Title

San Diego I-15 Integrated Corridor Management (ICM) System: Stage II (Analysis, Modeling, and Simulation)

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San Diego I-15 Integrated Corridor Management (ICM) System: Stage II (Analysis, Modeling, and Simulation)

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Final Report for Task Order 6333

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SAN DIEGO I-15 INTEGRATED CORRIDOR MANAGEMENT (ICM) SYSTEM: STAGE II (ANALYSIS, MODELING, AND SIMULATION)

Mark A. Miller
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Final Report for PATH Task Order 6333

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The authors thank Gurprit ("Pete") Hansra of Caltrans DRI for his support and advice during the project; Alex Estrella, Mike Calandra, and Samuel Johnson of the San Diego Association of Governments (SANDAG) for their valuable input to the research team throughout the project. Finally, the authors thank Albinder Dhindsa and Dorothy Morallos of Cambridge Systematics, Inc. for their valuable contributions to and support of the project's objectives.

ABSTRACT

This report describes the Stage II work – Analysis, Modeling, and Simulation (AMS) – to date of the US Department of Transportation's (DOT) federally-sponsored Integrated Corridor Management (ICM) Program for the I-15 Corridor in San Diego County, California, between State Route 163 in the city of San Diego and State Route 78 in the city of Escondido. Stage II of the federal ICM Program involves performing the analysis, modeling, and simulation work for the I-15 corridor in San Diego County. Major tasks in Stage II consist of data collection, tools and software support, models validation and calibration, alternatives analysis, and performance measurement assessment. An Experimental Plan was developed by the Contractor AMS Team (Cambridge Systematics, Inc.) during the course of Stage II and serves as a guidebook to follow throughout the course of Stage II work covering areas such as the AMS methodology, analysis scenarios and ICMS strategies, performance measures, and model calibration and validation.

Key Words: *integrated corridor management, analysis, modeling, and simulation, decision support system*

EXECUTIVE SUMMARY

This report constitutes the final deliverable for PATH Project Task Order 6333 under contract 65A0208 — "San Diego Integrated Corridor Management Stage II: Analysis, Modeling, and Simulation". We describe in this report the Stage II work to date of the US Department of Transportation's (DOT) federally-sponsored Integrated Corridor Management System Program for the I-15 Corridor in San Diego County, California between State Route 163 in the city of San Diego and State Route 78 in the city of Escondido.

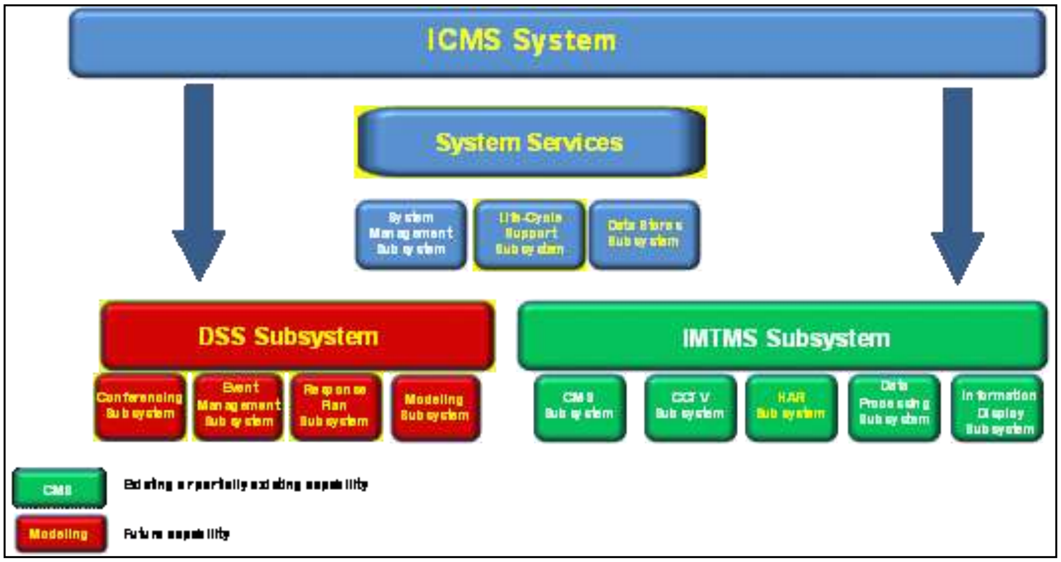
Stage II of the federal ICM Program involves performing the analysis, modeling, and simulation work for the I-15 corridor in San Diego County. Major tasks in Stage II consist of data collection, tools and software support, preparation of modeling input files such as network coding and OD matrices, models validation and calibration, alternatives analysis, and performance measurement assessment. An Experimental Plan was developed by the Contractor AMS Team (Cambridge Systematics, Inc.) during the course of Stage II and has served as a guidebook to follow throughout the course of Stage II work covering areas such as the AMS methodology, analysis scenarios and ICMS strategies, performance measures, and model calibration and validation.

The products of Stage I – the Concept of Operations and the Systems Requirements Specifications – were initially reviewed in detail with a focus on the specifics of the I-15 ICMS operational concept including its primary strategies and operational scenarios. This activity was performed to better familiarize the entire team, especially the Contractor AMS group that was not involved in Stage I work, with these products because the I-15 ICMS operational concept would eventually have to be represented in the modeling and simulation environment, which is an integrated platform that can support corridor management planning, design, and operations by combining the capabilities of existing tools.

The integrated approach is based on interfacing travel demand models and microscopic simulation models both of which may be applied for evaluating ICM strategies. The integration of these tools is achieved by extracting the study area from the travel demand model into the micro-simulation model. The AMS methodology applies a macroscopic trip table manipulation for the determination of overall trip patterns, a mesoscopic analysis of the impact of driver behavior in reaction to ICM strategies (both within and between modes), and a microscopic analysis of the impact of traffic control strategies at roadway junctions (such as arterial intersections or freeway interchanges). The methodology also includes the development of interfaces between different tools, and the application of a performance measurement and benefit/cost module.

In terms of hardware and software components for San Diego's I-15 ICM system, there already are various systems that manage the networks for individual modes – modal management systems – for the freeway, arterial, and transit networks. Connecting these individual systems is the Intermodal Transportation Management System (IMTMS), which ties together the modal management systems and allows for the sharing of data and functional capabilities across modes. There is, however, a major part of the I-15 ICM system that is currently at the conceptual level. It is called the Decision Support System (DSS), which will support the ability to generate suggested action plans in response to regional events. The events may be recurring, planned, or

unplanned and unexpected. The figure below shows the I-15 operational concept and represents the components of this concept that have already been implemented and those that need to be implemented, the IMTMS and the DSS, respectively.



The Decision Support System, which is currently under development, represents a generically higher level of decision-making that translates into actionable control strategies such as the following:

- Pre-Trip and En-Route Traveler Information
- Transit Signal Priority
- Ramp-Metering and Arterial Signal Coordination
- Bus Rapid Transit
- Congestion Pricing for Managed Lanes

There are a total of six AMS scenarios that represent different combinations of these strategies implemented as part of the DSS in response to an incident or non-incident event. There are two baseline scenarios, both without incidents or use of the DSS. One, the Base Scenario, is currently being calibrated to 2003 demand levels while the other, the Future Baseline Scenario, with 2012 demand levels. The final four AMS scenarios, consisting of daily operations without incident, freeway incident, arterial incident, and disaster response, will be tested and evaluated in both with and without DSS settings during the morning peak period.

The development of a DSS for any of these scenarios involves the establishment of a decision logic that combines different response measures, which can be implemented once a particular scenario has been identified to have occurred. The decision logic would consist of the implementation of centrally controlled measures like en-route traveler information, transit signal priority, etc. in a certain sequence. The AMS focuses on implementation of four samples of

decision logic, representing the DSS, within the simulation to come up with different responses to different scenarios. The following is a summary of the response strategies for each of the four AMS scenarios. The list shows the scenario with the corresponding strategies that are being modeled as part of the current Stage II AMS work:

- Daily Operations Scenario (no incident):
  - Pre-Trip and En-Route Traveler Information
  - Transit Signal Priority
  - Ramp-Metering and Arterial Signal Coordination
  - BRT
  - Congestion Pricing for Managed Lanes
- Freeway Incident Scenario (Appendix E):
  - Pre-Trip and En-Route Traveler Information
  - Transit Signal Priority
  - Ramp-Metering and Arterial Signal Coordination
  - BRT
  - Congestion Pricing for Managed Lanes
- Arterial Incident Scenario:
  - Pre-Trip and En-Route Traveler Information
  - Transit Signal Priority
  - Ramp-Metering and Arterial Signal Coordination
- Disaster Response Scenario:
  - Pre-Trip and En-Route Traveler Information
  - Transit Signal Priority
  - Ramp-Metering and Arterial Signal Coordination
  - BRT
  - Congestion Pricing for Managed Lanes

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CHAPTER 1

INTRODUCTION

This report constitutes the final deliverable for PATH Project Task Order 6333 under contract 65A0208 — "San Diego Integrated Corridor Management Stage II: Analysis, Modeling, and Simulation". We describe in this report the Stage II work *to date* of the US Department of Transportation's (DOT) federally-sponsored Integrated Corridor Management System Program for the I-15 Corridor in San Diego County, California.

The San Diego region was one of eight pioneer sites selected in 2006 by the U.S. Department of Transportation (USDOT) to participate in its Integrated Corridor Management (ICM) Program's System Definition Stage I: *Concept of Operations and System Requirements Specification*, which was completed in March 2008. The San Diego region was again selected as one of three (along with Dallas, Texas and Minneapolis/St. Paul, Minnesota) of the original eight pioneer sites to continue with Stage II of the ICM Program: *Analysis, Modeling, and Simulation (AMS)*. In Stage II the San Diego site is currently analyzing, modeling, and evaluating its proposed Integrated Corridor Management system with data, and modeling and simulation tools and a well-described ICMS to support the analysis.

San Diego originally proposed the Interstate 15 Corridor between the interchange with State Route 163 in the south to the junction with State Route 78 in the north, a distance of 21 miles where congestion is a major and growing problem for the freeway, arterials, and the public transit network (Figure 1). For the freeway, traffic congestion problems affect commuters and businesses along the corridor, as well as commercial vehicle operators. Arterial congestion of major concern occurs at the interfaces between the freeway's on-ramps and adjacent arterials and on arterials used by buses to travel between transit transfer stations. Also included in the study area are the following principal arterial roadways:

- Centre City Parkway;
- Pomerado Road;
- Rancho Bernardo Road;
- Camino Del Norte Road;
- Ted Williams Parkway;
- Black Mountain Road; and
- Scripps Parkway.

The southernmost 8 miles of the I-15 freeway is currently configured as a High Occupancy Toll (HOT) facility with reversible lanes physically segregated from the general purpose lanes. Carpools with two or more people use the facility for free, while single occupant vehicles are charged a dynamic toll based on the congestion level. A Fastrak transponder is required to use the facility as there are no cash toll booths. In September 2008 the first phase or middle section of the new Managed Lanes project opened to traffic. This phase of the project added 32 lane-miles (4 x 8 miles) of a bi-directional, reconfigurable, dynamically priced HOT facility with multiple access points and Direct Access Ramps (DAR) for Bus Rapid Transit (BRT) service. The second phase of construction includes the northern part of the corridor and it will add another 20 lane-miles (4 x 5 miles) of bi-directional, non-reconfigurable HOT in the north segment of the I-15 corridor to be completed in 2011. The third phase of construction will replace the 8-mile reversible-lane south segment with 32 lane-miles of reconfigurable HOT lanes and is scheduled to complete by 2012. Five BRT stations and DAR facilities will be an integral part of this 21-mile corridor. The flexibility of this new corridor provides many opportunities to employ Intelligent Transportation Systems (ITS) technologies to better inform the traveling public, increase information sharing between transportation and public safety agencies and enhance the response to routine and extraordinary incidents. As examples of the latter, the I-15 corridor has twice experienced major wildfire closures in the firestorms of 2003 and 2007 in San Diego County.

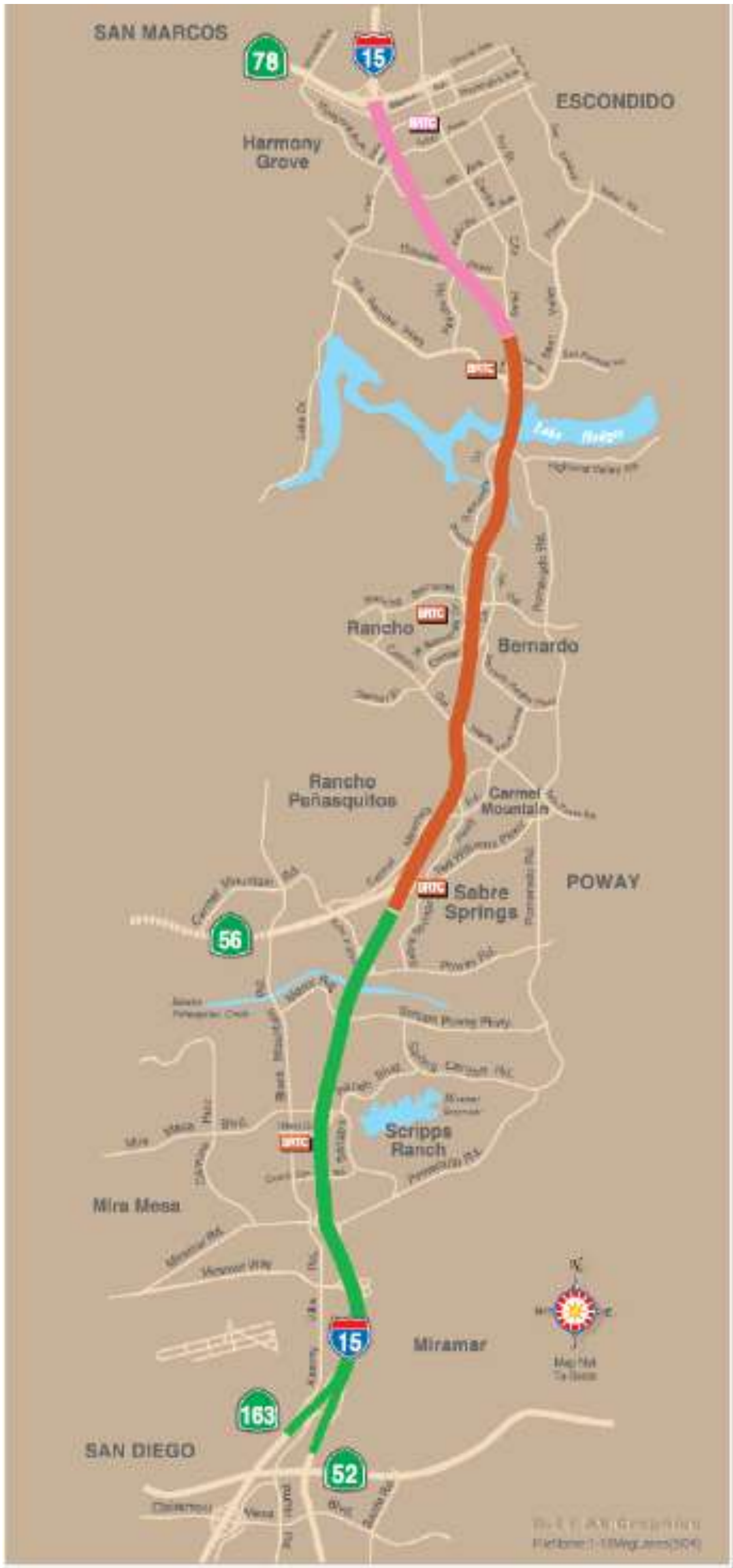

Figure 1 I-15 Corridor: Study Area

The San Diego I-15 ICM Team is led by the San Diego Association of Governments (SANDAG). Local and regional members of the stakeholder team include the California Department of Transportation (Caltrans) District 11, the Cities of San Diego, Escondido, and Poway, the two transit agencies Metropolitan Transit System (MTS) and North County Transit District (NCTD), the San Diego Service Authority for Freeway Emergencies (SD SAFE), and the County of San Diego Emergency Services.

Stage II AMS work is currently scheduled for completion in the Fall 2009, which will be followed by Stage III of the US DOT's Integrated Corridor Management Program, which is the Pioneer Site Demonstration and Implementation stage. Those Pioneer Sites, including San Diego, which submitted applications in the Spring of 2009 to participate in Stage III work, are currently awaiting selection notification from US DOT.

Summaries of the final versions of Stage I's ConOps and the SysReqSpec are provided in (Miller, 2008)[1]; the complete version of each product may be obtained by contacting Alex Estrella of SANDAG at aes@sandag.org or 619-699-1928.

[1] Miller, M.A., L. Novick, Y. Li, and A. Skabardonis, *San Diego I-15 Integrated Corridor Management (ICM) System: Phase I*, California PATH Research Report, UCB-ITS-PRR-2008-33, California PATH Program, Institute of Transportation Studies, University of California, Berkeley, December 2008.

CHAPTER 2

INTEGRATED CORRIDOR MANAGEMENT SYSTEM: CONCEPT DESCRIPTION

The I-15 ICM system will conceptually consist of the following:

- sharing and dissemination of information among the corridor's agencies
- improving coordination at network junctions, especially at freeway on-ramps and off-ramps where the freeway and arterial networks converge
- promoting shifts between networks, such as arterials accommodating traffic diverted from I-15 or travelers using transit instead of their cars based on information from the 511 system and
- managing the needs of people who want to travel given the capacity limits of available roadway facilities

In terms of hardware and software components, a lot of what San Diego envisions for its I-15 ICM system already exists in that there are various systems that manage the networks for individual modes – called modal management systems – for example, for the freeway, arterial, and transit networks (See Table 1 for a listing of current planned implementation dates for new data feeds and external systems that impact ICMS deployments). Connecting these individual systems is the Intermodal Transportation Management System (IMTMS) – the "glue" that ties together the modal management systems and allows for the sharing of data and functional capabilities across modes. For example, IMTMS is what allows a transit agency to receive information on traffic conditions, and IMTMS is the system that allows cities to share event management information, as well as traffic video and camera control, with other cities and Caltrans. IMTMS facilitates communication between agencies within an individual management system and between different management systems. Table 1 shows a timeline for the operational deployment of the I-15 corridor assets.

There is, however, a major part of the I-15 ICM system that is currently at the conceptual level. It is called the Decision Support System (DSS). DSS will support the ability to generate suggested action plans in response to regional events. The events may be recurring (morning and afternoon peak travel), planned (San Diego Chargers football games at Qualcomm Stadium), or unplanned and unexpected (major wildland-urban interface firestorms such as what occurred in October 2003 and October 2007). Figure 2 shows the I-15 Operational Concept and represents the components of this concept that have already been implemented and those that need to be implemented, the IMTMS and the DSS, respectively. Figure 3 depicts the conceptual monitoring and control strategies, along with the data elements needed to support these strategies. In addition, this figure presents the IMTMS system as an informational exchange utility that interfaces with a variety of decision-making layers.

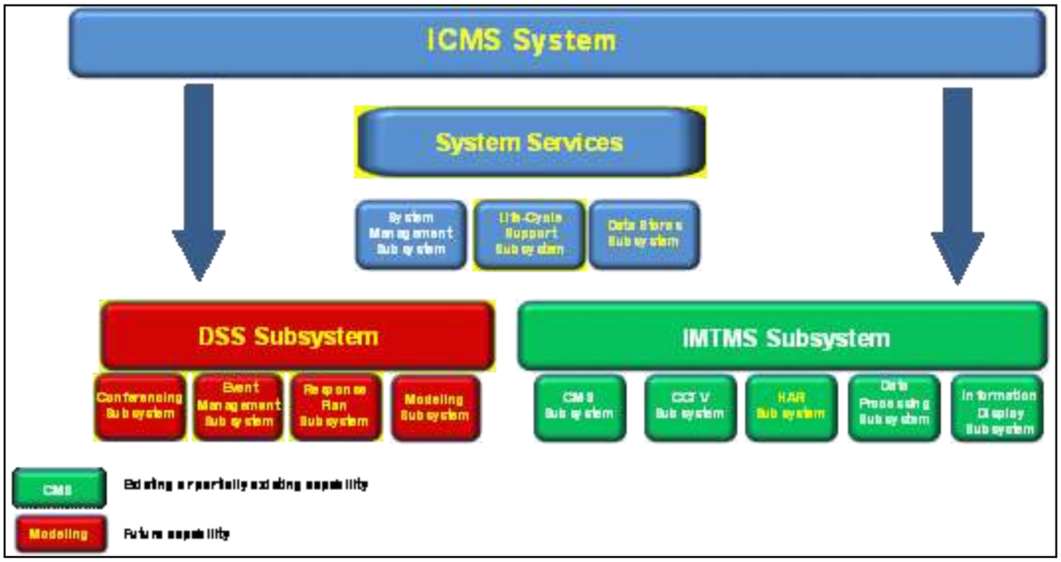

Figure 2: Operational Concept for San Diego ICMS

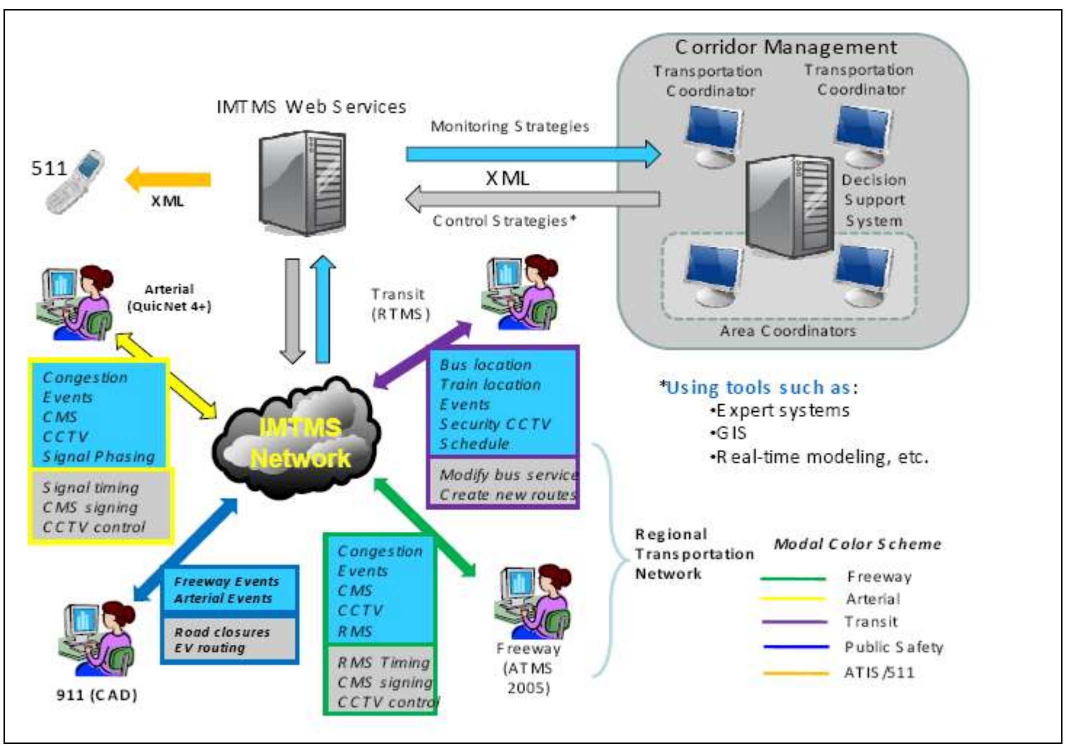

Figure 3: Sample Decision Support System (DSS)

Table 1 Schedule for Operational Deployment of Assets — I-15 Corridor

1. Managed Lanes Control System (MLCS) (together with Congestion Pricing System) a. Middle Segment b. North Segment c. South Segment	a. Operational b. January 2012 c. January 2013
2. Bus Rapid Transit Stations & Direct Access Ramps a. Middle Segment b. North Segment c. South Segment d. New vehicles, more frequent service, Bus arrival signage	a. Phased deployment: Jul 2008-Jan 2009 b. January 2012 c. January 2013 d. January 2013
3. Arterial Data Collection Capabilities a. A-PeMS Initial Deployment Phase along primary I-15 arterials (Centre City Parkway, Pomerado Road, Kearny Villa/Black Mountain Road) b. Extended Implementation beyond I-15 arterials	a. March 2010 b. December 2009
4. Advanced Transportation Management System (ATMS)	Operational
5. Intermodal Transportation Management System (IMTMS) (less RIWS and RAMS)	Operational
6. Lane Closure System (LCS)	Operational
7. Regional Arterial Management System (RAMS) a. Initial Deployment Phase b. Integration of QuicNet 4+ into IMTMS environment c. Full Implementation Phase (regionalization of QuicNet 4+)	a. July 2008 b. August 2009 c. November 2009
8. Regional Event Management System (REMS) (currently CHP CAD)	Operational
9. Regional Integrated Work Stations (RIWS)	Operational
10. Regional Transit Management System (RTMS)	Operational
11. CHP Media Incident feed and Integration into IMTMS	Operational

12. Regional Communication Networks a. Communication Plan with gaps identified and most cost effective strategies identified; 90% complete by 2012 b. South Segment of Managed Lanes c. Middle Segment of Managed Lanes d. North Segment of Managed Lanes	a. Complete b. Complete c. 2012 d. 2012
13. Caltrans Fiber Optic Network	Operational
14. Upgrades in Freeway Management System monitoring capabilities (more detectors and full coverage CCTV).	Phase 1 – Pilot Complete Phase 2: 2012
15. Revised/Upgraded Incident Management procedures for Automated Detection and Response	Oct – Dec 2008 (Phase 1)/2012 (Phase 2)
16. Expanded implementation of Changeable Message Signs (along I-15 Managed Lanes)	Oct – Dec 2008 (Phase 1)/2012 (Phase 2)
17. Upgrading of I-15 Reversible Lane Control System (RLCS) on South Segment of I-15	Completed
18. Compass Card Financial Clearinghouse System a. Pre-Test Phase b. Employee Initial Test Phase (SANDAG, MTS, and NCTD) c. Mini-Customer Initial Test d. Full System Launch	a. Completed b. Completed c. Completed d. July 2009
19. 511 Advanced Traveler Information System a. Initial System Launch for phone and web b. Launch for Public Access TV Channel	a. Completed b. Completed
20. Smart Parking System (SPS) a. Initial Deployment Phase (*Coaster* rail stations along I-5) b. Framework for regional extensibility	a. July 2009 b. December 2009

21. San Diego Performance Measurement System (PeMS) a. Freeway b. Arterial c. Transit c1. Framework of functionality c2. Initial Deployment	a. Operational b. December 2009 – March 2010 (See #3 above) c. December 2010 c1. June 2010 c2. December 2010
22. VCTMC/Decision Support System (DSS)	March 2011
23. Transit Signal Priority on NCTD Bus Route 350 in Escondido (BRT Feeder)	August 2009

CHAPTER 3

INTEGRATED CORRIDOR MANAGEMENT SYSTEM DEVELOPMENT: CONCEPT OF OPERATIONS AND SYSTEM REQUIREMENTS SPECIFICATION

The realization of the San Diego region's vision for its Integrated Corridor Management System requires development of a system that is capable of supporting real-time inter-agency collaboration by integrating existing and planned modal management subsystems. The San Diego ICM corridor benefits from a substantial regional investment in ITS technology – on the flip side, this existing technology presents unique integration challenges. Stage I produced a Concept of Operations and a System Requirements Specification as a prelude to the Analysis, Modeling and Simulation (AMS) Stage II of the ICM program.

The I-15 ICMS Concept of Operations (ConOps) was essentially a user-oriented perspective of integrated corridor management and thus, corridor stakeholders played the primary and invaluable role in its development and have marked the initial milestone along the road to I-15 ICMS implementation for the corridor's stakeholders. The development of the ConOps has, in essence, been the first test of institutional coordination and integration for the I-15 corridor stakeholder team and because of the history and strong foundation that these stakeholders have in successfully working together under the leadership of SANDAG, the stakeholder team moved efficiently through the ConOps development task.

The ConOps document lays out the I-15 ICMS concept, explains how things are expected to work once it is in operation, and identifies the roles and responsibilities of the various stakeholders to make this happen. The ConOps answers the following set of core questions:

- **Why**: Justification for the system, identifying what the corridor currently lacks, and what the system will provide
- **What**: Currently known elements and the high-level capabilities of the system
- **Where**: Geographical and physical extents of the system
- **Who**: Stakeholders involved with the system and their respective responsibilities
- **When**: Time sequence of activities that will be performed
- **How**: Resources needed to design, build, operate, and maintain the system

The ConOps does not delve into technology or detailed requirements of the ICMS, but it does address the operational scenarios and objectives, information needs, and overall functionality. The ConOps also addresses the "institutional" environment in which integrated corridor management must be deployed, operated, and maintained.

Based on the development of the I-15 ICMS concept and its operational description, the following list of User Needs in Table 2 was developed by the I-15 corridor stakeholders.

This set of User Needs is complete and appropriate for the I-15 ICM operational concept and that the planned I-15 ICM System must satisfy. The User Needs describe the operational functions of the proposed I-15 ICMS based on San Diego's vision, goals, and objectives for the system. Subsequent to development of the ConOps was to identify specific requirements for the I-15 ICM system, and these requirements were explicitly derived from this set of User Needs. Each user need was decomposed to an appropriate level of detail to develop the corresponding set of unambiguous, complete, and correct requirements. For example, "Collect and process data" generated 90 detailed requirements in the System Requirements Specification.

Table 2: Concept of Operations User Needs for San Diego ICMS

Number and Title	Description/Rationale
1. Access/Store ICMS Configuration Data	Create and manage a configuration database that maintains static information on various I-15 corridor parameters.
2. Collect and Process Data	Collect data from a variety of existing and planned systems after which processing algorithms are invoked to produce a higher level of information aggregation.
3. Access/Store ICMS Historical Information	Create and populate a historical database that contains real- time information on corridor performance derived from data collected.
4. Publish Information to System Managers	Disseminate data from all sources to agencies that manage one or more modes in the integrated corridor network.
5. Interactively Conference with Multiple Agencies	Allow system managers from multiple agencies to directly collaborate in real-time prior to, during or after a major corridor event using voice, video and data formats.
6. Display Information	Display a variety of data formats that agency decision-makers can use to visualize corridor operations, make decisions and take actions to implement the various decision components.
7. Coordinate Transportation & Public Safety Operations	Promote coordination and sharing of data between transportation and public safety communities.
8. Share Control of Devices	Allow agencies to remotely control selected field device functions regardless of location or agency ownership based on interagency agreements.
9. Manage Video Imagery	Produce and share among system users a variety of video imagery that shows a critical view of emerging and on-going corridor events.
10. Respond to Corridor Planned and Unplanned Events	Allows ICMS users and managers to use a decision-support tool that fuses data collected at the event site to generate a response plan that can be updated as necessary before transmitting plan components to the affected systems.
11. Assess Impact of Corridor Management Strategies	Allows corridor managers to model various traffic and service management strategies to gauge their impact on corridor performance and return timely results to affect decision-making during a major event.
12. Publish Information to System Users	Provides corridor information to the regional 511 system for dissemination to various system users across a variety of media; makes available a standard XML data stream and video imagery to other entities for dissemination to system users.
13. Measure Corridor	Examines multi-modal corridor data from both short-term and long-term

Number and Title	Description/Rationale
Performance	perspectives from both historical databases and PeMS.
14. Manage Corridor Demand and Capacity to Optimize Long-Term Performance	Provides for corridor managers to collaboratively develop longer-term corridor capacity and demand management strategies.
15. Measure System Performance	Monitoring of field devices, server systems and communications networks needed to support corridor management functions. Based on monitored data, metrics for system components will be measured and stored in the historical database.
16. Manage ICMS System	Provides administrative functions of ICMS including data management for ICMS configuration data, user account management incorporating system-wide security functions and IT- centric functions such as data backup and archival.
17. Maintain the ICMS System Throughout its Full Life-Cycle	Provides logistical support to the ICMS system through its full life-cycle (definition, development, testing, documentation, training and maintenance).

CHAPTER 4

INTEGRATED CORRIDOR MANAGEMENT SYSTEM: ANALYSIS, MODELING, AND SIMULATION

The ICM AMS I-15 Corridor *Experimental Plan* was developed by the Contractor AMS Team (Cambridge Systematics, Inc.) as the primary document that outlines the various tasks associated with the application of the ICM AMS tools and strategies to this corridor in order to support benefit-cost assessment for the successful implementation of ICM. The *Experimental Plan* contains the following major components:

- Description of the I-15 Corridor in San Diego and the methodology used for the AMS
- ICM strategies that are being tested together with a list of AMS scenarios (Appendix A)
- Simulation model calibration requirements and data collection needs for this calibration (Appendix B)
- Performance measures that are being utilized in the analysis of the ICM strategies on the corridor

AMS Modeling Approach

The modeling approach is an integrated platform using the Transmodeler[2] application that can support corridor management planning, design, and operations by combining the capabilities of existing tools. The integrated approach is based on interfacing travel demand models and microscopic simulation models both of which may be applied for evaluating ICM strategies. The integration of these tools is achieved by extracting the study area from the travel demand model into the micro-simulation model.

The AMS methodology applies a macroscopic trip table manipulation for the determination of overall trip patterns, a mesoscopic analysis of the impact of driver behavior in reaction to ICM strategies (both within and between modes), and a microscopic analysis of the impact of traffic control strategies at roadway junctions (such as arterial intersections or freeway interchanges.) The methodology also includes the development of interfaces between different tools, and the application of a performance measurement and benefit/cost module as is shown in Figure 4, which indicates the generic set-up of these components. The flow of logic in the figure indicates that the travel demand model will be used as the starting point for estimation of the number of trips passing through the corridor. Different strategies like peak spreading and zonal disaggregation will be applied to these trip tables to ensure that the flow of traffic is realistically constrained by the capacity of the system. The feedback component of the model is utilized to ensure that these trip tables are controlled not only temporally, but also spatially by taking advantage of the dynamic assignment features within the simulation model.

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[2] TransModeler can simulate ITS systems such as ramp metering, HOT lanes, driver response to ATIS information and transit operations. TransModeler is being run as a mesoscopic model in a real-time, or near real-time mode to affect decision-making during major incidents. Run in the micro-simulation mode in conjunction with TransCAD, TransModeler is a tool for longer-range corridor management and can investigate detailed ramp meter, HOT lane and signal timing scenarios.

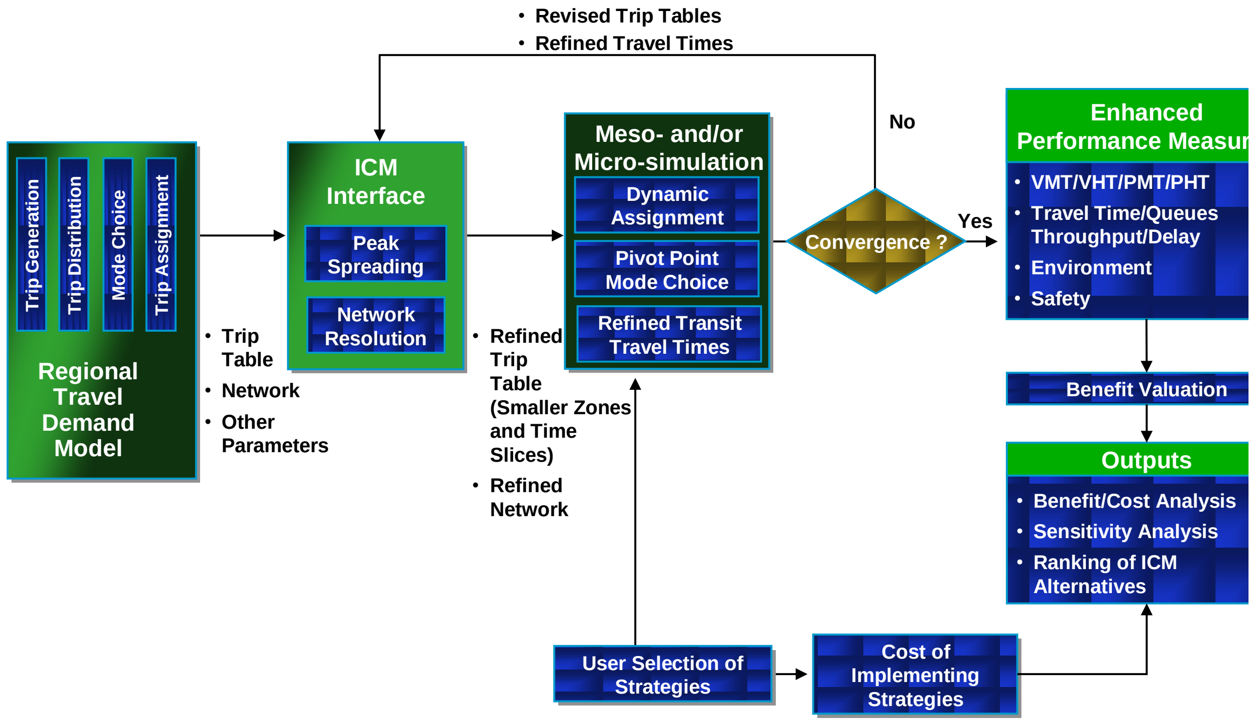

Figure 4 ICM AMS Framework (Source: Stage II San Diego *Experimental Plan*)

Decision Support System: ICMS Strategies and Scenarios
As mentioned previously, the Decision Support System, which is currently under development, represents a generically higher level of decision-making that translates into actionable control strategies such as the following:

- Pre-Trip and En-Route Traveler Information (Appendix C)
- Transit Signal Priority
- Ramp-Metering and Arterial Signal Coordination
- Bus Rapid Transit
- Congestion Pricing for Managed Lanes

There are a total of six AMS scenarios that represent different combinations of these strategies implemented as part of the DSS in response to an incident or non-incident event. There are two baseline scenarios, both without incidents or use of the DSS. One, the Base Scenario[3], is currently being calibrated to 2003 demand levels while the other, the Future Baseline Scenario[4], with 2012 demand levels. The final four AMS scenarios, described below, are being tested and evaluated in both with and without DSS settings during the morning peak period[5].

[3] The base analysis year is based on the available validated model year in the regional travel demand model.
[4] The analysis year is based on the 2012 roadway configuration and projected demand.
[5] 6 AM – 9 AM

Daily Operations – No incident scenario for projected 2012 demands (future baseline) and optimized for operations using the different ICM strategies. The scenario includes a combination of ICM strategies meant to improve daily operations.

Freeway Incident – One major freeway incident simulated at a central location of the general purpose lanes on I-15 which results in closure of a number of lanes on the segment. Major incidents have been classified as those that cause multiple lane closures, not related to on-going construction activities for the Managed Lanes facility.

Arterial Incident – One major arterial incident simulated at a central location of one of the arterials of the I-15 study area. A major incident leads to arterial closure for the segment. The frequency of arterial incidents will be determined based on data that is being acquired from studies in District 11.

Disaster Response Scenario – Wildland-urban interface fire assumed to cause shutdown of specific facilities. The Cedar Fire of October 2003 is used as a blueprint to close facilities that were affected during the fire. The regular demand is suppressed to create an evacuation scenario.

The development of a DSS for any of these scenarios involves the establishment of a decision logic that combines different response measures, which can be implemented once a particular scenario has been identified to have occurred. The decision logic would consist of the implementation of centrally controlled measures like en-route traveler information, transit signal priority, etc. in a certain sequence. The AMS focuses on implementation of four samples of decision logic, representing the DSS, within the simulation to come up with different responses to different scenarios. The framework developed to test the DSS would become part of the inventory that considers all possible conditions and also consists of the optimal response strategy which would be the basis of the DSS (Appendix D).

The following is a summary of the response strategies for each of the four AMS scenarios. The list shows the scenario with the corresponding strategies that are being modeled as part of the current Stage II AMS work:

- Daily Operations Scenario (no incident):
  - Pre-Trip and En-Route Traveler Information
  - Transit Signal Priority
  - Ramp-Metering and Arterial Signal Coordination
  - BRT
  - Congestion Pricing for Managed Lanes
- Freeway Incident Scenario (Appendix E):
  - Pre-Trip and En-Route Traveler Information
  - Transit Signal Priority
  - Ramp-Metering and Arterial Signal Coordination
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- Arterial Incident Scenario:
  - Pre-Trip and En-Route Traveler Information
  - Transit Signal Priority
  - Ramp-Metering and Arterial Signal Coordination
- Disaster Response Scenario:
  - Pre-Trip and En-Route Traveler Information
  - Transit Signal Priority
  - Ramp-Metering and Arterial Signal Coordination
  - BRT
  - Congestion Pricing for Managed Lanes

Figure 5 shows the assimilation of the simulation process into the DSS. The knowledge-based DSS can be enhanced by including scenarios through model runs. The DSS can also be simultaneously driven by simulation as new events occur. The simulation model plays the key role of optimizing the output (response) from the DSS. Each of the DSS scenarios that are included in the AMS for evaluation will be compared with a scenario without DSS. For the purposes of the analyses, this scenario refers to the Future Baseline scenario that will include the systems that are planned to be operational by 2012. The Future Baseline scenario and non-DSS scenarios would also be induced with an identical incident scenario; however, the systems will not operate under a DSS-based response, but will continue to function with whatever feedback is programmed for 2012. This control case without DSS is intended to show the incident impact to the system with all the programmed changes in place in order to isolate the effective impact of a DSS based smart response. The I-15 corridor will already have a lot of the components of system management in place by 2012; however, the benefits of integrating these components are of interest as part of this AMS effort. The non- DSS scenario will therefore have the IMTMS (green part in Figure 2) architecture that is scheduled to be deployed by 2012, but will not include the DSS subsystem (red part in Figure 2) that in effect coordinates the operations of different components of the IMTMS.

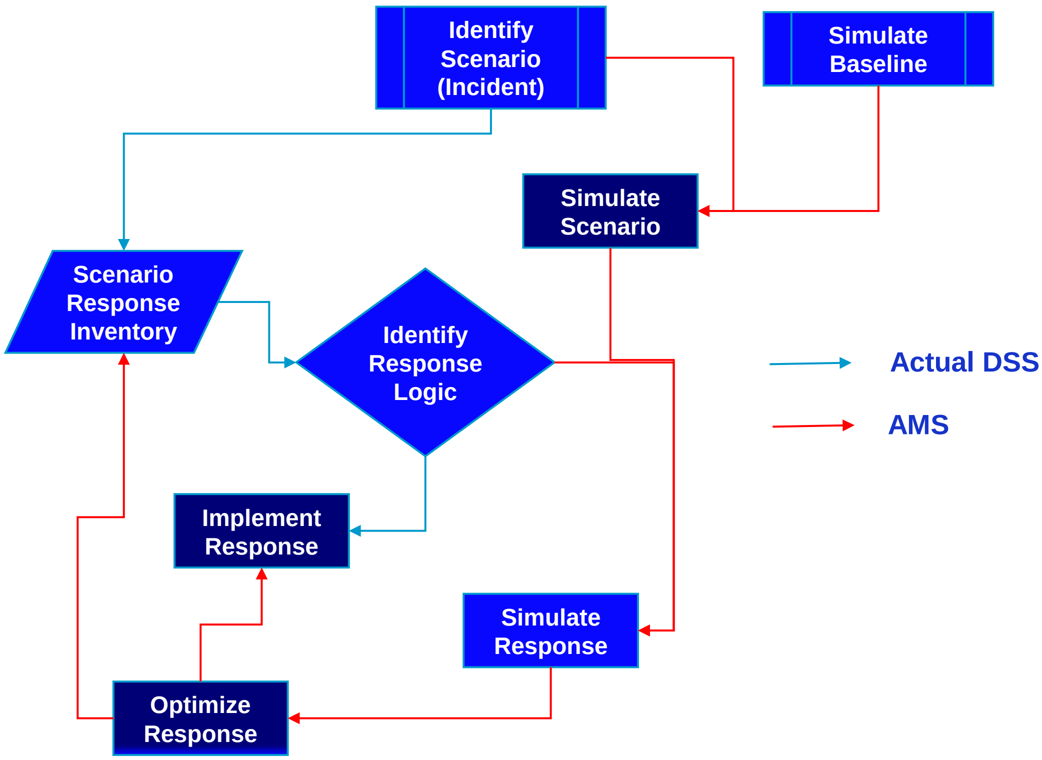

Figure 5 Simulation as part of DSS Response (Source: Stage II San Diego Experimental Plan)

Performance Measures for Analysis of I-15 ICM Strategies
The performance measures that are being used for the evaluation of ICM strategies within the I-15 Corridor were selected and will be applied in order to compare different investments within the corridor. Such measures will also

- Provide an understanding of traffic conditions in the study area;
- Demonstrate the ability of ICM strategies to improve corridor mobility, throughput, reliability, and safety based on current and future conditions; and
- Help prioritize individual investments or investment packages within the Test Corridor for short- and long-term implementation.

To the extent possible, the measures will be reported by:

- **Mode –** SOV, HOV, transit, and freight;
- **Facility Type –** Freeway, expressway, arterial, and local streets; and
- **Jurisdiction –** Region, county, city, neighborhood, and corridor-wide.

The performance measures will focus on the following key areas:

- **Mobility** – Describes how well the corridor moves people and freight; in terms of travel time, delay, and throughput
- **Reliability of Travel Time**– Captures the relative predictability of the public's travel time;
- **Safety** – Captures the safety characteristics in the corridor, including crashes (fatality, injury, and property damage); and
- **Emissions and Fuel Consumption** – Captures the impact on emissions and fuel consumption.

For the identified ICM strategies, planning-level cost estimates will also be prepared including life-cycle costs (capital, operating, and maintenance). Costs will be expressed in terms of net present value of various components.

CHAPTER 5

CONCLUSIONS

As previously stated, an *Experimental Plan* was written by the Contractor AMS Team to provide guidance throughout Stage II. At this point in Stage II work, focus is on the model calibration and validation component for the 2003 Baseline Year after which preparation of the 2012 Future Baseline Year including network coding and development of OD matrices will be made; this work will be followed by the alternatives analysis and evaluation for the 2012 Future Baseline Year with an expected completion date of late 2009. In the midst of Stage II work San Diego (and its selected team of subcontractors, including PATH) has also prepared and submitted its application for participation in the ICM Stage III Demonstration Project. The San Diego Pioneer Site is currently awaiting notification from US DOT on whether its application has been approved. In its Stage III application, San Diego highlighted the following four key areas that help demonstrate its readiness for Stage III based on its I-15 corridor deployments during as well as prior to Stages I and II:

- Embraced the concept of system integration and data sharing as a means to promote coordinated transportation operations and management;
- Has a proven track record of institutional and cooperative partnerships;
- Continued success in pursuing, testing, and implementing innovative transportation solutions as a means to reduce congestion and improve mobility; and
- Embraced the concept of corridor system planning, operations, and management

APPENDIX A

SUMMARY OF SAN DIEGO ICM AMS STRATEGIES PRIORITIZED FOR MODELING REQUIREMENTS

The following table summarizes the ICM strategies for the San Diego I-15 ICM Stage II (AMS) Project based on the ConOps from Stage I, together with notes to the AMS modeling team.

Strategies	**Notes to AMS Modeling Team**	High – Definitely needs to be modeled Medium – Borderline may not need modeling Low – Does not need modeling	**Scenarios**					
			Daily Operations	Freeway Incident	Arterial Incident	Transit Incident	Special Event (planned)	Disaster Response
1. Share/Distribute Information								
1.1 Pre-trip traveler information	Information will be provided to the public via the 511 system (telephone, internet) and the public access TV system. People will be able to decide whether to take their trip as originally planned or change departure time, trip route, and/or travel mode.	High	X	X	X	X	X	X
1.2 En-route traveler information	Information will be provided to the public via multiple media including changeable message signs (CMSs), Next Bus informational sign displays at bus stops/stations, phone, and PDA/Blackberry. This information will allow travelers to potentially change mode, alter route or departure time	High	X	X	X	X	X	X

Strategies	Notes to AMS Modeling Team	High – Definitely needs to be modeled Medium – Borderline may not need modeling Low – Does not need modeling	Scenarios: Daily Operations	Freeway Incident	Arterial Incident	Transit Incident	Special Event (planned)	Disaster Response
2. Junctions/Interfaces Improvement								
2.1 Signal pre-emption	Because of the urgent need to accommodate emergency vehicles, signal preemption has been a standard practice for a long time. This strategy helps identify the "best route" for emergency vehicles during incidents and response to emergency situations/disasters.	Low			X	X		X
2.2 Multi-modal electronic payment	This is SANDAG's Universal Transportation Account (UTA) that will make it convenient for travelers to make inter-modal trips. It will begin with a regional automated fare collection system, which will deploy a smart card-based fare collection network throughout San Diego County and initially used for transit. The UTA will combine elements so that the same electronic toll collection tag/smart card can be used to pay transit fares, tolls, and parking for added convenience.	Medium	X					
2.3 Transit Signal Priority	Transit signal priority on arterials can	High	X				X	

Strategies	Notes to AMS Modeling Team	High – Definitely needs to be modeled Medium – Borderline may not need modeling Low – Does not need modeling	Scenarios: Daily Operations	Freeway Incident	Arterial Incident	Transit Incident	Special Event (planned)	Disaster Response
	reduce transit vehicle travel time, improve reliability, and help maintain transit schedule adherence. It is a means of enhancing corridor management across networks. Although to-date transit signal priority has yet to be deployed on arterials in the corridor, it is being implemented on North County Transit District Bus Route 350 (bus feeder for corridor BRT system) with implementation complete in 2008. This is an important addition to the set of I-15 ICMS assets.							
2.4 Ramp meters/arterial traffic signals coordination	At this crucially important junction of the freeway and arterial networks it is very important to establish and successfully maintain coordinated activities across the networks. Doing so help achieve ICMS goals of accessibility for corridor travelers to travel options and attain enhanced mobility levels.	High	X	X	X	X	X	X
2.5 Bus Rapid Transit	This strategy refers to operational and physical aspects of enhancing transit service such as queue jumpers, dedicated bus lanes or access ramps, and decreased	High	X	X			X	

Strategies	Notes to AMS Modeling Team	High – Definitely needs to be modeled Medium – Borderline may not need modeling Low – Does not need modeling	Scenarios: Daily Operations	Freeway Incident	Arterial Incident	Transit Incident	Special Event (planned)	Disaster Response
	headways and other anticipated through the implementation of BRT systems along the I-15 corridor.							
2.6 Transit hub connection protection	This means holding one transit service while waiting for another transit service to arrive. This strategy is governed by the Regional Transit Management System (RTMS), which is currently operational and supports all fixed-route transit operations for the San Diego Metropolitan Transit System and the North County Transit District; will support other regional transit operators in the future. RTMS allows data-sharing and information exchange as needed to promote more efficient regional transit operations and coordination of transit services between operators, such as to coordinate passenger transfers between transit systems.	Low				X	X	
3. Accommodate/Promote Network Shifts								

Strategies	**Notes to AMS Modeling Team**	High – Definitely needs to be modeled Medium – Borderline may not need modeling Low – Does not need modeling	**Scenarios** Daily Operations	Freeway Incident	Arterial Incident	Transit Incident	Special Event (planned)	Disaster Response
3.1 Modify ramp metering rates	This strategy will help accommodate traffic, including transit buses that are shifting from arterials	High	X	X	X	X	X	X
3.2 Promote route and mode shifts	This strategy focuses on shifts between roadways and transit by means of en-route and pre-trip traveler information services	Medium/High	X	X	X	X	X	
3.3 Congestion pricing for ML	Currently under phased construction; initial segment fully implemented in 2008.	High	X	X	X	X	X	X
3.4 Modify arterial signal timing	This strategy will help accommodate traffic that shifts from the I-15 freeway	High	X	X	X	X	X	X
4. Capacity/Demand Management (Short-Term)								
4.1 Lane use control	This primarily involves changes to the Managed Lanes lane configuration from default of two lanes per direction to 3/1 or 4/0 split, especially for evacuation purposes during the Disaster Response Scenario	Low		X			X	X
4.2 Modify HOV restrictions	This focuses on increasing the minimum number of occupants required in HOVs	High		X				X

Strategies	Notes to AMS Modeling Team		Scenarios					
		High – Definitely needs to be modeled Medium – Borderline may not need modeling Low – Does not need modeling	Daily Operations	Freeway Incident	Arterial Incident	Transit Incident	Special Event (planned)	Disaster Response
4.3 Increase roadway capacity by opening HOV/HOT lanes and shoulders	This has been successfully implemented as a one-year demonstration project allowing buses on shoulders from I-805 and Nobel Drive to SR 52 and Kearny Villa Road during moving and afternoon peak periods. The use of shoulders as a low-speed bypass of congested freeway lanes offers a low-cost, easily implemented strategy that should increase transit operating speeds, on-time performance, and trip reliability.	Medium		X				X
4.4 Temporary addition of transit capacity	This is primarily used during planned special events, though is applicable during incidents and the worst case scenario (Disaster Response).	Low			X		X	X

Strategies	Notes to AMS Modeling Team	High – Definitely needs to be modeled Medium – Borderline may not need modeling Low – Does not need modeling	Scenarios: Daily Operations	Freeway Incident	Arterial Incident	Transit Incident	Special Event (planned)	Disaster Response
4.5 Modify parking fees	This refers to the Smart Parking System (SPS) that is currently undergoing a Pilot Test on I-5 in conjunction with the Coaster commuter rail system. SPS uses a variety of technologies to collect real-time parking data and provides this information to transit users. Focus is placed on parking facilities at Bus Rapid Transit stations.	Low	X					
5. Capacity/Demand Management (Long-Term)								
5.1 Ride sharing programs	Can this be modeled given the inherent variability over time in such programs? Can this be viewed alternatively as an incentive for carpooling/HOV?	Medium	X				X	
5.2 Expand transit capacity	This refers to practices such as adding a route or decreasing headway.	Medium				X	X	

APPENDIX B

DATA COLLECTION PLAN SUMMARY

Principles in Developing and Executing the Data Collection Plan
A number of principles apply in developing and executing the Data Collection Plan. These are summarized as follows:

- **Resource and Schedule Constraint –** The overall ICM AMS effort must take place within the budget and schedule specified in the Experimental Plan. In particular, available data at the San Diego Pioneer Site will be leveraged in the AMS effort.
- **Recognize Current Limitations in Available Data –** There are known gaps in the available data that must be bridged by collecting additional field data and deriving estimates for other missing data.
- **Collate Information on Current and Future Traffic Management Systems –** The data collection plan also includes a listing of the resources used by the AMS team to obtain information about current and future (planned) systems that will be replicated in the AMS effort. These systems include hardware components, operational characteristics, and creation and modification attributes, which will be summarized to the extent possible by the AMS team. Any significant assumptions that would be required as a result of absence of any such information will be provided in the experimental plan.
- **Correlation between Data Collection for Model Calibration and 2003 Baseline Year –** 2003 is the base year selected for analysis since it is the most appropriate time period when there was no significant construction activity happening along the I-15 corridor and for which there is a validated travel demand model. A significant portion of the data collected is for purposes of model calibration and validation for this baseline year.

Methodology for Developing the Data Collection Plan

The methodology for developing the Data Collection Plan comprises a four-step process described as follows:

1. Review all relevant and appropriate I-15 ICM reports and documentation that deal with the I-15 ICM data collection effort in general and specifically about information regarding current and planned transportation management systems. The following resource list has been reviewed:
   a. Integrated Corridor Management – Analysis, Modeling, and Simulation *Sample Data List* report, December 2006;
   b. Integrated Corridor Management – Analysis, Modeling, and Simulation for the San Diego I-15 in San Diego, California *Experimental Plan Draft*, November 2008;

c. San Diego I-15 Integrated Corridor Management (ICM) System, *Final I-15 ICM Concept of Operations*, March 2008; and

d. San Diego I-15 Integrated Corridor Management (ICM), *Final I-15 ICM System Requirements*, March 2008.

2. Assess the current state of required data by corridor agency stakeholders, including the following:

   a. SANDAG;

   b. Caltrans;

   c. Cities of San Diego, Escondido, and Poway; and

   d. Metropolitan Transit System and North County Transit District.

3. Identify gaps between data requirements and available data.

4. Develop a specific timeline schedule with which to execute the data collection.

Documentation Review

The purpose of the *Sample Data List* report is to provide a sample data list for the AMS work to be conducted, which includes the following:

- Input data for AMS;
- Performance data for model calibration and validation; and
- Data for ICM Approaches and Strategies.

Input data for AMS is organized into the following components:

- Network;
- Travel Demand;
- Traffic Control;
- Transit; and
- ITS elements.

Table B-1 below provides a summary of the input data required for AMS. The *Sample Data List* report provides a full description of each of these input data components.

Performance data for model calibration and validation is based on a three-step framework for microscopic models that is described in the *Sample Data List*. The framework suggests that the following data are important for model calibration and performance analysis:

- Capacity at bottleneck locations,
- Traffic volumes at key network locations,
- Travel times on network links, and
- Spatial and temporal extent of queuing.

Table B-1 Input Data for AMS

Network	Travel Demand	Traffic Control	Transit	ITS Elements
Link Distances	Link volume	Freeways	Transit routes	Surveillance system
Free-flow speeds	Traffic composition	Ramp Metering	Transit stops	*detector type*
Geometrics-freeways	On & off-ramp volumes	*type (local, systemwide)*	*location*	*detector spacing*
# travel lanes	Turning movement counts	*detectors*	*geometrics*	*CCTV*
presence of shoulders	Vehicle trip tables	*metering rates*	*dwell times*	Information Dissemination
#HOV lanes (if any)	Person trip tables	*algorithms (adaptive metering)*	Transit schedules	*CMS*
Operation of HOV lanes	Transit Ridership	Mainline control	Schedule adherence data	*HAR*
Accel/Dec lanes		*metering*	Transfer locations	*Other (e.g., 511)*
Grade		*lane use signals*	Transit speeds	*In vehicle systems*
Curvature		*variable speed limits*	Transit Fares	Incident management
Ramps		Arterials	*payment mechanisms*	*incident detection*
Geometrics – arterials		Signal system description	Paratransit	*CAD system*
# lanes		*controller type*	*demand-responsive*	*Response & clearance*
Lane usage		*phasing*	*ride-share programs*	*Incident Data Logs*
length of turn pockets		*detector type & placement*		Tolling system
Grade		*signal settings*		*type*
turning restrictions		Signal timing plans		*pricing mechanisms*
Parking		Transit signal priority system		TMC
Parking facilities		*control logic*		*Control software/ functions*
Location		*detection*		*Communications*
Capacity		*settings*		*Data archival/ dissemination*
Park & ride lots		Emergency preemption system		Transit/Fleet management system
Location		*control logic*		*AVL*
Capacity		*detection*		*Communications*
		settings		*Traveler information bus stops*
	These data must be provided for all links in the corridor study area			
	These data must be provided for a consistent analysis time period including the same date for data from all facilities in the corridor area			
	To facilitate the assessment of variability in traffic volumes & speeds, data must be provided for multiple days of the week and months of the year for all facilities in the study corridor			

Source: *Sample Data List*, December 2006.

Table B-2 shows the Data Requirements for the San Diego I-15 ICM Approaches and Strategies based on work performed in the development of the *Experimental Plan*, which in turn, was formulated from the *Concept of Operations*. The table is configured as a matrix with ICM Approaches and Strategies, together with the AMS Input Data components.

Table B-2 Data Requirements for San Diego I-15 ICM Approaches and Strategies

ICM Approaches and Strategies	Data Requirements				
	Network Data	Demand	Control	Transit	ITS Elements
ATIS pre-trip information	X	X			X
ATIS en-route traveler information	X	X			X
Signal priority to transit	X	X	X	X	X
Coordinated operation ramp meters and arterial traffic signals	X		X		X
Physical Bus Priority			X	X	
Modify ramp metering rates to accommodate traffic shifting from arterial		X	X		
Modify HOV restrictions	X	X		X	
Congestion pricing on Managed Lanes		X			

Source: *Sample Data List*, December 2006.

Table B-3 maps the data shown per category in Table B-2 with the ICM Approaches and Strategies to produce the sample data list for each ICM strategy.

Table B-3 Data List for San Diego I-15 ICM Approaches and Strategies

ICM Approaches and Strategies	Data Requirements				
	Network Data	Demand	Control	Transit	ITS Elements
ATIS pre-trip information	Link distances, geometrics	Link volumes			
ATIS en-route traveler information	Link distances, geometrics	Link volumes			
Signal priority to transit	Link distances, free-flow speeds, geometrics (arterials)	Link volumes, turning movement counts, transit ridership	Arterial signal timing plans, transit signal priority system, QuicNet 4+ system	Transit routes, stops, schedules, schedule adherence data, speeds	
Coordinated operation ramp meters and arterial traffic signals	Link distances, free-flow speeds, geometrics		Freeway ramp metering, arterial signal timing plans, QuicNet 4+ system		
Physical Bus Priority					
Modify ramp metering rates to accommodate traffic shifting from arterial	Link volumes, on-ramp volumes, turning movement counts		Freeway ramp metering		
Modify HOV restrictions	Geometrics (freeway)			Paratransit, transit routes	
Congestion pricing on Managed Lanes					

Source: *Sample Data List*, December 2006.

The *Concept of Operations and System Requirements* documents provide information on the I-15 ICM System including currently existing and planned for systems together with a timeline for their implementation. Of particular relevance to and importance for the Data Collection Plan are the Intermodal Transportation Management System (IMTMS) and the Decision Support System (DSS). The IMTMS system is an existing data acquisition and dissemination network within the San Diego region; it is, in turn, connected to a number of existing and planned external systems in the region including, but not limited to, the Regional Arterial Management System (RAMS), the Regional Transit Management System (RTMS), and the ATMS 2005 (Advanced Transportation Management System). Since these systems will be replicated in the course of the AMS effort, the team is collecting data/information about such systems as they relate to the selected ICM strategies and application scenarios.

Current State of Required Data and Gap Identification

The current state of required data varies by individual network: arterial, freeway, and transit. Data availability (by year) was determined for signal timings, vehicle through volumes, turning movement counts, and pedestrian volumes along the seven primary arterial roadways in the study area:

- Centre City Parkway,
- Pomerado Road,
- Rancho Bernardo Road,
- Camino Del Norte Road,
- Ted Williams Parkway,
- Black Mountain Road, and
- Scripps Parkway/Mercy Road.

Details for arterials data availability and gaps are shown in the Integrated Corridor Management – Analysis, Modeling, and Simulation for the San Diego I-15 in San Diego, California Experimental Plan, November 2008. Any missing signal timing plans have been requested from both Caltrans and local government agencies. Acquiring vehicle turning movement counts were subcontracted to a data collection firm for all intersections as there was a significant gap in the availability of traffic count information along the arterials. Turning movement counts were conducted on typical weekdays (Tuesday, Wednesday, and Thursday) during the AM peak period between the hours of 5:00 a.m. and 10:00 a.m. Counts were also conducted preferably within a similar timeframe window (a minimum two weeks). Details on the

For the I-15 freeway, Caltrans' PeMS web site is capable of providing data as fine as 30-second intervals. PeMS data was collected and archived 24/7 for all operating loop detectors on the freeway system, and the data obtained from it can be aggregated to any time interval: http://pems.eecs.berkeley.edu/. Availability of PeMS data for I-15 is shown in the Experimental Plan.

In addition to PeMS data, the following freeway-related information is also available from Caltrans and other public agencies:

- CHP CAD logs are available for freeway incidents, which provides data including date, time, location, lane number, incident type, incident impact (e.g., lane closure, traffic backup);
- Caltrans' Advanced Transportation Management System (ATMS 2005) contains the following data:
  - Freeway congestion,
  - Freeway incidents,
  - Travel times,
  - Planned events,
  - CMS status and current messages,

  - CCTV imagery,
  - Coverage of VDS along I-15 (location and loop status), and
  - Snapshots of freeway loops; and
- Freeway ramp metering rates include the following:
  - Cycles/minute,
  - Vehicles/cycle,
  - Vehicles/hour/lane,
  - Seconds/cycle,
  - Vehicles per hour, and
  - Occupancy.

A request has been made to obtain this data for a set of 62 I-15 ramps (both NB and SB).

- Caltrans signal phasing/timing plans at on- and off-ramps to I-15 freeway;
- ITS operations along I-15 freeway, including traffic control systems (signal systems, emergency preemption, and ramp metering) and ITS elements (surveillance systems, information dissemination, incident management, and TMC); and
- Speed Limit information for Baseline Year (2003) on I-15 and primary arterials: AMS Team has received a GIS layer from Caltrans D11 regarding this data.

Transit-Related Data

In addition to data along freeways and arterials, the availability of transit-related information along the Corridor has also been assessed. The I-15 Corridor is primarily serviced by the following six bus routes:

5. Premium Express Bus Route 810 – Escondido to Downtown San Diego;
6. Premium Express Bus Route 820 – Poway to Downtown;
7. Premium Express Bus Route 850 – Rancho Peñasquitos to Downtown;
8. Premium Express Bus Route 860 – Rancho Bernardo to Downtown;
9. Express Service Bus Route 20 – Downtown San Diego to North County Fair; and
10. Express Service Bus Route 210 – Mira Mesa to Downtown San Diego.

Bus schedules and route information are available through the local transit agency, San Diego Metropolitan Transit System (MTS). We are currently collecting the following transit-related data from MTS and SANDAG; data collection is scheduled for completion in December 2008:

- For the 800 series and Routes 20 and 210 MTS bus routes, we have the following:
  - Passenger survey data between 1995 and 2008.
- For the two express service Routes 20 and 210, we have the following:
  - AVL data (schedule adherence) as far back as 2007; and
  - APC data as far back as 2006.
- We have from multiple data bases of incident data (accident logs, incident logs, interrupted service occurrence logs) going back as far as 2001. Data will be supplied on a DVD.

Timeline Schedule for Data Collection

Travel Time Runs (Arterial and Freeway Locations)

Following the boundaries of the study area as shown in Figure 1, Table B-4 lists the locations of the travel time runs that were performed. Travel time runs were conducted along the freeway and arterials during the AM peak period between the hours of 5:00 and 9:00 a.m. during the week of January 5, 2009. Two runs were conducted for each segment during a period of two typical weekdays (Tuesday, Wednesday, or Thursday), for a total of four runs per location.

Table B-4 Travel Time Runs Locations

Location	From	To
Pomerado Road	I-15	Highland Valley Road
Centre City Parkway	I-15	I-15
Rancho Bernardo Rd	Pomerado Rd	Camino Del Norte
Camino Del Norte	Pomerado Rd	Rancho Bernardo Rd
Ted Williams Parkway (SR 56)	Pomerado Rd	Black Mountain Rd
Black Mountain Road	Pomerado Rd/Miramar Road	SR 56
Scripps Parkway/Mercy Road	Pomerado Rd	Black Mountain Rd
I-15 Southbound & Northbound	SR 52	SR 78

Arterial Data Collection

There were 106 arterial intersections for which turning movement counts were collected between the hours of 5:00 and 10:00 a.m., beginning the week of January 5, 2009.

Freeway Data Collection

There are data gaps at particular I-15 on- and off-ramp locations; however, this data is not being collected because the physical configuration has changed from that which existed in 2003, the Baseline Year. Moreover, time and resource constraints have also contributed to this data not being collected.

APPENDIX C

LITERATURE REVIEW ON USE OF VARIABLE MESSAGE SIGNS AND 511 SYSTEM FOR ROUTE CHOICE DECISION MAKING

A review of the literature was conducted to determine estimates of the percentage of drivers who use traveler information provided by freeway variable message signs (VMS) and 511 traveler information systems in making route choice decisions while driving. Findings from the literature scans are as follows:

VARIABLE MESSAGE SIGNS

The body of research found in the literature typically covers the areas of driver awareness, use, and satisfaction with VMS, together with driver behavior, that is, diverting, resulting from the provided traffic information, e.g., travel time, incidents. In this instance we focus on driver use of the information and its usefulness.

In general terms, survey findings typically show that traffic information is perceived as being useful. A summary of results from the literature review concerning the perceived usefulness of VMS is shown in Table C-1, although it should be noted that survey results vary considerably from site to site, and depend on the nature and level of detail of the information that the VMS provides (e.g., travel time, emergency situations, current roadway, etc.) and the number of times drivers see such information. Because of such factors together with differences in methodological approaches, these results are not directly comparable; nonetheless, they do give a fairly extensive picture of VMS usefulness.

Table C-1 Usefulness Findings for Variable Message Signs

Location	**“Usefulness” Finding**	**Reference**
Glasgow	More than 65% of drivers who had seen the VMS thought they were at least “fairly helpful”	(1)
London	40% of drivers rated the VMS information as “very” or “quite” useful; 40% as only “occasionally” useful	(2)
Southampton	49% of the commuters generally rated the VMS as being “very useful” or “quite useful”	(3)
Paris	90% of drivers thought VMS information was a minimum necessity	(4)
Paris	84% of drivers considered the information to be useful	(5)
Toulouse	77% of drivers perceived VMS as useful	(6)
Amsterdam	89% found the information generally useful	(7)
New York	75% rated VMS information as at least “moderately” useful	(8)
Pennsylvania	68% rated VMS information as very or extremely useful; 23% as useful	(9)
Milwaukee	32% rated VMS information as very useful; 44% as somewhat useful	(10)
Montana	At least 50% of survey respondents found VMS information useful	(11)

Northern Virginia	VMSs influenced survey respondents' driving: "often" for 49% of respondents; "occasionally" for 38% of respondents	(12)
Wisconsin	54% of respondents found VMS messages on current travel time to be useful or very useful; 83% of respondents found VMS messages on traffic congestion and on accidents affecting traffic to be useful or very useful;	(13)

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(10) Peng, Z., et al., "Motorist Response to Arterial Variable Message Signs", Proceedings of the 83rd Annual Meeting of the Transportation Research Board, Washington D.C., U.S., January 2004.

(11) Eidswick, J. et al., "SAFE-PASSAGE Motorist Communication System Evaluation", *Proceedings of the 9th World Congress on Intelligent Transport Systems, Chicago,* U.S., October 2002.

(12) Benson, B., "Motorist Attitudes about Content of Variable Message Signs", Transportation Research Record 1550, pp. 48-57, 1997.

(13) Lee, C., et al., "Evaluation of Drivers' Responses to ATIS: A Practical VMS Based Analysis", KSCE Journal of Civil Engineering, Volume 8, Number 2, March 2004, pp. 233-237.

511 System

In general terms, survey findings typically show that the 511 traveler information service is perceived as being useful, sometimes referred to in terms of level of satisfaction. A summary of results from the literature review concerning the perceived usefulness of 511 systems is shown in Table C-2.

Table C-2 Usefulness Findings for 511 System

Location	"Usefulness" Finding	Reference
San Francisco Bay Area	88% of survey respondents are very satisfied with the usefulness of the information provided; 9% are somewhat satisfied.	(1)
Minnesota	22% of survey respondents thought the information service was very useful; 36% somewhat useful (May 2002)	(2)
Minnesota	41% of survey respondents were very satisfied with information service; 52% somewhat satisfied (December 2002)	(3)
Montana	48% of survey respondents were very satisfied with usefulness of information service; 37% were satisfied	(4)
Virginia	90% of survey respondents thought 511 was somewhat useful or very useful	(5)
Arizona	71% of survey respondents were satisfied with 511 service	(6)
Florida	96.3% of 2002 survey respondents either agreed or strongly agreed with the statement "Overall, the information that I received is useful"; 99.8% of 2003 survey respondents either agreed or strongly agreed with the statement "Overall, the information that I received is useful".	(7)

(1) Godbe Research, Inc., "2004 511 Phone Satisfaction Survey", Metropolitan Transportation Commission, August 2004
(2) Minnesota Department of Transportation Market Research, "Mn/DOT's Understanding of Traveler Information Satisfaction, May 2002
(3) MarketLine Research, Inc., "MnDOT 511 User Study", MnDOT ATIS Office and Office of Market Research, December 2002
(4) Western Transportation Institute, Montana State University, "Greater Yellowstone Regional Traveler and Weather Information 511 Evaluation Summary", Montana Department of Transportation and the Federal Highway Administration, August 2004
(5) Virginia Tech University Transportation Institute, "511 Virginia Evaluation", Virginia Department of Transportation, January 2004
(6) Battelle, Inc., "Final Report Model Deployment of a Regional, Multi-Modal 511 Traveler Information System", U.S. Department of Transportation, Report No. FHWA-JPO-06-013, EDL No. 14248, Washington D.C., September 2005
(7) Lawther, W. and E. Berman, "Second Annual Evaluation of the SmartRoute Systems Advanced Traveler Information Services Contract for Miami-Dade, Broward and Palm Beach Counties May 2002 – December 2003, July 2004

APPENDIX D

WILLINGNESS TO PAY AND VALUE OF TIME

While trying to implement a congestion pricing module that diverts drivers based on their value of time, we realized that in low volume conditions, nobody would use the Managed Lane (ML) facility ML. This is because the time savings were small, which convert to a low percentage when using a logit model to calculate toll-share. However, in reality, each driver has a different value of time and those with a high value of time may option to take the ML even if a fraction of a minute is saved.

Consequently, the project team developed an income prediction function based on the desired average value of time of $40/hour. The income prediction function assumes that $40/hour is the median income, consequently 50% of the users have a value of time between $12-$40/hour and 50% of the users have a value of time between $40-$100/hour. Consequently, even in periods of low flow, vehicles with a high value of time will be diverted to the ML.

Now the $40/hr and the corresponding 12 and 100 bins are estimated values we used to get this off and running. For purpose of the project we would need to more specifically determine a more specific value for San Diego and as such it was useful to compile a list of resources where we were able to find additional estimates (stated or revealed preference studies, national household survey, etc) for the value of time. The objective was to justify using a number in place of $40/hr and, hence, a literature and resource survey was performed.

Three primary information sources were discovered on "willingness to pay" and "value of time" information that was intimately connected to the I-15 San Diego corridor. The primary source was the following:

Brownstone, D., A. Ghosh, T. F. Golob, C. Kazimi, and D.V. Amelsfort, "Drivers' Willingness-to-Pay to Reduce Travel Time: Evidence from the San Diego I-15 Congestion Pricing Project", *Transportation Research Part A: Policy and Practice*, Volume 37, Issue 4, May 2003, Pages 373-387. This paper documents a revealed preference study performed on the southern 8-mile segment of the I-15 Express "HOT" Lanes during the late 1990s. The two additional related sources included the following two papers:

1. Golob, J.M., J. Supernak, T.F. Golob, and K. Kawada, "An Evaluation of a High Occupancy Toll (HOT) Lane Demonstration Project in San Diego", *Proceedings of the European Transport Conference: Seminar C: Policy, Planning and Sustainability*, Volume 2, pp. 255-269. PTRC Education and Research Services, London, 1998, and

2. Supernak, J., J.M. Golob, K. Kawada, and T.F. Golob, "San Diego's I-15 Congestion Pricing Project: Preliminary Findings", Presented at the *79th Annual Meeting of the Transportation Research Board*, January 1999, Washington D.C.

The authors of the primary article used data collected from a panel survey of travelers who used I-15 in the vicinity of the Express Lanes during the morning peak period together with time-specific traffic flow data obtained from loop detectors embedded in the roadway and time-specific data on FasTrak tolls.

Tolls from this previous research were trip-based while current congestion pricing tolls are distance-based.

Note also that this research does not report willingness to pay/value of time estimates as a percentage of hourly wage as the authors had insufficient data to make such a calculation and they note that previous research does not bear out the relationship assumption between value of time and income.

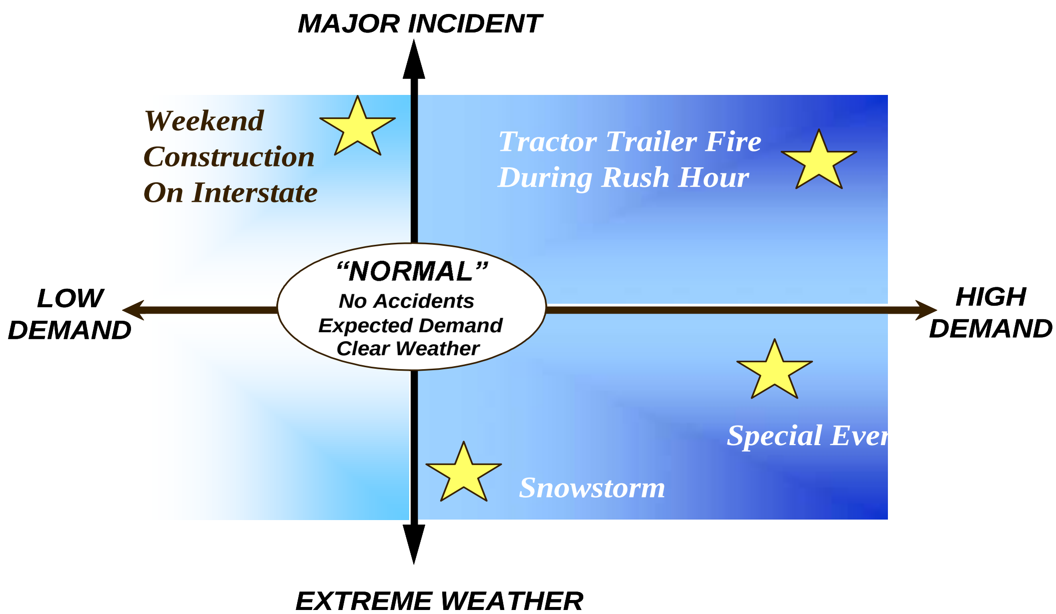
The research gave the following information for the distribution of willingness to pay/value of time values:

- Median value of time = $30/hour
- Upper quartile of the distribution is $43/hour
- Lower quartile of the distribution is $23/hour

APPENDIX E

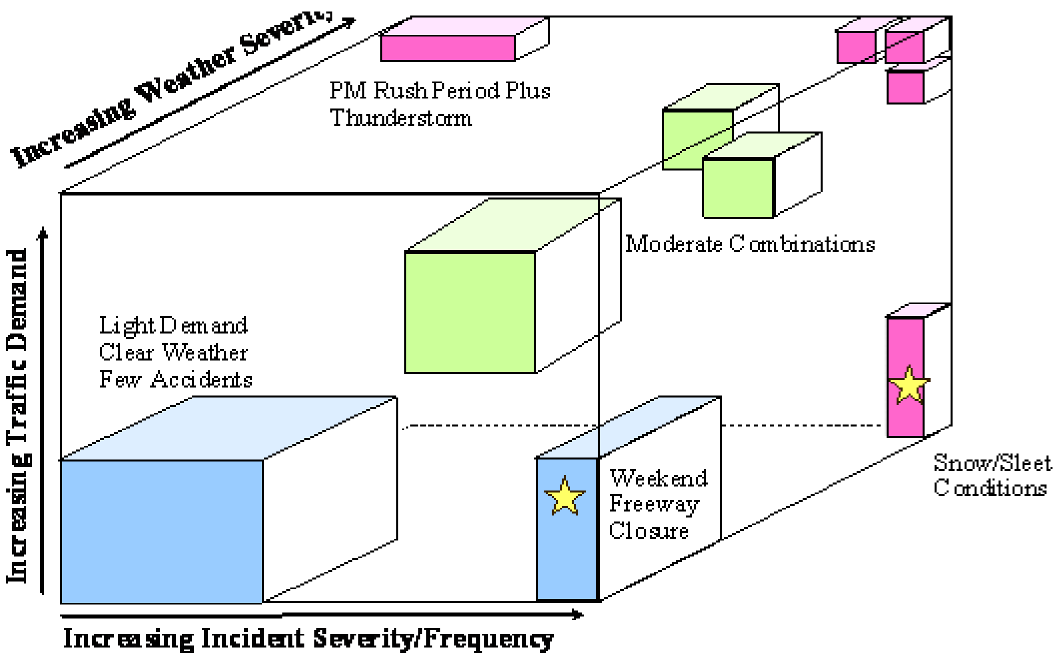
INCIDENT DATA ANALYSIS

The I-15 AMS *Experimental Plan* provides tools and procedures capable of supporting the analysis of both recurrent and non-recurrent congestion scenarios. The Pioneer Corridor non-recurrent congestion scenarios entail combinations of increases of demand and decreases of capacity. Figure E-1 depicts how key ICM impacts may be lost if only "normal" travel conditions are considered. The relative frequency of non-recurrent conditions also is important to estimate in this process – based on archived traffic conditions, as shown in Figure E-2. The proposed scenarios for the San Diego ICM analyze the high demand periods during a typical day, with and without incidents. The non-recurrent congestion scenarios modeled for this corridor include some incident scenarios that were identified in the San Diego Concept of Operations. The typical day is identified by looking at the PeMS detection data from the corridor during the periods of April to May and September to November of the base year, and choosing the weekday that matches the hourly traffic counts most closely for the peak period. This weekday is determined by taking an average of volumes for the entire peak season, and identifying the day that is closest to the average in terms of volume. The determination of the closeness is based on a calculation of the deviation for the entire time series. The volumes from this day will be balanced to reflect the conservation of flow on the corridor.



Source: Wunderlich, K., et al., Seattle 2020 Case Study, PRUEVIIN Methodology, Mitretek Systems. This document is available at the FHWA Electronic Data Library (http://www.itsdocs.fhwa.dot.gov/).

Figure E-1 Key ICM Impacts May Be Lost If Only "Normal" Conditions Are Considered



Source: Wunderlich, K., et al., Seattle 2020 Case Study, PRUEVIIN Methodology, Mitretek Systems. This document is available at the FHWA Electronic Data Library (http://www.itsdocs.fhwa.dot.gov/).

Figure E-2 Sources of System Variation: Classifying Frequency and Intensity

For the purposes of this study, a similar analysis of incident data was undertaken by the project team. The primary source of incident data was PeMS and the focus of the examination was on incidents that occurred on the southbound general purpose lanes of I-15 between Post Miles 15 and 35 during the Baseline year 2003.

Initially we looked at incident and incident frequency versus volume-to-capacity ratio (V/C) during average weekdays, that is, Tuesdays, Wednesdays, and Thursdays, to better understand nonrecurring congestion during various times of such days. There were a total of 432 incidents for this study road section and time period. During the off-peak, AM peak, and PM peak periods there were 268, 100, and 64 incidents, respectively. Figures E-3 and E-4 show the relationships between the number of incidents and their frequency to V/C ratios for both off-peak and peak hour incidents respectively. When the V/C ratio is relatively low (<0.65), the incident frequency of the off-peak period is always higher than that of the peak period. When the V/C ratio is relatively high (>=0.65), the incident frequency for the off-peak period is always lower than that for the peak hour. The maximum incident frequency for the off-peak period (approximately 1.8 incidents/mile for V/C ratio 0.5-0.55) is higher than for the peak period (1.2 incidents/mile for V/C ratio 0.7-0.75).

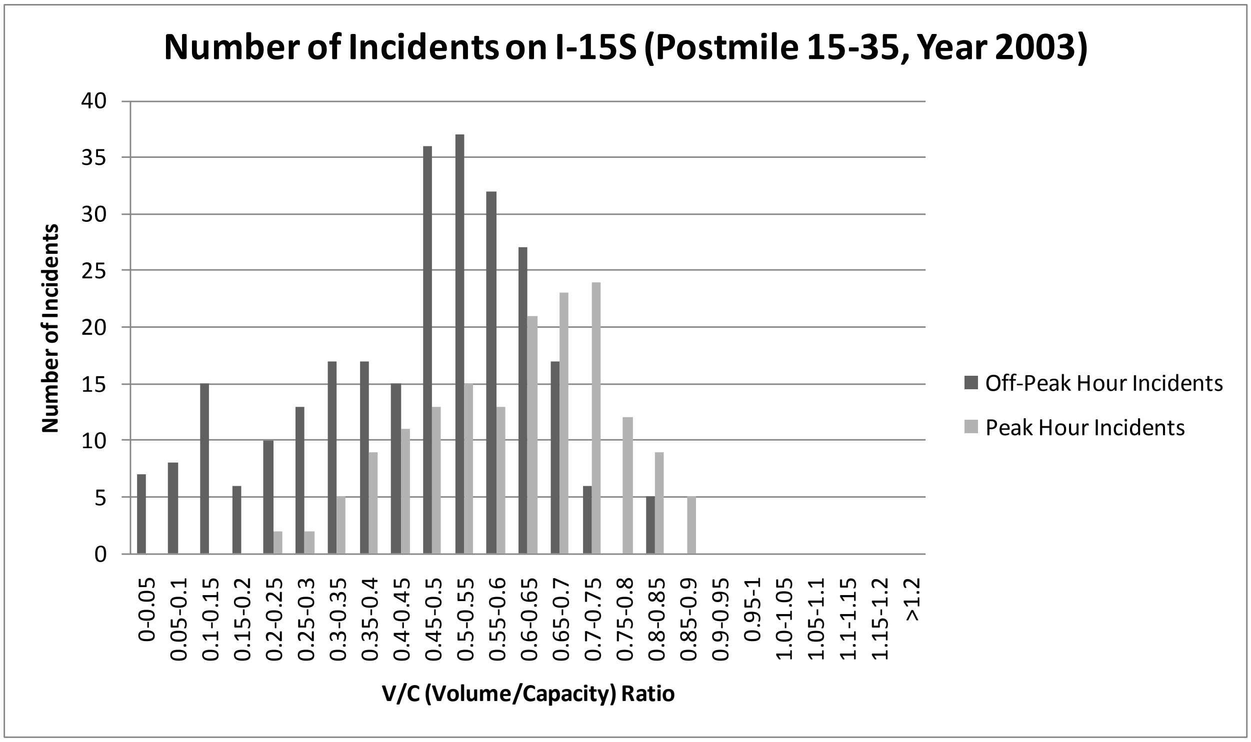


Figure E-3 Distribution of the Number of the Incidents by V/C Ratio

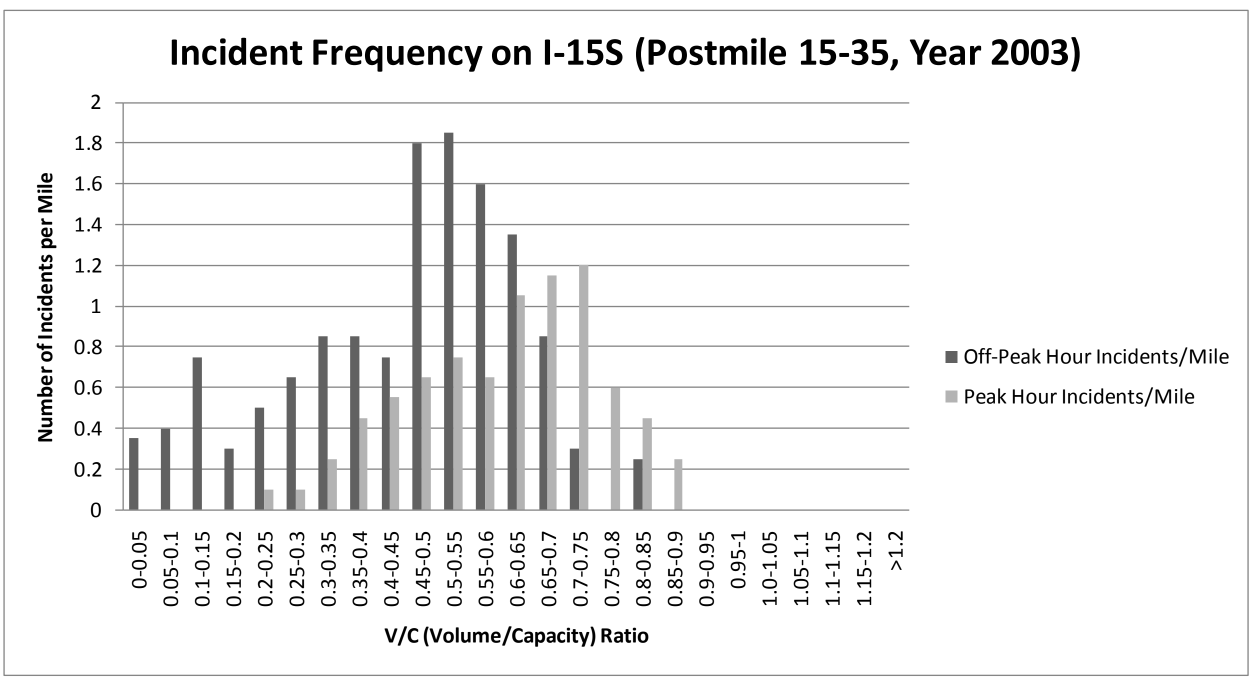


Figure E-4 Distribution of Incident Frequency by V/C Ratio

Figures E-5 and E-6 show similar pictures for the AM peak period. The maximum incident frequency for the AM peak period is 0.85 incident/mile for V/C ratio range 0.65-0.75.

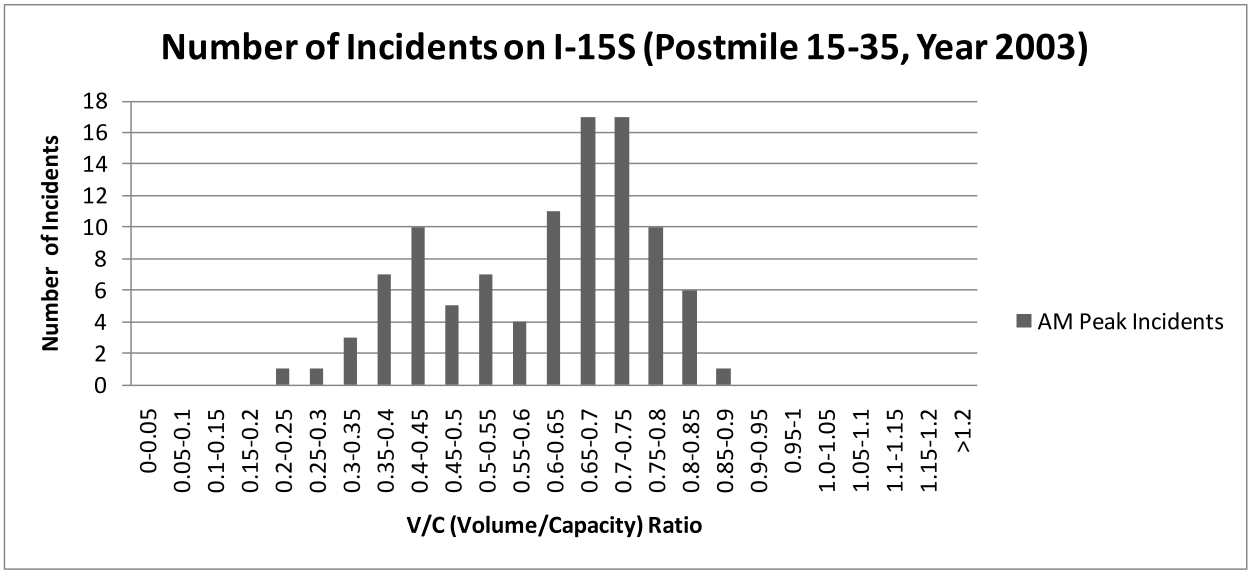


Figure E-5 Distribution of the Number of the Incidents by V/C Ratio for AM Peak

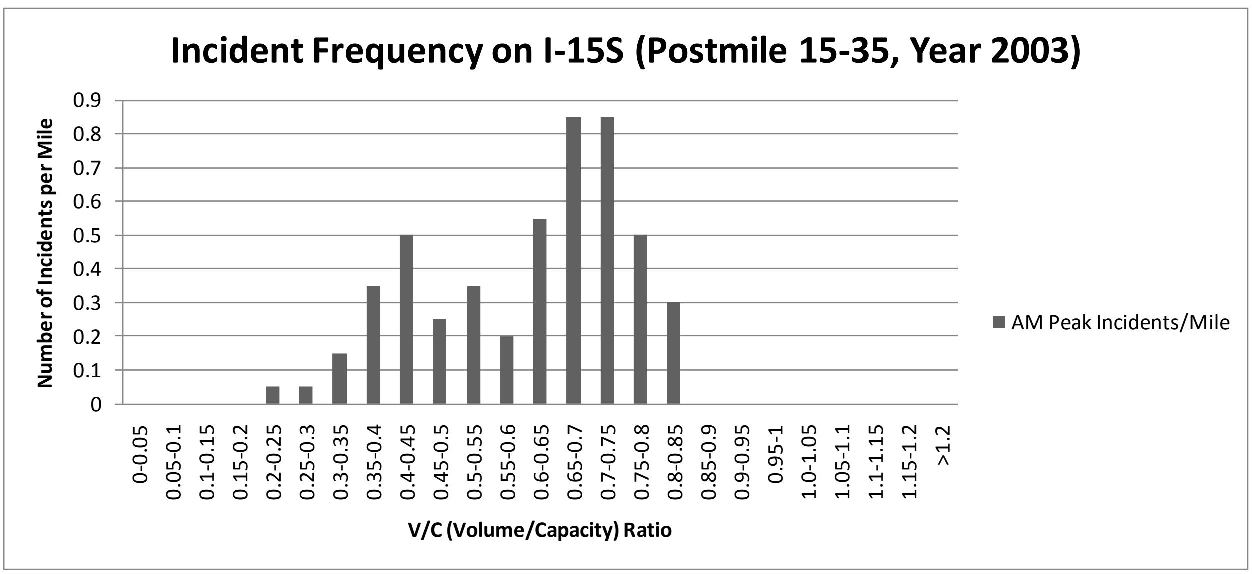


Figure E-6 Distribution of Incident Frequency by V/C Ratio for AM Peak

Next we examined the distribution of the number of days in 2003 by incident type and by travel demand level during the AM peak period over the course of the baseline year as shown in Tables E-1 and E-2. Demand is measured in terms of vehicle miles traveled (VMT) and demand levels are divided into three categories – low, medium, and high – based on their percentage of median VMT as follows:

- Low, if VMT is less than 75% of median VMT value
- Medium, if VMT is greater than 75% of and less than 102% of median VMT value
- High, if VMT is greater than 102% of median VMT value

Table E-1 Distribution of Number of Days in 2003 by Incident Type X Demand Level

Number of days in a year		Incident			Total
		Major	Minor	No incident	
Demand	Hi	38	5	128	171
	Med	17	4	60	81
	Lo	31	1	81	113
Total		86	10	269	365

Table E-2 Percentage Distribution of Number of Days in 2003 by Incident Type X Demand Level

% of days in a year		Incident			Total
		Major	Minor	No incident	
Demand	Hi	10.4%	1.4%	35.1%	46.8%
	Med	4.7%	1.1%	16.4%	22.2%
	Lo	8.5%	0.3%	22.2%	31.0%
Total		23.6%	2.7%	73.7%	100.0%

Nearly three-fourths of the days of the year during the AM peak period have no incidents occurring while approximately one-quarter of the days of the year have a major incident occurring on those days.

We also show in Tables E-3 and E-4 the distribution of vehicle hours of delay in 2003 again by incident type and by travel demand level during the AM peak period over the course of the baseline year. The most striking yet not surprising element of the data from these tables is the observation that total delay associated with low level of demand contributes only negligible amounts to total delay.

Table E-3 Distribution of Delay in 2003 by Incident Type X Demand Level

Delay		Incident			Total
		Major	Minor	No incident	
Demand	Hi	109304	18276	381466	509046
	Med	70040	23724	265704	359468
	Lo	123	0	295	418
Total		179467	42000	647465	868932

Table E-4 Distribution of Percentage of Delay in 2003 by Incident Type X Demand Level

Percentage of Delay		Incident			Total
		Major	Minor	No incident	
Demand	Hi	12.6%	2.1%	43.9%	58.6%
	Med	8.1%	2.7%	30.6%	41.4%
	Lo	0.0%	0.0%	0.0%	0.0%
Total		20.7%	4.8%	74.5%	100.0%