a summary description of the system to be built, including:

- Control framework
- Connected systems
- System components
- System architecture
- Categories of users
- States of operation
- Mode of operation
- Institutional support framework

2.8.1. CONTROL FRAMEWORK

Figure 2-3 illustrates the basic control framework of the I-210 Pilot ICM system. This framework involves two distinct courses of action:

- **Response to active incidents/events** – Sequence of activities when an incident, planned event, or unplanned event is occurring.
- **Post incident/event corridor management** – Sequence of activities after a previously active incident, planned event, or unplanned event has terminated.

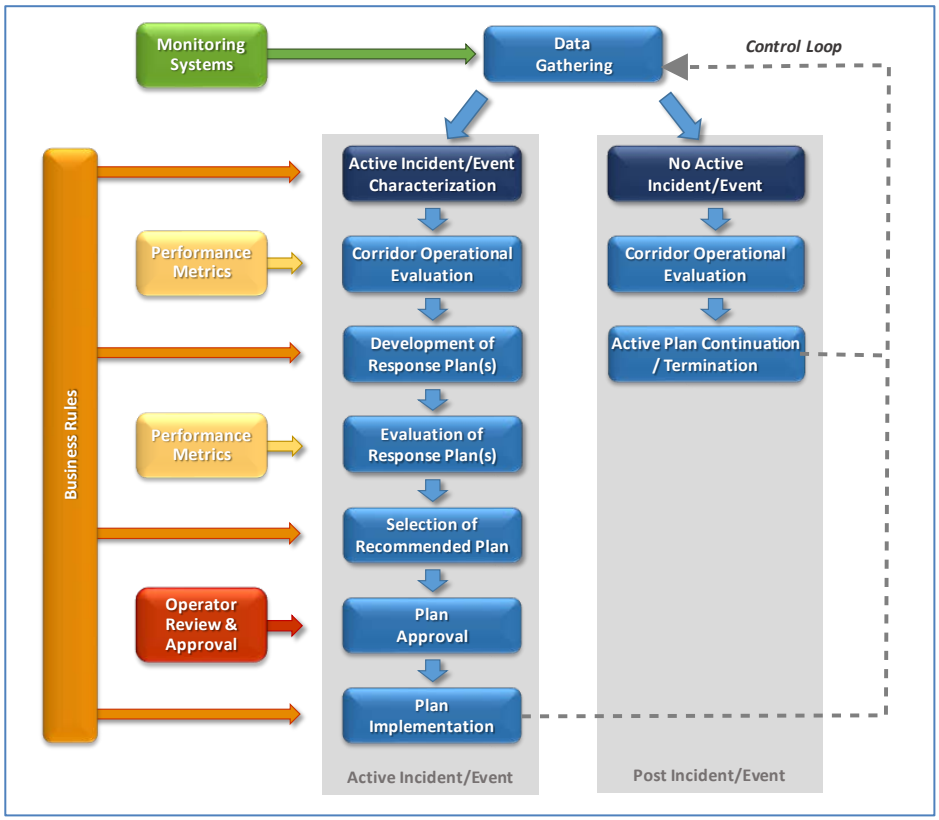

Figure 2-3 – I-210 Pilot ICM Incident/Event Response Control Framework

As the figure shows, specific control activities to be executed by the system include:

- **Data gathering** – Gathering of data characterizing travel conditions within the corridor from traffic sensors, automated vehicle location systems, travel time monitoring devices, etc.
- **Corridor operational evaluation** – Evaluation of travel conditions within the corridor based on the collected data and performance metrics of interest to system operators.
- **Development of response plan(s)** – Identification of traffic control changes, transit service adjustments, and information dissemination needs in response to incidents or events, including the potential development of travel demand management strategies.
- **Evaluation of response plan(s)** – Use of analytical or simulation tools to assess the projected operational performance of the various response plans developed.
- **Selection of recommended plan** – Selection of a recommended course of action based on the results of the evaluations and performance thresholds agreed upon by system operators.
- **Plan approval –** Review and approval of recommended response plan by corridor stakeholders.
- **Plan implementation** – Implementation of approved control actions.
- **Active plan continuation/termination** – Termination of active response plan after corridor operations have returned to normal following the end of an incident or event.
- **Control loop** – Periodic re-evaluation of travel conditions within the corridor and, if necessary, generation of new response plans until the need for ICM control disappears.

2.8.2. CONNECTED SYSTEMS

Figure 2-4 presents a preliminary view of the systems to be connected to the ICM system and how information is expected to flow between them. Core ICM components are represented by the two circles at the center of the figure. The inner circle, labeled DSS for Decision Support System, represents the components that will be tasked with making decisions. Surrounding it, the circle labeled ICM represents various supporting ICM functionalities, such as data processing and communication with external systems.

Communication between the core ICM functionalities and external components operated by project stakeholders will be conducted through various existing communication networks. This can include the IEN and RIITS networks, as well as Caltrans' existing fiber communication network along the I-210 freeway. Where no communication network exists, or where limitations of existing networks may constrain system operations, use of leased communication lines may also be considered.

Surrounding the communication ring are the various entities that will potentially contribute information to the core ICM system or receive information from it. These entities are color-coded as follows, based on their anticipated role in the operation of the ICM corridor:

- **Roadway operators**, shown in blue
- **Transit operators**, shown in green
- **Law enforcement and first responders**, shown in red
- **511 services/Information providers**, shown in purple
- **Parking operators**, shown in dark gray
- **Other data suppliers**, shown in blue-green

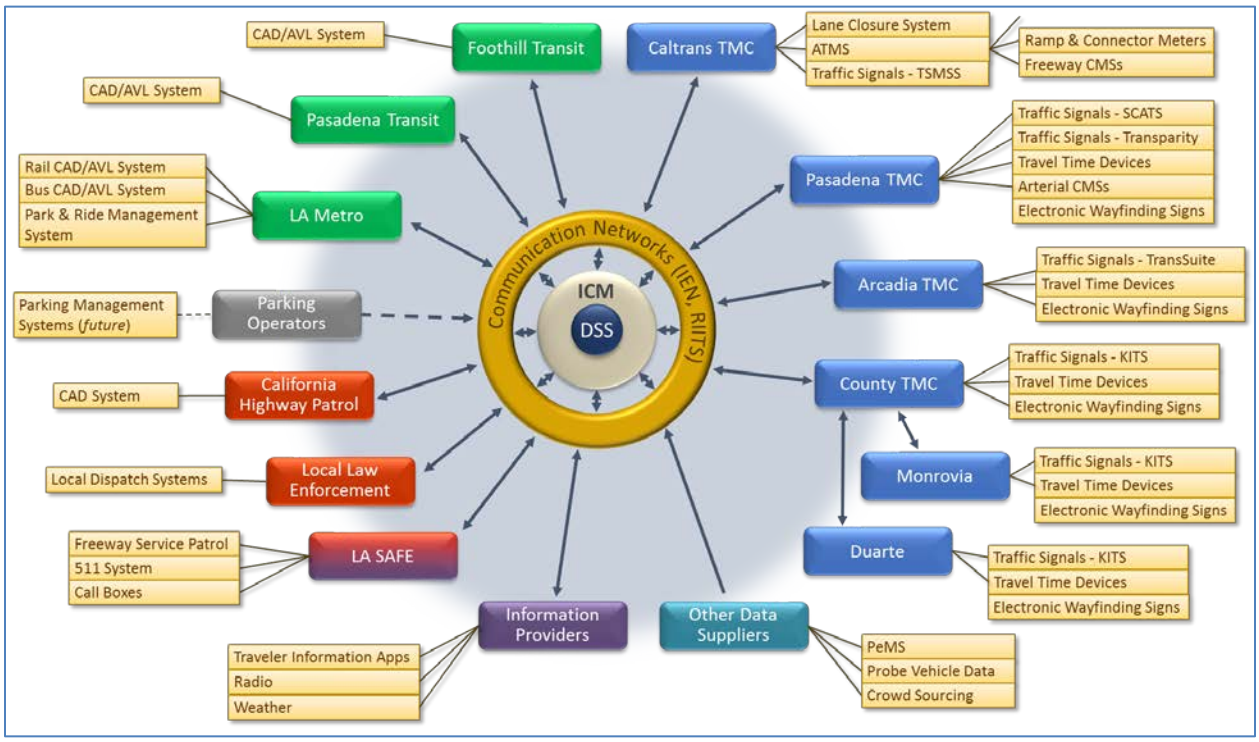

Figure 2-4 – I-210 Pilot ICM Envisioned Information Flows

For each entity, the arrow shows the direction that information is exchanged between the entity and the ICM system. One-directional arrows indicate entities only supplying information to the ICM system or only receiving data from it. Two-directional arrows indicate entities both supplying information to the ICM system and receiving information from it. Dotted lines indicate communication lines that do not currently exist but are planned for the future. The boxes attached to each entity further show the systems the ICM Core System is expected to draw information from and/or provide control recommendations to.

2.8.3. SYSTEM COMPONENTS

Figure 2-5 identifies the key components of the ICM system and how they relate to each other. Starting from the outer ring and moving toward the center, the figure identifies the following components:

- **Field control and informational elements** – Devices used to collect data from various systems to support ICM operations. This includes:
    - *Traffic detectors* supplying information about traffic flows on roadway elements, such as loop detectors, video traffic detection systems.
    - *Travel time sensors* used to measure travel time between various points.
    - *Onboard devices* that may be used to collect information about the movements of individual vehicles, including passenger cars, trucks, buses, and trains.
    - *Freeway on-ramp and connector metering signals* used to meter the flow of vehicles entering freeways from local arterials or connecting from one freeway to the next.
    - *Traffic signals* used to control traffic movements at intersections along arterials and supporting centralized traffic signal control systems.

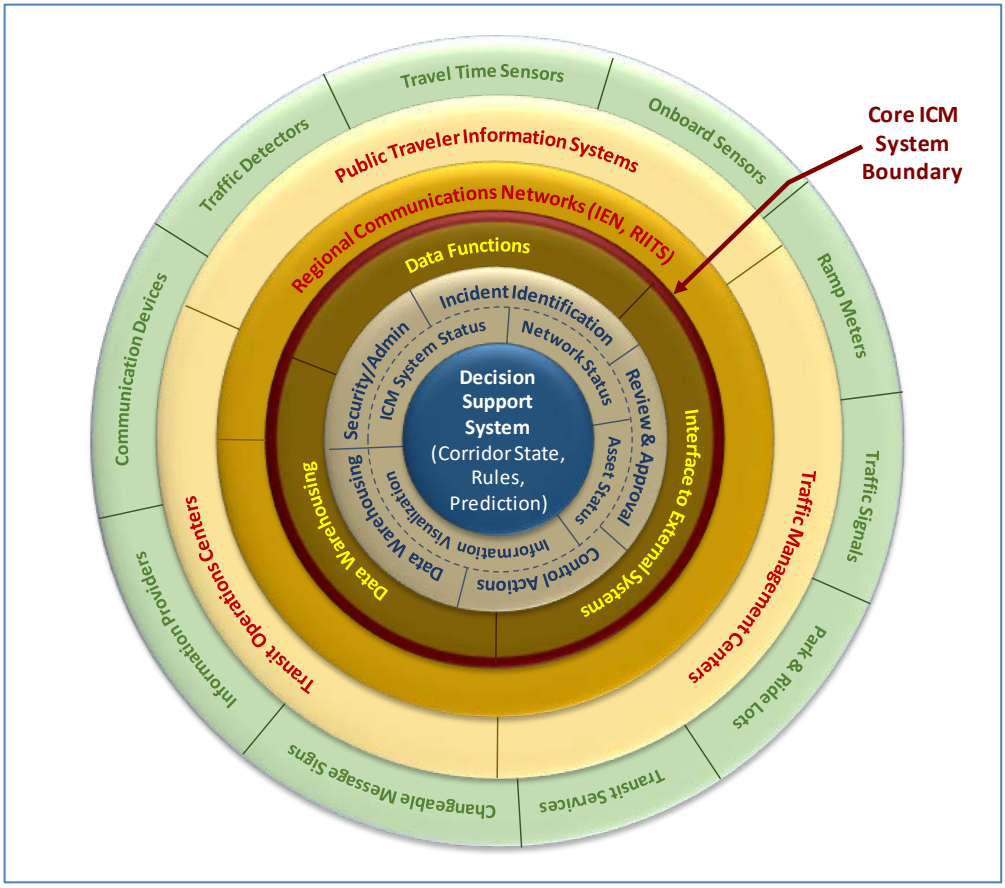

Figure 2-5 – I-210 Pilot ICM System Key Components

- *Park-and-ride lots* available to travelers within the corridor.
- *Transit services* operated within the corridor by the Los Angeles County Metropolitan Transportation Authority (Metro), Foothill Transit, Pasadena Transit, and other agencies.
- *Changeable message signs* installed along freeways and arterials to inform motorists of travel conditions or provide route guidance.
- *Information services* provided by 511 services and third-party information providers.
- *Communication devices* used by transit dispatchers/supervisors to contact bus or train drivers.

- **Management and operations centers** – Local decision centers providing connections between the ICM system and the various field elements. Key components in this category include:
  - *Traffic management systems* used by local and regional roadway operators to control the various devices under their jurisdiction and collect data generated by the monitoring systems they are operating.
  - *Transit operations systems* used to manage transit services offered within the corridor.

  - *Traveler information systems* operated by public agencies, such as the regional 511 traveler information system operated by LA Safe, Caltrans' Quickmap real-time traffic information system, or the NextTrip information system operated by Metro.

- **Regional communication networks** – Communication networks that may be used to exchange information between system components housed at different locations. The two key networks currently considered for supporting data exchanges within the I-210 corridor are:
  - *Information Exchange Network (IEN)* – Communication network developed by the Los Angeles County Department of Public Works to enable the sharing of traffic signal data across the various systems used within the county.
  - *Regional Integration of Intelligent Transportation Systems (RIITS)* – Communication network developed by Metro to enable real-time information exchange among freeway, traffic, transit, and emergency service agencies.

- **Technical ICM system elements** – System components directly operated by the ICM server and providing support to the various decision-making processes:
  - *ICM System Status* – Processes defining how ICM components are operating.
  - *Network Status* – Processes identifying the operational status of roadway segments, transit systems, etc.
  - *Asset Status* – Processes identifying the operational status and availability of traffic control and travel management assets.
  - *Information Visualization* – Methods enabling system users to visualize the collected data and the results of evaluations conducted by the ICM system.
  - *Security/Admin* – Processes used to control who has access to the system and to ensure the security of operations.
  - *Incident/Event Identification* – Processes used to identify incidents and events, and to characterize their impacts on network operations.
  - *Review & Approval* – Processes enabling stakeholders to review, if automated approval has not been enabled, the suggestions made by the Decision Support System, make changes to the recommended actions, and ultimately approve/disapprove the recommended plans.
  - *Control Actions* – Processes converting an approved response plan into control commands to be transmitted to system assets and verifying that the requested changes have been successfully implemented. Also includes processes to terminate an implemented response plan and return control assets to normal operations.
  - *Data Warehousing* – Database holding all relevant information collected to characterize corridor operations, as well as information generated by the ICM system during corridor evaluations and the development of response plans.

- **Supporting data** – Information collected by the ICM system to support its decision-making activities. Key data elements to be potentially collected, if available include:
  - Data characterizing traffic flow demand and patterns

- Data characterizing the transit services operated within the corridor
- Data characterizing the operational status of the various control and informational devices available for use
- Data characterizing the operational performance of buses and train routes operated within the corridor, such as whether vehicles on a given route are being delayed, when an arrival is expected at a particular location, etc.
- Data characterizing various constraints that must be considered, such as school schedules, roadway closure timetables, etc.

- **Decision Support System** – Module implementing the intelligence of the ICM system. Key elements of this module include:
  - *Business rules* used to identify whether response plans should be developed to address an active incident or event, and to develop appropriate responses when needed.
  - *Simulation and analytical models* used to perform corridor performance assessments under current and possible future traffic, transit, and travel management strategies.

2.8.4. SYSTEM ARCHITECTURE

Figure 2-6 presents the currently proposed system architecture for the I-210 Pilot ICM system. The figure illustrates the various components that are to be developed and the communication links that are to be established between them. Four key elements are illustrated:

- Green boxes: Information entering and exiting the core ICM system
- Red boxes: Data processing components within the core ICM system
- Blue box: Decision support module, where the intelligence of the system will reside
- Purple box: User interface

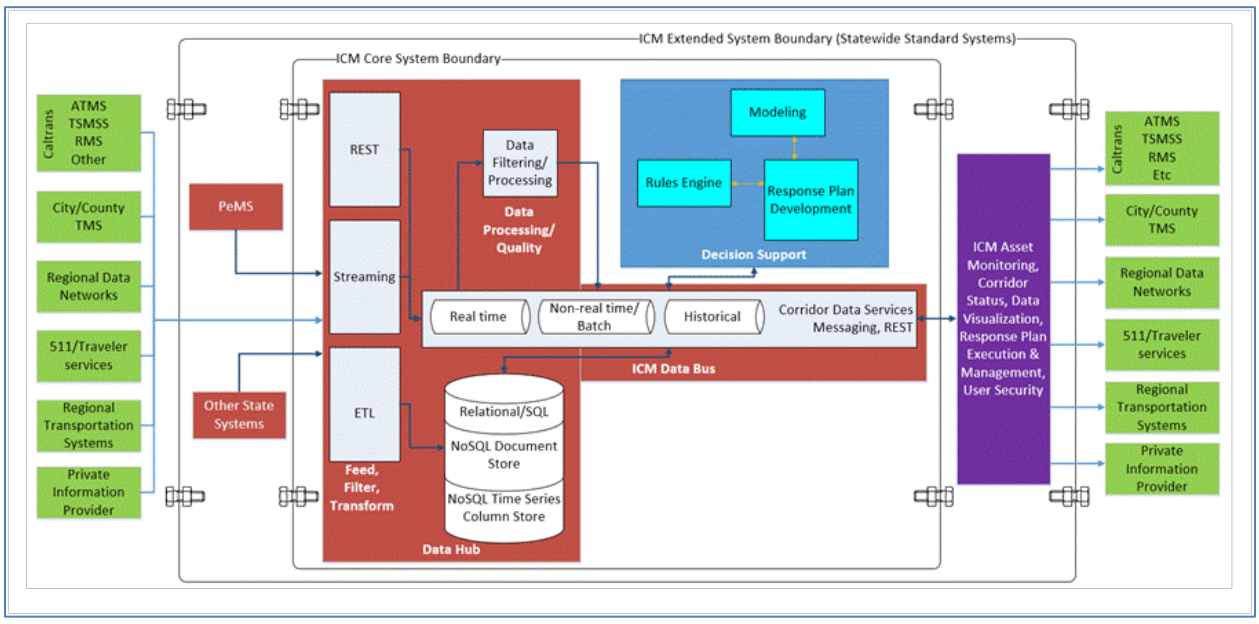

Figure 2-6 – Proposed ICM System Architecture

The specific systems that originate the entering data or receive the exiting data are illustrated in Figure 2-4, presented earlier.

2.8.5. CATEGORIES OF USERS

Two main categories of system users are distinguished based on how individual users would interact with the system:

- **System Operators (Direct Users)** – Individuals actively participating in the operation of the system and having administrative access to some or all of its components. These include:
    - Traffic managers
    - Traffic management center operators
    - Traffic control system operators
    - Traffic engineers
    - Transit field supervisors
    - Transit dispatchers
    - Participating parking facilities operators
    - Participating information providers
    - Maintenance staff
- **End Users (Indirect Users)** – Individuals who do not actively participate in the operation of the system but who may use it to view how the corridor is operating or gather information that may help them make decisions. These include:
    - Transit vehicle drivers
    - Transit system managers
    - California Highway Patrol (CHP)
    - Local police departments
    - Local fire departments
    - Metro Freeway Service Patrol
    - Parking facility operators not in system operations
    - Transportation system planners
    - Transportation supervisors
    - Transportation department directors
    - Agency/city executives and decision-makers
    - Public information officers
    - 511 services
    - Third-party information service providers
    - Commercial fleet operators/managers
    - Travelers

2.8.6. STATES OF OPERATION

The I-210 Pilot ICM system is projected to be mainly active during incidents and events. When not engaged in responding to specific incidents and events, the ICM system will simply keep monitoring and periodically evaluating travel conditions within the corridor on a 24/7 basis.

In addition to considering the operational situations described above, the ICM system should be robust enough to keep operating in a state of partial failure. Periodic system checks should assess whether individual system components are operating as intended, as well as the health of input data feeds and the quality of input data. Following the detection of potential operational problems, such as issues with detector data or an inability to communicate with field devices, the system should inform transportation system operators of detected problems and try to continue its operation, to the extent possible, by compensating for the identified problems. Should a major failure preventing adequate system operation be detected, the system should then revert to a fail-safe operational mode allowing it to implement predetermined control strategies in response to incidents or events, or simply shut down if a certain minimal state of operation cannot be guaranteed.

2.8.7. MODE OF OPERATION

A pivotal step in the control framework is the requirement for the operators of individual systems affected by a response plan to review and approve the recommended response actions before they can be implemented. This approval process will typically be implemented as follows:

1. The system's decision-support intelligence evaluates corridor travel conditions, develops one or more response plans to an incident or event, and recommends a preferred plan, all without intervention from the system operator.
2. Following the identification of a preferred plan, information about the plan is sent to the operators of involved systems for review and approval.
3. System operators provide an approval/rejection decision on the submitted response plan.
4. If the recommended response plan is approved, the system then implements the plan, directly operating the control devices necessary to address the incident or event.

The level of user oversight described above means that the ICM system will typically operate in a **semi-automated** mode.

2.8.8. INSTITUTIONAL SUPPORT FRAMEWORK

Figure 2-7 shows the institutional framework supporting the operation of the I-210 Pilot ICM system. This framework includes the following groups or individuals:

- **Corridor Manager** – Caltrans staff member tasked with assessing how the corridor is operating. While this person may have direct authority to approve/reject control changes affecting Caltrans-operated devices, traffic managers from each agency will retain decision authority over their respective systems. The Corridor Manager can be viewed as a system coordinator tasked with assessing how well the individual systems connected to the ICM system are operating together, and determining whether specific issues need to be escalated for consideration by the Technical and Operational Advisory Committee or Connected Corridors Steering Committee. Another important role will be to ensure that agreed-upon action items are carried through by the individual agencies participating in the operation of the ICM system.
- **Corridor Technical Manager** – Caltrans individual tasked with ensuring the good operation of the ICM system components. This includes managing system configuration, as well as maintenance needs and repairs. While responsible for maintaining the ICM Core System, this

individual will not be responsible for maintaining devices operated by Caltrans or other agencies. Each agency will retain maintenance responsibility for their respective systems. The only responsibility of the Corridor Technical Manager with respect to the maintenance of the various systems connected to the ICM system would be to follow up on identified maintenance and repair needs, and to report on the status of those activities to the Corridor Manager.

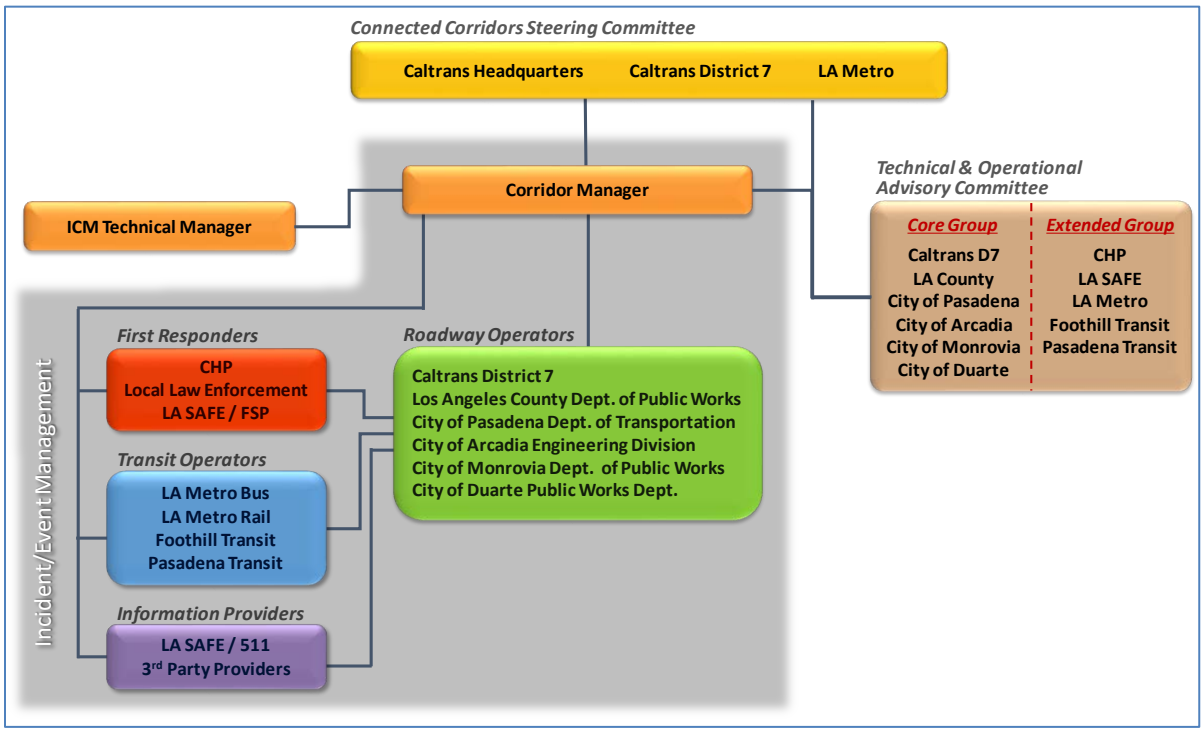

Figure 2-7 – Institutional Framework

- **Core System Operators** – Operators of the road networks managed by the ICM system. These represent the individuals responsible for approving/rejecting traffic control recommendations made by the ICM system when automated control is not enabled.
- **511 Services / Information Providers / Information Consumers** – Agencies and entities predominantly providing information to the ICM system or using information generated by it to inform their decision-making process. This includes first responders, transit agencies, and information providers.
- **Technical & Operational Advisory Committee** – Committee composed of a technical staff person from each of the agencies having a stake in the operation of the system and tasked with addressing operation issues that could not be resolved by the system operators and/or Corridor Manager. Depending on the issues being considered, representatives from the CHP, LA SAFE, Metro, and transit agencies are also expected to participate in its activities.
- **Connected Corridors Steering Committee –** Committee composed of representatives of Caltrans District 7, Caltrans Headquarters, and Metro; tasked with resolving any issues that cannot be resolved by the Technical & Operational Advisory Committee and with addressing funding, legal, operational policy, and organizational issues associated with the operation of the I-210 ICM system, as well as with developing strategic vision and plans for future system enhancements and/or deployments. Would meet as needed.

3. REFERENCED DOCUMENTS

- *Connected Corridors: I-210 Pilot Integrated Corridor Management System – Concept of Operations*. Partners for Advanced Transportation Technology, University of California, Berkeley, June 2015.

- *Connected Corridors: I-210 Pilot Integrated Corridor Management System – Systems Engineering Management Plan*. Partners for Advanced Transportation Technology, University of California, Berkeley, October 2015.

- *Connected Corridors: I-210 Pilot Integrated Corridor Management System – System Requirements*. Partners for Advanced Transportation Technology, University of California, Berkeley, August 2016.

- *I-210 Pilot System Requirements: Job Descriptions and Duties/Tasks*. Partners for Advanced Transportation Technology, University of California, Berkeley, September 2016.

- *Systems Engineering for Intelligent Transportation Systems: An Introduction for Transportation Professionals.* Publication No. FHWA-HOP-07-069, Federal Highway Administration, U.S. Department of Transportation, January 2007.

- *Systems Engineering Guidebook for ITS – Version 3.0*. California Division, Federal Highway Administration, U.S. Department of Transportation and Caltrans, November 2009.

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4. VALIDATION FRAMEWORK

This section outlines how validation of the ICM system will be accomplished. Specific elements covered in the section include:

- Schedule of validation activities
- Validation setup
- Participants in validation activities
- Roles and responsibilities of participants
- General evaluation process to be followed
- Evaluation criteria to be used to assess success of the validation
- Handing of anomalies
- Documents to be prepared

4.1. VALIDATION SCHEDULE

As illustrated in Figure 4-1, validation will occur at the end of the system development process, when all the relevant system components will have been verified to meet their respective system requirements and deployed in the field, just before the system is ready to be formally put into operations. The exact timing of the validation effort will thus depend on when the verification activities will be completed.

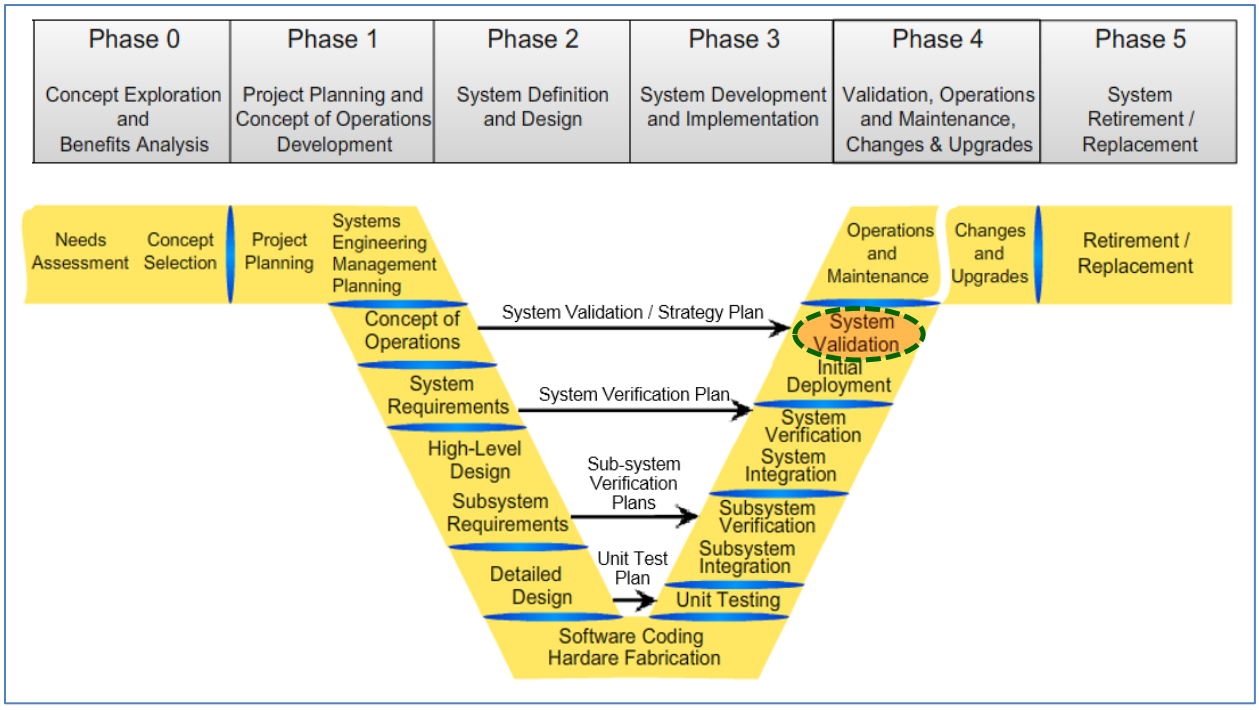

Figure 4-1 – Validation Activities within Systems Engineering Process

Figure 4-2 illustrates the sequence of validation activities to be conducted. As indicated earlier, the objective of the validation effort is to ensure that the delivered product satisfies all the user needs that motivated its development. Early validation activities will focus on testing simple system functions. As the validation effort progresses, tests will involve an increasing number of functionalities and will

culminate with operational tests of the system's ability to effectively respond to incidents and events in a real-time context.

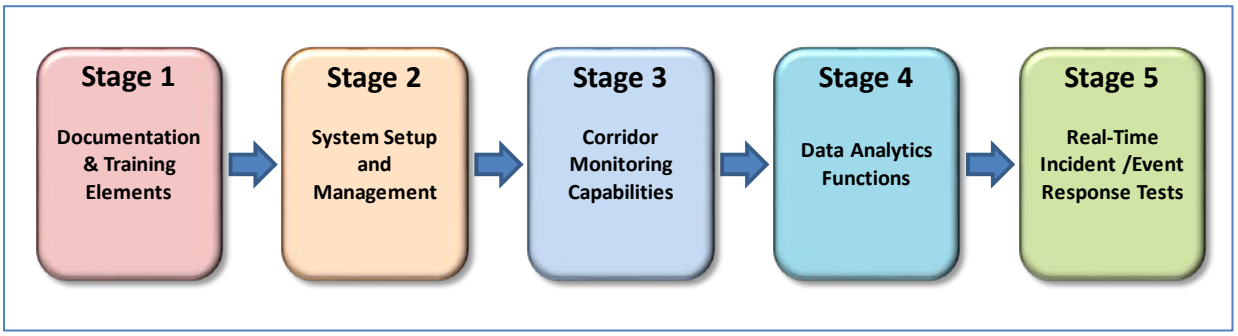

Figure 4-2 – Sequencing of Validation Activities

As the figure shows, validation activities will involve the following five test stages:

- **Stage 1 – Validation of documentation and training:** validation of availability of user manuals and training materials adequately supporting system operations.
- **Stage 2 – Validation of system setup and management functions:** validation of users' ability to access the ICM system, change the configuration of system elements, set up automated control options, modify network elements defined within the ICM system, modify rules used by the DSS to develop response plans, modify response plans produced by the system, and conduct system diagnostics.
- **Stage 3** – **Validation of basic corridor monitoring capabilitie**s: validation of users' ability to display corridor elements, view current traffic conditions within the corridor, and view the status of traffic management devices connected to the ICM system.
- **Stage 4 – Validation of data analytical capabilities**: validation of users' ability to conduct historical data analyses, generate estimations of current traffic states throughout the corridor, generate traffic forecasts, calculate performance metrics, and generate performance reports.
- **Stage 5 – Full operational tests:** testing of system responses to various incidents and events in a real-time context.

At each stage, several testing activities will be conducted to validate various system capabilities. Validation activities will not move from one stage to the next unless all elements to be tested within a stage have been appropriately validated.

4.2. VALIDATION SETUP

Validation activities will be conducted on the deployed I-210 Pilot ICM system that corridor stakeholders are expected to use in their day-to-day operation to manage responses to incidents and events. This means that all evaluation activities will be conducted on a fully operational system and a system for which all individual components have already been certified to meet their respective underlying system requirements. As a reference, a diagram of the architecture of the system expected to be delivered was shown in Figure 2-6, with Figure 2-7 further illustrating the various systems that are envisioned to be connected to the ICM system.

Figure 4-3 illustrates the setup that will be used for conducting the validation. Since the objective is to verify that the delivered product satisfies the user needs that prompted its development, validation activities will generally focus on the ability of the system to support corridor management operations. Specific focus will therefore be put on assessing how users are interacting with the system and how they are utilizing it for making decisions. This is what is represented by the two arrows connecting the system operators and managers with the ICM system at the bottom right of the diagram. In this context, evaluation activities will typically consist of (1) observing how users can execute various key management and operational tasks and (2) assessing the ability of the system to produce effective traffic management recommendations that will be accepted by system operators in response to various types of incidents and events.

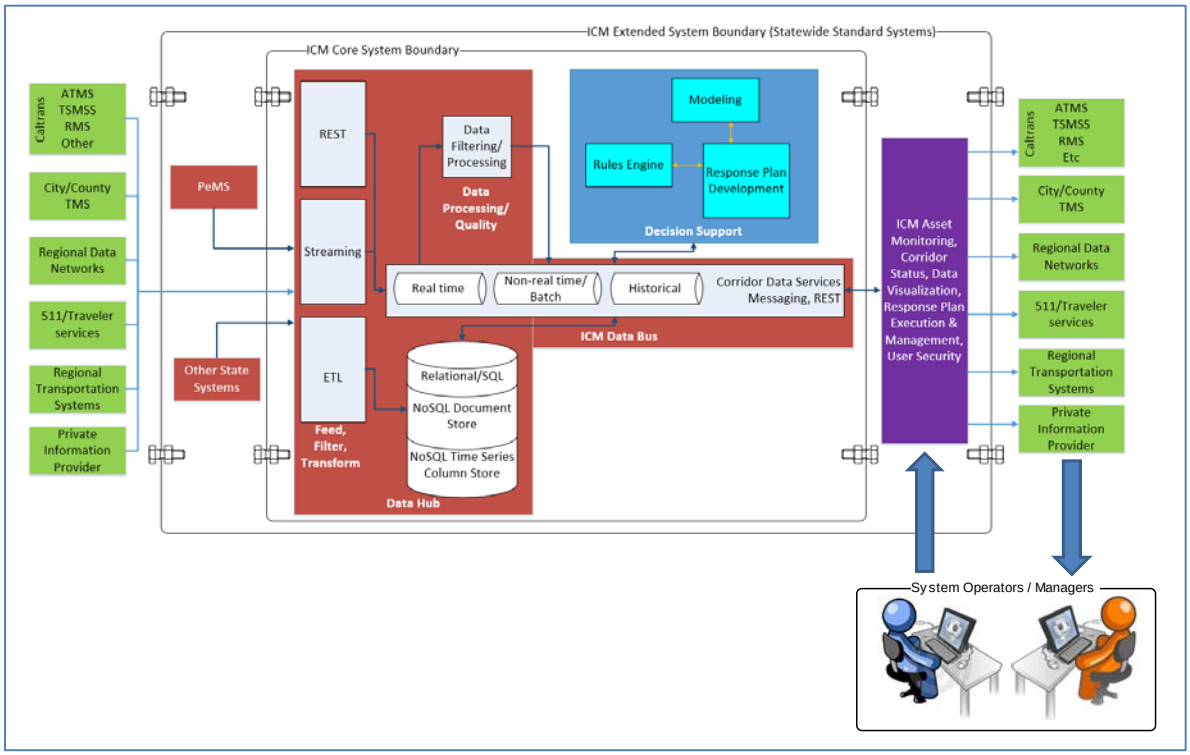

Figure 4-3 – Proposed ICM System Architecture

Core system validation activities will be conducted from a location where traffic managers and system operators from each participating agency could monitor their respective systems. An ideal candidate location is Caltrans' Los Angeles Regional Traffic Management Center. From this location, Caltrans could directly access the core ICM system components in addition to the various traffic management systems it operates within the I-210 corridor, while local agencies could be provided with terminals from which they could remotely access their respective systems. Other locations could also be used, such as the Los Angeles County Traffic Management Center, as long as adequate remote access to the needed core ICM system components can be established. Preference is given here to having all participants in the same room to facilitate evaluation discussions and, if needed, troubleshooting.

While the core system validation activities are expected to be conducted from a central location, individual validation tests will also be conducted within each jurisdiction to assess specific elements, such as the ability to log into the system from each location where users are expected to interact with the system.

4.3. PARTICIPANTS

Key participants in system validation will include the following:

Table 4-1 – Primary Participants in Validation Activities

Group	Participants
I-210 corridor managers	• Caltrans I-210 Corridor Manager • Caltrans I-210 Corridor Technical Manager
Agency staff responsible for managing traffic during incidents and events	• Traffic managers/engineers from Caltrans District 7 • Traffic managers/engineers from Los Angeles County • Traffic managers/engineers from the city of Pasadena • Traffic managers/engineers from the city of Arcadia • Traffic managers/engineers from the city of Monrovia • Traffic managers/engineers from the City of Duarte
Transportation data analysts	• Caltrans I-210 Data Analyst • Data analysts from local agencies
Support staff from stakeholder agencies assigned to the I-210 ICM system	• ICM Database Administrator • Information technology support staff • Information technology security support staff • Maintenance staff for field devices/systems • Software engineers • Electrical engineers
Contributors to the development, integration, and implementation of system components	• Developers from PATH • Staff from Caltrans District 7 • Staff from Caltrans Headquarters • Representatives from consultants hired to develop or implement specific components
PATH project management team	• PATH Project Manager • PATH Systems Engineering Manager

The following individuals may also be invited to participate in validating specific system elements:

Table 4-2 – Secondary Participants in Validation Activities

Group	Participants
Dispatchers/supervisors from transit agencies involved in the operation of the system	• Representative from Foothill Transit • Representative from Pasadena Transit • Representative from Metro
Representatives from first responding agencies	• Officers from the California Highway Patrol • Officers from the Los Angeles County Sheriff's Office • Officers from the Pasadena Police Department • Officers from the Arcadia Police Department • Officers from the Monrovia Police Department

4.4. GENERAL ROLES AND RESPONSIBILITIES OF PARTICIPANTS

The following table lists the anticipated general roles and responsibilities of the validation participants identified in section 4.3. Specific roles and responsibilities will be developed later in the project, when the evaluation procedures to be used for validation testing will be finalized.

Table 4-3 – Validation Roles and Responsibilities

Participant	General Roles/Responsibilities
Caltrans I-210 Corridor Manager	• Review of ICM system's user manual • Review of received training on ICM system operations • Identification of validation test cases • Use of system to monitor traffic conditions within corridor • Entry of data characterizing incidents and events into the Decision Support module • Evaluation of system of rules implemented by the Decision Support module • Review and approval of recommended response plans • Modification of recommended response plans • Evaluation of ability of individuals to analyze data
Caltrans I-210 Corridor Technical Manager	• Review of ICM system's user manual • Review of received training on ICM system operations • Identification of validation test cases • Setting ICM system configuration • Use of system to monitor traffic conditions within corridor • Evaluation of system of rules implemented by the Decision Support module • Diagnostics of ICM system core components • Diagnostics of information supplied by connected systems
Traffic managers/engineers from stakeholder agencies responsible for managing traffic during incidents and events	• Review of ICM system's user manual • Review of received training on ICM system operations • Identification of validation test cases related to the management of incidents and events • Use of system to monitor traffic conditions within corridor • Entry of data characterizing incidents and events into the Decision Support module • Observation of ICM decision-making activities • Review and approval of recommended response plans • Diagnostics of connected systems managed by each agency

Table 4-3 – Validation Roles and Responsibilities (cont'd)

Participant	General Roles/Responsibilities
Dispatchers/supervisors from transit agencies involved in the operation of the system	• Review of ICM system's user manual (mainly sections related to transit operations) • Review of received training on ICM system operations • Identification of validation test cases involving transit operations • Use of system to monitor traffic conditions within corridor • Entry of information characterizing transit incidents of interest to the ICM system • Observation of ICM decision-making activities • Provision of comments on potential improvements
Representatives from first responding agencies	• Use of system to monitor traffic conditions within corridor • Observation of ICM decision-making activities
Transportation data analysts	• Diagnostics of ICM system core components • Diagnostics of information supplied by connected systems
Support staff from stakeholder agencies assigned to the I-210 ICM system	• Review of ICM system's user manual (only for those individuals expected to interact with the ICM user functionalities) • Review of received training on ICM system operations • Observation of ICM system operations • Diagnostics of information supplied by connected systems
Contributors to the development and implementation of the ICM system	• Observation of ICM system operations • Core ICM system diagnostics
PATH Systems Engineering Management	• Identification of validation test cases • Development of validation procedures • Management of validation activities • Observation of system operations • Recording of comments made by participants in the validation effort • Documentation of efforts to resolve issues identified during validation effort • Writing of validation report
PATH Project Manager	• Identification of validation test cases • Development of validation procedures • Management of validation activities • Observation of system operations

4.5. EVALUATION PROCESS

This validation plan lays out the overall expectations for the assessment of the completed system. It does not specify the strict step-by-step procedures to be followed by system users to ensure that the system satisfies their needs. The plan only goes as far as detailing general evaluation cases that shall be considered during the validation efforts to ensure that all user needs and desired system functionalities have been satisfactorily included. The exact procedures to be followed during each validation case will be developed by PATH in collaboration with system users prior to the start of the validation effort. Since users may have had some experience working with some system components by that time, it is expected that the validation procedures to be used will be heavily influenced by what system users will have observed in their interactions with system components, as well as by their traditional way of managing traffic during incidents and events.

At this stage, only the general guidelines for the execution of each validation case have been defined. These guidelines stipulate that each case is to be executed and assessed using the following steps:

1. Review with system users the objective of the test to be executed
2. Review with system users the expected activities or tasks to be accomplished during the test
3. Execution of the assigned tasks by system users
4. Discussion of issues or problems that were encountered during the task, if any, and troubleshooting
5. Documentation of results of validation case

4.6. EVALUATION CRITERIA

System validation will be conducted on a simple Pass/Fail criterion.

For each test case, a Pass/Fail result will be assigned based on the results of the test conducted. Any test for which a Fail assessment is assigned will need to be redone after the issues that caused the assessment failure have been corrected.

For the overall system, a successful validation will require a Pass rating on all the test cases defined as part of the validation effort.

4.7. HANDLING OF ANOMALIES

Each validation test will be carefully monitored for unexpected issues or operational problems. Any identified issue will be documented, assessed, and marked as follows according to its severity:

- **Minor issue:** Issue affecting a single system component that can easily be addressed and for which there is no need to stop the validation effort.
- **Moderate issue:** Issue affecting a single system component that may require some substantial effort to fix. Depending on the case, some issues may require a temporary pause in validation activities until they are resolved.

- **Critical issue:** Issue requiring significant changes to one or more system components. Such issues will typically require a full stop of the validation effort and, depending on the situation, may even force a redo of some prior validation tests.

For each identified issue, the person in charge of conducting the validation test that uncovered the issue will be responsible for documenting it and reporting it to the PATH Project Manager. After being informed of an issue, the PATH Project Manager, in collaboration with the ICM Technical Manager, the ICM Corridor Manager, the PATH Systems Engineering Manager, and any other relevant technical support staff, will be responsible for determining an appropriate course of action to fix the issue. This will include determining whether validation activities should be suspended and what will need to be done to resume the validation effort once the issue has been resolved.

If an appropriate solution to an identified issue cannot be developed by the individuals assigned to review the issue, the ICM Corridor Manager will then escalate the issue to the Technical & Operational Advisory Committee. This committee would in turn try to determine what to do to resolve the issue. If a suitable solution cannot be found at this level, the issue would be escalated further to the Connected Corridors Steering Committee, which would then make a final decision on the matter.

Following the initial identification and documentation of an issue, the PATH Systems Engineering Manager, in collaboration with the PATH Project Manager, will be responsible for documenting the subsequent efforts to resolve the issue and to resume the validation effort.

4.8. DOCUMENTS TO BE PREPARED

Two specific documents are to be prepared as part of the validation activities:

- **Validation Test Cases and Procedures**: Document to be prepared prior to the start of the validation effort and detailing the validation cases to be considered, the specific system functions to be used, and the specific procedures to be followed during each validation case.
- **Validation Report**: Document detailing the results of the validation effort, including documentation of all system modifications, if any, that have been or will be implemented as a result of the validation effort.

5. VALIDATION CASES

This section presents the specific validation cases that will be used to verify that the deployed I-210 Pilot ICM system satisfies the user needs it was developed to address. The proposed test cases are listed at the top of Table 5-1 on page 34, grouped into the following five categories:

- **Stage 1 – Validation of documentation and training:** validation of availability of user manuals and training materials adequately supporting system operations.
- **Stage 2 – Validation of system setup, management functions, and people skills:** validation of users' ability to access the ICM system, change the configuration of system elements, set up automated control options, modify network elements defined within the ICM system, modify rules used by the DSS to develop response plans, modify response plans produced by the system, and conduct system diagnostics.
- **Stage 3** – **Validation of basic corridor monitoring capabilitie**s: validation of users' ability to display corridor elements, view current traffic conditions within the corridor, and view the status of traffic management devices connected to the ICM system.
- **Stage 4 – Validation of data analytical capabilities**: validation of users' ability to conduct historical data analyses, generate estimations of current traffic states throughout the corridor, generate traffic forecasts, calculate performance metrics, and generate performance reports.
- **Stage 5 – Full operational tests:** testing of system responses to various incidents and events in a real-time context.

For each test case, the table indicates the user needs that the test is meant to verify. The table distinguishes the user needs that are the main focus of the test (filled circle in shaded green cell) and those that are a secondary focus (hollow circle in white cell). The order in which the various tests should be executed should correspond to the order in which the various tests are presented. This will ensure that user needs representing basic system functions will be tested first, before the evaluation of more complex system functionalities.

More information about each test case is presented in the subsections that follow the table. The specific procedures to be used as part of each test are not defined within this document, as these are best developed just before executing the tests, when precise knowledge about system functionalities and their operating procedures is available. The information presented below provides only enough information about each test case to allow the reader to assess its purpose. Elements presented for each case include:

- Objective of the test
- Key user needs being verified
- Prerequisite successful tests
- Key participants in the validation tests
- Supporting participants (individuals tasked with managing test activities, recording test results, and addressing technical issues identified by key test participants)
- Information to be recorded
- Pass/Fail criteria
- Assumptions and constraints (if any)

Table 5-1 – User Needs Evaluation Traceability Matrix

		Docs		System Setup, Management Functions, People Skills											Corridor Monitoring					Data Analytics					Incident/Event Responses						
ID	User Need	Review of User Manuals	Review of Received Training	Accessing ICM System Environment	Managing Access to ICM System	Setting ICM System Configuration	Adding/Modifying/Deleting Network Elements	System Diagnostics - ICM Core Components	System Diagnostics - Connected Systems	Managers' Traffic Data Analysis Capability	Automated Control Setup	Modifying/Editing DSS Rules	Modifying Recommended Response Plans	Displaying of Corridor Elements	Monitoring of Traffic Conditions on Freeway	Monitoring of Traffic Conditions along Arterial Routes	Monitoring of Individual Intersection Performance	Monitoring of Status of Traffic Management Assets	Execution of Historical Analysis	Generation of Traffic Estimations	Generation of Traffic Forecasts	Calculation of Performance Metrics	Generation of Performance Reports	Creating/Editing Incidents	Response to Freeway Incident - Moderate	Response to Freeway Incident - Major	Response to Arterial Incident - Major	Response to Planned Lane/Road Closure	Response to Planned Event	Response to Gold Line Incident - Major
System Monitoring																														
1	Collect and Process Multimodal Data Characterizing Corridor Performance														●	●	●		O	O	O	O	O	O	O	O	O	O	O	O
2	Collect and Process Multimodal Corridor Travel Demand Data														●	●	●		O	O	O	O	O	O	O	O	O	O	O	O
3	Monitor Asset Availability																	●		O	O	O	O	O	O	O	O	O	O	O
Decision Support																														
4	Decision-making Assistance					O						O							●	O	O	O	O	●	●	●	●	●	●	●
5	Operational Forecast Capability																			●	●			O	O	O	O	O	O	O
6	Strategy Effectiveness Assessment					O						O								●	●	●	●	O	O	O	O	O	O	O
Control Capabilities																														
7	Multi-Agency Coordination Support																								●	●	●	●	●	●
8	Automated Incident Response Capability					O					●														O	O	O	O	O	O
9	Manual Control Capability												●											O	O	O	O	O	O	O
10	Preferred Control Options					●						●																		
11	Device Modification and Addition Capability						●																							
12	Information Visualization					O	O							●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Information Dissemination																														
13	Provision of Real-Time, Multi-Modal Information to System Operators														●	●	●	●		O	O	O	O	●	●	●	●	●	●	●
14	Provision of Real-Time, Multi-Modal Information to End Users (Travelers)														O	O	O					O	O	O	●	●	●	●	●	●
Data Management																														
15	Historical Data Archiving														O	O	O	O	●											
System Management and Maintenance																														
16	ICM System Management			●	●	●	●	O	O		●	●																		
17	System Maintenance							●	●																					
18	Training Support	●	●							●																				

● User need primarily considered by test O User need indirectly considered by test

5.1. SYSTEM DOCUMENTATION AND TRAINING MATERIAL

5.1.1. REVIEW OF USER MANUALS

- *Objective* – Review of user manuals for completeness and clarity.
- *Key user needs tested (numbers from Table 5-1)* – Training Support (18).
- *Prerequisite successful tests* – None.
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies participating in the operation of the ICM system; I-210 Corridor Manager; I-210 Corridor Technical Manager; support staff expected to interact with the system user functionalities.
- *Support participants* – PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – Comments about potential improvements to the I-210 ICM User's Guide.
- *Pass criteria* – Approval of user's guide by all individuals expected to interact with the ICM system.
- *Assumptions and constraints* – None.

5.1.2. REVIEW OF RECEIVED TRAINING

- *Objective* – Review of training material and training provided to system users.
- *Key user needs tested (numbers from Table 5-1)* – Training Support (18).
- *Prerequisite successful tests* – None.
- *Participants* – Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies participating in the operation of the ICM system; I-210 Corridor Manager; I-210 Corridor Technical Manager; support staff expected to interact with the system user functionalities.
- *Support participants* – PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – Comments about potential improvements to the training material or training programs.
- *Pass/Fail criteria* – Positive evaluation of training activity from all system users.
- *Assumptions and constraints* – None.

5.2. SYSTEM SETUP, MANAGEMENT CAPACITIES, AND PEOPLE SKILLS

5.2.1. ACCESSING ICM SYSTEM ENVIRONMENT

- *Objective* – Verify that system users can access the ICM system environment from their respective workplaces and from remote locations.
- *Key user needs tested (numbers from Table 5-1)* – ICM System Management (16).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies participating in the operation of the ICM system; representative from first responding agencies expected to access the system; I-210 Corridor Manager; I-210 Corridor Technical Manager; support staff expected to interact with the ICM user functionalities.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – Number of successful and failed attempts; documentation of failed attempts.
- *Pass/Fail criteria* – Ability for all system users to access the ICM system from all locations where access may be necessary.
- *Assumptions and constraints* – None.

5.2.2. MANAGEMENT OF ACCESS TO ICM SYSTEM

- *Objective* – Verify that the ICM system administrators can manage user accounts and system access privileges.
- *Key user needs tested (numbers from Table 5-1)* – ICM System Management (16).
- *Prerequisite successful tests* – Accessing ICM System Environment (section 5.2.1).
- *Key participants* – I-210 Corridor Technical Manager; IT security support staff.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – Operational issues preventing the execution of specific tasks.
- *Pass/Fail criteria* – Ability to perform all identified management tasks successfully.
- *Assumptions and constraints* – None.

5.2.3. SETTING ICM SYSTEM CONFIGURATION

- *Objective* – Verify that ICM system administrators can manage parameters framing the operation of the Decision Support System.

- *Key user needs tested (numbers from Table 5-1)* – Preferred Control Options (10); ICM System Management (16).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); Accessing ICM System Environment (section 5.2.1).
- *Key participants* – I-210 Corridor Manager; I-210 Corridor Technical Manager; Traffic Managers/Engineers from stakeholder agencies having authority to manage configuration elements linked to their agency.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – Number of successful and failed attempts; documentation of failed attempts.
- *Pass/Fail criteria* – Ability to set without problems all parameters that system administrators are allowed to modify.
- *Assumptions and constraints* – None.

5.2.4. ADDING/MODIFYING/DELETING NETWORK DEVICES

- *Objective* – Verify that system administrators can add, modify, or delete network devices in the ICM inventory, such as traffic signals, ramp meters, changeable message signs, and trailblazer signs. This also includes the ability to alter the traffic signal and ramp metering control parameters used by the ICM system to plan responses to incidents and events.
- *Key user needs tested (numbers from Table 5-1)* – Device Modification (11); ICM System Management (16).
- *Prerequisite successful tests* – Review of User Manual (section 5.1.1); Accessing ICM System Environment (section 5.2.1).
- *Key participants* – I-210 Corridor Technical Manager; Traffic Managers/Engineers from stakeholder agencies having authority to modify system elements linked to their respective agency.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – ICM system operations under defined periods of automated control.
- *Pass/Fail criteria* – Successful ability for all system users to direct the ICM system to automatically approve response plans when instructed to do so and to seek manual approval at other times.
- *Assumptions and constraints* – None.

5.2.5. SYSTEM DIAGNOSTICS – ICM CORE COMPONENTS

- *Objective* – Verify that the ICM system can provide alerts and diagnostics about malfunctioning core ICM components.
- *Key user needs tested (numbers from Table 5-1)* – System Maintenance (17).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); Accessing ICM System Environment (section 5.2.1).
- *Key participants* – I-210 Corridor Technical Manager; ICM Database Administrators from local agencies; IT support staff, maintenance staff, software engineers, and electrical engineers from Caltrans assigned to the maintenance of the ICM system.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – Results of diagnostic tests executed on core system components; data supporting the diagnostics.
- *Pass/Fail criteria* – Successful ability of the ICM system to perform self-checks on core components and to alert designated individuals of the identified problems.
- *Assumptions and constraints* – None.

5.2.6. SYSTEM DIAGNOSTICS – CONNECTED SYSTEMS

- *Objective* – Verify that the ICM system can provide diagnostic alerts about issues affecting the normal operation of connected systems, such as local traffic signal control systems, ramp metering control systems, or systems used to manage changeable message signs and trailblazer signs.
- *Key user needs tested (numbers from Table 5-1)* – System Maintenance (17).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); Accessing ICM System Environment (section 5.2.1).
- *Key participants* – I-210 Corridor Technical Manager; Traffic Managers/Engineers from stakeholder agencies tasked with managing individual connected systems; maintenance staff, software engineers, and electrical engineers from stakeholder agencies assigned to the maintenance of systems connected to the ICM system.
- *Support participants* – Caltrans I-210 Data Analyst; Data Analysts from local agencies; ICM Database Administrators from local agencies; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – Results of diagnostic tests executed; data provided by connected systems to support the diagnostics.
- *Pass/Fail criteria* – Successful ability for the ICM system to report detected problems associated with connected systems.
- *Assumptions and constraints* – Ability of system to communicate with all connected systems used to manage travel within the I-210 corridor.

5.2.7. MANAGERS' TRAFFIC DATA ANALYSIS CAPACITY

- *Objective* – Verify that traffic managers have the appropriate skills to analyze traffic data provided to them by the ICM system, in particular metrics used by the system to determine recommended courses of action.
- *Key user needs tested (numbers from Table 5-1)* – Training Support (17).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); Accessing ICM System Environment (section 5.2.1).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; I-210 Corridor Manager; I-210 Corridor Technical Manager.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – Metrics provided by the ICM system.
- *Pass/Fail criteria* – Successful ability for all system users to understand the metrics provided to them and to use the metrics to correctly assess travel conditions within the corridor.
- *Assumptions and constraints* – None.

5.2.8. AUTOMATED CONTROL SETUP

- *Objective* – Verify that system users can allow the Decision Support System to automatically approve recommended response plans when desired.
- *Key user needs tested (numbers from Table 5-1)* – Automated Response Capability (8); ICM System Management (16).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); Accessing ICM System Environment (section 5.2.1).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; I-210 Corridor Manager; I-210 Corridor Technical Manager.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – ICM system operations under defined periods of automated control.
- *Pass/Fail criteria* – Successful ability of all system users to direct the ICM system to automatically approve response plans when instructed to do so and to seek manual approval at other times.
- *Assumptions and constraints* – None.

5.2.9. MODIFYING/EDITING DECISION SUPPORT SYSTEM RULES

- *Objective* – Verify that system administrators can modify, if needed, the rules used by the Decision Support module to identify the incidents and events for which a response plan should be developed and to subsequently develop a suitable response plan.
- *Key user needs tested (numbers from Table 5-1)* – Preferred Control Options (10).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); Accessing ICM System Environment (section 5.2.1); Setting ICM System Configuration (section 5.2.3).
- *Key participants* – I-210 Corridor Manager; I-210 Corridor Technical Manager.
- *Support participants* – Traffic Managers/Engineers; Data Analysts; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – Results of attempts to modify the rules used by the Decision Support module to identify incidents and generate response plans.
- *Pass/Fail criteria* – Successful ability to change the rules used by the Decision Support module.
- *Assumptions and constraints* – None.

5.2.10. MODIFYING RECOMMENDED RESPONSE PLANS

- *Objective* – Verify that system operators can change upon request minor elements of an implemented response plans for which an online modification permission exists. Examples of capabilities that may be validated, depending on final system design agreement between system stakeholders, include the ability to change messages being disseminated to 511 systems or being posted on changeable message signs.
- *Key user needs tested (numbers from Table 5-1)* – Manual Control Capability (9).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); Accessing ICM System Environment (section 5.2.1); Setting ICM System Configuration (section 5.2.3).
- *Key participants* – I-210 Corridor Manager; I-210 Corridor Technical Manager; Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – Results of attempts to modify specific components of an implemented response plan.
- *Pass/Fail criteria* – Ability to successfully change elements of implemented response plans.
- *Assumptions and constraints* – None.

5.3. CORRIDOR MONITORING

5.3.1. DISPLAYING OF CORRIDOR ELEMENTS

- *Objective* – Verify that ICM system users can obtain lists of field devices connected to the ICM system, view the location of these devices on maps, and access relevant detailed information about each device from the items provided in a list or displayed on a map.
- *Key user needs tested (numbers from Table 5-1)* – Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9).
- *Key participants* – I-210 Corridor Manager; I-210 Corridor Technical Manager; Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies participating in the operation of the ICM system.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – User comments about data visualization features.
- *Pass/Fail criteria* – Acceptance by system users of developed lists and/or data visualization features.
- *Assumptions and constraints* – None.

5.3.2. MONITORING OF TRAFFIC CONDITIONS ON FREEWAYS

- *Objective* – Verify that ICM system users can use the ICM system to monitor, in real time, travel conditions on the I-210 freeway and sections of I-605 and SR-134 included in the ICM coverage area. This includes monitoring traffic volumes, detector occupancy, traffic density, and observed speeds on mainline and HOV lanes along successive freeway segments, as well as traffic volumes on individual on-ramps and off-ramps.
- *Key user needs tested (numbers from Table 5-1)* – Collect and Process Multi-modal Data Characterizing Operational Performance (1); Collect and Process Multi-modal Corridor Travel Demand Data (2); Provision of Real-Time, Multi-modal Information to System Operators (13); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9), Displaying of Corridor Elements (section 5.3.1).
- *Key participants* – I-210 Corridor Manager; I-210 Corridor Technical Manager; Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies participating in the operation of the ICM system.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.

- *Information to be recorded* – User comments about provided performance data and data visualization features.
- *Pass/Fail criteria* – Acceptance by system users of data visualization features.
- *Assumptions and constraints* – None.

5.3.3. MONITORING OF TRAFFIC CONDITIONS ALONG ARTERIAL ROUTES

- *Objective* – Verify that ICM system users can use the ICM system to monitor, in real time, travel conditions along arterials under ICM management. This includes monitoring traffic volumes, travel times, incurred delays, and detector occupancy on successive segments along each possible detour route.
- *Key user needs tested (numbers from Table 5-1)* – Collect and Process Multi-modal Data Characterizing Operational Performance (1); Collect and Process Multi-modal Corridor Travel Demand Data (2); Provision of Real-Time, Multi-modal Information to System Operators (13); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Displaying of Corridor Elements (section 5.3.1).
- *Key participants* – I-210 Corridor Manager; I-210 Corridor Technical Manager; Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies participating in the operation of the ICM system.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – User comments about provided performance data and data visualization features.
- *Pass/Fail criteria* – Acceptance by system users of data visualization features.
- *Assumptions and constraints* – None.

5.3.4. MONITORING OF INDIVIDUAL INTERSECTION PERFORMANCE

- *Objective* – Verify that ICM system users can use the ICM system to monitor, in real time, the operation of individual intersections along arterials under ICM management. This includes monitoring volumes, detector occupancy, turn percentages, and queue estimates where possible on individual intersection approaches and for the whole intersection.
- *Key user needs tested (numbers from Table 5-1)* – Collect and Process Multi-modal Data Characterizing Operational Performance (1); Collect and Process Multi-modal Corridor Travel Demand Data (2); Provision of Real-Time, Multi-modal Information to System Operators (13); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9), Displaying of Corridor Elements (section 5.3.1).

- *Key participants* – I-210 Corridor Manager; I-210 Corridor Technical Manager; Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies participating in the operation of the ICM system.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – User comments about provided performance data and data visualization features.
- *Pass/Fail criteria* – Acceptance by system users of data visualization features.
- *Assumptions and constraints* – None.

5.3.5. MONITORING OF STATUS OF TRAFFIC MANAGEMENT ASSETS

- *Objective* – Verify that ICM system users can use the ICM system to monitor, in real time, the operational status of individual traffic management devices, such as traffic signals, ramp meters, changeable message signs, and trailblazer signs.
- *Key user needs tested (numbers from Table 5-1)* – Monitor Asset Availability (3); Provision of Real-Time, Multi-modal Information to System Operators (13); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9), Displaying of Corridor Elements (section 5.3.1).
- *Key participants* – I-210 Corridor Manager; I-210 Corridor Technical Manager; Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events.
- *Support participants* – System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – User comments about provided status data and data visualization features.
- *Pass/Fail criteria* – Acceptance by system users of data visualization features.
- *Assumptions and constraints* – None.

5.4. DATA ANALYTICAL CAPABILITIES

5.4.1. EXECUTION OF HISTORICAL ANALYSES

- *Objective* – Verify that ICM system users can query historical data to analyze past observed traffic conditions and generate summary performance reports.
- *Key user needs tested (numbers from Table 5-1)* – Historical Data Archiving (15); Information Visualization (12); Decision-Making Assistance (4).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5).

- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; Caltrans I-210 Data Analyst; Data Analysts from local agencies; ICM Database Administrators from local agencies; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – User comments about ability to conduct queries, retrieved historical data, and data visualization features.
- *Pass/Fail criteria* – Acceptance by system users of historical data query and analysis functions.
- *Assumptions and constraints* – None.

5.4.2. GENERATION OF TRAFFIC ESTIMATIONS

- *Objective* – Verify that the ICM system can develop adequate estimates of current traffic conditions for the freeways and arterial segments under ICM management based on real-time data supplied by connected traffic monitoring and management systems.
- *Key user needs tested (numbers from Table 5-1)* – Operational Forecast Capability (5); Strategy Effectiveness Assessment (6); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; Caltrans I-210 Data Analyst; Data Analysts from local agencies; ICM Database Administrators from local agencies; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – User comments about adequacy of traffic estimations and the data visualization features used to present the results of the estimation.
- *Pass/Fail criteria* – Acceptance by system users of estimation results.
- *Assumptions and constraints* – None.

5.4.3. GENERATION OF TRAFFIC FORECASTS

- *Objective* – Verify that the ICM system can provide users with adequate near-term forecasts of traffic conditions within the ICM corridor under a given traffic management plan.
- *Key user needs tested (numbers from Table 5-1)* – Operational Forecast Capability (5); Strategy Effectiveness Assessment (6); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; I-210 Corridor Manager.

- *Support participants* – I-210 Corridor Technical Manager; Caltrans I-210 Data Analyst; Data Analysts from local agencies; ICM Database Administrators from local agencies; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – User comments about the adequacy of the forecast results and the summary and detailed performance metrics extracted from the forecast.
- *Pass/Fail criteria* – Acceptance of forecast process and results by system users.
- *Assumptions and constraints* – None.

5.4.4. CALCULATION OF PERFORMANCE METRICS

- *Objective* – Verify that the ICM system produces performance metrics of interest to the corridor's traffic managers.
- *Key user needs tested (numbers from Table 5-1)* – Strategy Effectiveness Assessment (6); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; Caltrans I-210 Data Analyst; Data Analysts from local agencies; ICM Database Administrators from local agencies; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – User comments about calculated performance metrics.
- *Pass/Fail criteria* – Acceptance of calculated performance metrics by system users.
- *Assumptions and constraints* – None.

5.4.5. GENERATION OF PERFORMANCE REPORTS

- *Objective* – Verify that the ICM system can produce usable, easy-to-understand performance reports summarizing performance metrics of interest to traffic managers.
- *Key user needs tested (numbers from Table 5-1)* – Strategy Effectiveness Assessment (6); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; Caltrans I-210 Data Analyst; Data Analysts from local agencies; ICM Database Administrators from local agencies; System Developers; PATH Systems Engineering Manager; PATH Project Manager.

- *Information to be recorded* – User comments about content and format of performance reports produced by the ICM system.
- *Pass/Fail criteria* – Acceptance by system users of produced performance reports.
- *Assumptions and constraints* – None.

5.5. INCIDENT/EVENT RESPONSE SCENARIOS

5.5.1. CREATING/EDITING/DELETING INCIDENT RECORDS

- *Objective* – Verify that ICM system users can create, edit, and delete incident characterization records used by the Decision Support module to assess the need for response plans and develop required plans.
- *Key user needs tested (numbers from Table 5-1)* – Collect and Process Multi-modal Data Characterizing Operational Performance (1); Manual Control Capability (8).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – User comments about ability to create/edit/delete incident records within the ICM system.
- *Pass/Fail criteria* – Ability to successfully create, modify, delete incident records.
- *Assumptions and constraints* – Test to be conducted on live system.

5.5.2. RESPONSE TO MODERATE FREEWAY INCIDENT

- *Objective* – Validate that the ICM system can be used to respond to moderate freeway incidents requiring the implementation of a single detour route across multiple jurisdictions. This includes verifying system activities related to:
    - the ability to capture the incident
    - the assessment of the near-future impacts of the incident on traffic demand and corridor operations
    - the generation of suitable response plans based on the anticipated impacts of the incident on corridor operations
    - the submission of a recommended plan to affected agencies for review and approval
    - the implementation of control actions and information dissemination contained in an approved response plan
- *Key user needs tested (numbers from Table 5-1)* – Provision of Real-Time, Multi-modal Information to System Operators (13); Decision-Making Assistance (4); Multi-Agency

Coordination Support (7); Provision of Real-Time, Multi-Modal Information to End Users (14); Information Visualization (12).

- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5); Data Analytical Capability tests (section 5.4.1 to 5.4.5); Creating/Editing/Deleting Incident Records (section 5.5.1).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – ICM system activities related to the characterization of incidents, corridor operational assessments, response plan generation, selection of a recommended response plan, approval of recommended plan by affected agencies, and response plan implementation.
- *Pass/Fail criteria* – Ability to successfully respond in a timely manner to the considered moderate freeway incident .
- *Assumptions and constraints* – Test to be conducted on live system by entering a dummy active freeway incident into the system and tracking response of connected systems until field implementation of all related recommended response actions.

5.5.3. RESPONSE TO MAJOR FREEWAY INCIDENT

- *Objective* – Validate that the ICM system can be used to respond to a major freeway incident requiring the implementation of one or multiple detours across several jurisdictions. This includes verifying system activities related to:
    - the ability to capture the incident
    - the assessment of the near-future impacts of the incident on traffic demand and corridor operations
    - the generation of suitable response plans based on the anticipated impacts of the incident on corridor operations
    - the submission of a recommended plan to affected agencies for review and approval
    - the implementation of control actions and information dissemination contained in an approved response plan
- *Key user needs tested (numbers from Table 5-1)* – Provision of Real-Time, Multi-modal Information to System Operators (13); Decision-Making Assistance (4); Multi-Agency Coordination Support (7); Provision of Real-Time, Multi-Modal Information to End Users (14); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5); Data Analytical Capability tests (section 5.4.1 to 5.4.5); Creating/Editing/Deleting Incident Records (section 5.5.1).

- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – ICM system activities related to incident characterization, corridor operational assessments, response plan generation, selection of a recommended response plan, approval of recommended plan by affected agencies, and response plan implementation.
- *Pass/Fail criteria* – Ability to successfully respond in a timely manner to the considered major freeway incident.
- *Assumptions and constraints* – Test to be conducted on live system by entering a dummy active freeway incident into the system and tracking response of connected systems until field implementation of all related recommended response actions.

5.5.4. RESPONSE TO MAJOR ARTERIAL INCIDENT

- *Objective* – Validate that the ICM system can be used to respond to a major incident on an arterial parallel to the I-210 creating a need to implement a detour involving freeway segments across one or multiple jurisdictions. This includes verifying system activities related to:
    - the ability to capture the incident
    - the assessment of the near-future impacts of the incident on traffic demand and corridor operations
    - the generation of suitable response plans based on the anticipated impacts of the incident on corridor operations
    - the submission of a recommended plan to affected agencies for review and approval
    - the implementation of control actions and information dissemination contained in an approved response plan
- *Key user needs tested (numbers from Table 5-1)* – Provision of Real-Time, Multi-modal Information to System Operators (13); Decision-Making Assistance (4); Multi-Agency Coordination Support (7); Provision of Real-Time, Multi-Modal Information to End Users (14); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5); Data Analytical Capability tests (section 5.4.1 to 5.4.5); Creating/Editing/Deleting Incident Records (section 5.5.1).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies involved in the operation of the system; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – ICM system activities related to incident characterization, corridor operational assessments, response plan generation, selection of a recommended response plan, approval of recommended plan by affected agencies, and response plan implementation.

- *Pass/Fail criteria* – Ability to successfully respond in a timely manner to the considered arterial incident.
- *Assumptions and constraints* – Test to be conducted on live system by entering a dummy active arterial incident into the system and tracking response of connected systems until field implementation of all related recommended response actions.

5.5.5. RESPONSE TO PLANNED LANE/ROAD CLOSURE

- *Objective* – Validate that the ICM system can be used to respond to a planned lane/road closure event expected to significantly impact corridor operations, such as the planned closure of multiple lanes on the freeway or on a busy parallel arterial. This includes verifying system activities related to:
    - the ability to capture and appropriately consider the planned event
    - the assessment of the near-future impacts of the closure on corridor operations
    - the generation of suitable response plans based on the anticipated impacts on corridor operations
    - the submission of a recommended plan to affected agencies for review and approval
    - the implementation of control actions and information dissemination contained in an approved response plan
- *Key user needs tested (numbers from Table 5-1)* – Provision of Real-Time, Multi-modal Information to System Operators (13); Decision-Making Assistance (4); Multi-Agency Coordination Support (7); Provision of Real-Time, Multi-Modal Information to End Users (14); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5); Data Analytical Capability tests (section 5.4.1 to 5.4.5); Creating/Editing/Deleting Incident Records (section 5.5.1).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies involved in the operation of the system; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – ICM system activities related to the characterization of planned events, corridor operational assessments, response plan generation, selection of a recommended response plan, approval of recommended plan by affected agencies, and response plan implementation.
- *Pass/Fail criteria* – Ability to successfully respond to the lane closure.
- *Assumptions and constraints* – Test to be conducted on live system by entering into the system a dummy scheduled lane closure expected to start shortly in the future and tracking response of connected systems until field implementation of all related recommended response actions.

5.5.6. RESPONSE TO PLANNED OFF-ROAD EVENT

- *Objective* – Validate that the ICM system can be used to respond to a scheduled off-road event expected to significantly impact travel demand and traffic conditions in the corridor, such as a sports event at the Rose Bowl. This includes verifying system activities related to:
    - the ability to capture and appropriately consider the planned event
    - the assessment of the near-future impacts of the event on corridor operations
    - the generation of suitable response plans based on the anticipated impacts of the event on corridor operations
    - the submission of a recommended plan to affected agencies for review and approval
    - the implementation of control actions and information dissemination contained in an approved response plan
- *Key user needs tested (numbers from Table 5-1)* – Provision of Real-Time, Multi-modal Information to System Operators (13); Decision-Making Assistance (4); Multi-Agency Coordination Support (7); Provision of Real-Time, Multi-Modal Information to End Users (14); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5); Data Analytical Capability tests (section 5.4.1 to 5.4.5); Creating/Editing/Deleting Incident Records (section 5.5.1).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies involved in the operation of the system; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – ICM system activities related to the characterization of the planned event, corridor operational assessments, response plan generation, selection of a recommended response plan, approval of recommended plan by affected agencies, and response plan implementation.
- *Pass/Fail criteria* – Ability to successfully respond to the scheduled off-road event.
- *Assumptions and constraints* – Test to be conducted on live system by entering into the system a dummy off-road event expected to start shortly in the future and tracking response of connected systems until field implementation of all related recommended response actions.

5.5.7. RESPONSE TO GOLD LINE CLOSURE

- *Objective* – Validate that the ICM system can be used to respond to a major transit incident expected to significantly increasing traffic demand within the I-210 corridor, assumed here to take the form of a full closure of Metro's Gold light-rail line. This includes verifying system activities related to:
    - the ability to capture the transit incident

  - the assessment of the near-future impacts of the incident on traffic demand and corridor operations
  - the generation of suitable response plans based on the anticipated impacts of the incident on corridor operations
  - the submission of a recommended plan to affected agencies for review and approval
  - the implementation of control actions and information dissemination contained in an approved response plan

- *Key user needs tested (numbers from Table 5-1)* – Provision of Real-Time, Multi-modal Information to System Operators (13); Decision-Making Assistance (4); Multi-Agency Coordination Support (7); Provision of Real-Time, Multi-Modal Information to End Users (14); Information Visualization (12).
- *Prerequisite successful tests* – Review of User Manuals (section 5.1.1); System Setup and Management tests (section 5.2.1 to 5.2.9); Corridor Monitoring tests (section 5.3.1 to 5.3.5); Data Analytical Capability tests (section 5.4.1 to 5.4.5); Creating/Editing/Deleting Incident Records (section 5.5.1).
- *Key participants* – Traffic Managers/Engineers from stakeholder agencies responsible for managing traffic during incidents and events; Dispatchers/Supervisors from transit agencies involved in the operation of the system; I-210 Corridor Manager.
- *Support participants* – I-210 Corridor Technical Manager; System Developers; PATH Systems Engineering Manager; PATH Project Manager.
- *Information to be recorded* – ICM system activities related to incident characterization, corridor operational assessments, response plan generation, selection of a recommended response plan, approval of recommended plan by affected agencies, and response plan implementation.
- *Pass/Fail criteria* – Ability to successfully respond in a timely manner to the considered transit incident.
- *Assumptions and constraints* – Test to be conducted on live system by entering a dummy active transit incident into the system and tracking response of connected systems until field implementation of all related recommended response actions.

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APPENDIX A - ACRONYMS

The following acronyms and abbreviations are used in this document.

CHP	California Highway Patrol
CMS	Changeable Message Sign
ConOps	Concept of Operations
FHWA	Federal Highway Administration
ICM	Integrated Corridor Management
IEN	Information Exchange Network
ITS	Intelligent Transportation System
LA SAFE	Los Angeles County Service Authority for Freeway Emergencies
PATH	Partners for Advanced Transportation Technology
RIITS	Regional Integration of Intelligent Transportation Systems
SCAG	Southern California Association of Governments
SGVCOG	San Gabriel Valley Council of Governments
USDOT	United States Department of Transportation