Integrated Corridor Management Initiative: Demonstration Phase Evaluation

San Diego Technical Capability Analysis Test Plan

www.its.dot.gov/index.htm
Final Report — August 21, 2012
Publication Number FHWA-JPO-13-044

U.S. Department of Transportation

Produced by Integrated Corridor Management Initiative: Demonstration Phase Evaluation
U.S. Department of Transportation
Research and Innovative Technology Administration
Federal Highway Administration
Federal Transit Administration

Notice

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-JPO-13-044		

4. Title and Subtitle	5. Report Date
Integrated Corridor Management Initiative: Demonstration Phase Evaluation – San Diego Technical Capability Analysis Test Plan	August 21, 2012
	6. Performing Organization Code
7. Author(s) Matt Lee, URS	8. Performing Organization Report No.
9. Performing Organization Name and Address Battelle 505 King Avenue Columbus, OH 43201	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DTFH61-06-D-00007/ T.O. BA07081
12. Sponsoring Agency Name and Address U.S. Department of Transportation Research and Innovative Technology Administration Federal Highway Administration Federal Transit Administration 1200 New Jersey Avenue, S.E. Washington, DC 20590	13. Type of Report and Period Covered
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report presents the test plan for conducting the Technical Capability Analysis for the United States Department of Transportation (U.S. DOT) evaluation of the San Diego Integrated Corridor Management (ICM) Initiative Demonstration. The ICM projects being deployed in San Diego include a suite of strategies aimed at balancing corridor transportation supply and demand to promote overall corridor efficiency and safety. Operational strategies to be deployed in the San Diego I-15 highway corridor include: simulations to predict travel conditions for improved incident response, interdependent response plans among agencies, traffic diversion to strategic arterials, traveler mode shift to the BRT system during major freeway incidents, and comparative travel time information to the public and operating agencies for freeway, HOT lanes, arterial streets, and BRT. Technologies that will be used to carry out these strategies include a Decision Support System, a 511 traveler information system (telephone and website), a regional center-to-center information exchange network, dynamic message signs, adaptive ramp metering, and responsive traffic signals. This Technical Capability Test Plan is based on the ICM Initiative Demonstration National Evaluation Framework. This test plan provides an overview of the Technical Capability Analysis and describes the specific qualitative and quantitative data that will be collected to support the analysis. Data analysis methodologies as well as risks and mitigations associated with this evaluation analysis are also discussed in this test plan.

17. Key Word	18. Distribution Statement
Integrated Corridor Management, ICM, evaluation, test plan, Technical Capability	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
		54	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

This page intentionally left blank

ACKNOWLEDGEMENTS

Many individuals from the San Diego site team provided crucial input to the development of this test plan. We acknowledge and appreciate the assistance provided by U.S. DOT and the local partners in San Diego, particularly Mr. Alex Estrella, Mr. Peter Thompson, and Mrs. Carolyn Alkire of the San Diego Association of Governments (SANDAG) and Mr. Mike Washkowiak and Mr. Derek Toups (Kimley-Horn).

This page intentionally left blank

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

Page

List of Tables

List of Figures

LIST OF ABBREVIATIONS

AMS	Analysis, Modeling and Simulation
BRT	Bus Rapid Transit
CHP	California Highway Patrol
DMS	Dynamic Message Sign
DSS	Decision Support Systems
FHWA	Federal Highway Administration
FSP	Freeway Service Patrol
FTA	Federal Transit Administration
GP	General Purpose
GUI	Graphical User Interface
HOT	High-Occupancy Tolling
HOV	High-Occupancy Vehicle
I-15	Interstate-15
ICM	Integrated Corridor Management
ICMS	Integrated Corridor Management System
IMTMS	Intermodal Transportation Management System
iNET	Intelligent NETworks
ITS	Intelligent Transportation Systems
KTT	Knowledge and Technology Transfer
LRT	Light Rail Transit
MOE	Measure of Effectiveness
MTS	Metropolitan Transit System
NCTD	North County Transit District

OES	Office of Emergency Services
PeMS	Performance Measurement System
PDT	Project Development Team
RITA	Research and Innovative Technology Administration
R/T	Real-time
SANDAG	San Diego Association of Governments
SD SAFE	San Diego County Service Authority for Freeway Emergencies
S.R.	State Route
TMC	Transportation Management Center
TMDD	Traffic Management Data Dictionary
UMD	University of Maryland
U.S. DOT	U.S. Department of Transportation
VMT	Vehicle-Miles Travelled
Volpe Center	John A. Volpe National Transportation System Center

1.0 INTRODUCTION

This report presents the plan for conducting the Technical Capability Analysis, one of seven analyses that comprise the United States Department of Transportation (U.S. DOT) national evaluation of the San Diego Integrated Corridor Management (ICM) Initiative demonstration phase. The ICM demonstration phase includes multimodal deployments in the U.S. 75 corridor in Dallas, Texas and the Interstate 15 (I-15) corridor in San Diego, California. Separate evaluation test plan documents are being prepared for each site. This document, which focuses on San Diego, is referred to as a "test plan" because, in addition to describing the specific data to be collected, it describes how that data will be used to test various evaluation hypotheses and answer various evaluation questions.

The primary thrust of the national ICM evaluation is to thoroughly understand each site's ICM experience and impacts. However, it is expected that various findings from the two sites will be compared and contrasted as appropriate and with the proper caveats recognizing site differences.

The remainder of this introduction chapter describes the ICM program and elaborates on the hypotheses and objectives for the demonstration phase deployments in Dallas and San Diego, as well as the subsequent evaluation analyses. The remainder of the report is divided into five sections. Chapter 2 summarizes the Technical Capability Analysis overall. Chapters 3 and 4 describe the quantitative and qualitative data that will be used in this analysis. Chapter 5 describes how the data will be analyzed. Chapter 6 presents the risks and mitigations associated with technical capability data.

1.1 ICM Program[1]

Congestion continues to be a major problem, specifically for urban areas, costing businesses an estimated $200 billion per year due to freight bottlenecks and drivers nearly 4 billion hours of time and more than 2 billion gallons of fuel in traffic jams each year. ICM is a promising congestion management tool that seeks to optimize the use of existing infrastructure assets and leverage unused capacity along our nation's urban corridors.

ICM enables transportation managers to optimize use of all available multimodal infrastructure by directing travelers to underutilized capacity in a transportation corridor—rather than taking the more traditional approach of managing individual assets. Strategies include motorists shifting their trip departure times, routes, or modal choices, or transportation managers dynamically adjusting capacity by changing metering rates at entrance ramps or adjusting traffic signal timing plans to accommodate demand fluctuations. In an ICM corridor, travelers can shift to transportation alternatives—even during the course of their trips—in response to changing traffic conditions.

[1] This section has largely been excerpted from the U.S. DOT ICM Overview Fact Sheet, "Managing Congestion with Integrated Corridor Management," http://www.its.dot.gov/icms/docs/cs_over_final.pdf, developed by SAIC for U.S. DOT. At the direction of U.S. DOT, some of the original text has been revised to reflect updates and/or corrections.

The objectives of the U.S. DOT ICM Initiative are:

- Demonstrate how operations strategies and Intelligent Transportation Systems (ITS) technologies can be used to efficiently and proactively manage the movement of people and goods in major transportation corridors through integration of the management of all transportation networks in a corridor.
- Develop a toolbox of operational policies, cross-network operational strategies, integration requirements and methods, and analysis methodologies needed to implement an effective ICM system.
- Demonstrate how proven and emerging ITS technologies can be used to coordinate the operations between separate multimodal corridor networks to increase the effective use of the total transportation capacity of the corridor.

The U.S. DOT's ICM Initiative is occurring in four phases:

- Phase 1: Foundational Research – This phase researched the current state of corridor management in the United States as well as ICM-like practices around the world; conducted initial feasibility research; and developed technical guidance documents, including a general ICM concept of operations to help sites develop their own ICM concept of operations.
- Phase 2: Corridor Tools, Strategies and Integration – U.S. DOT developed a framework to model, simulate and analyze ICM strategies, working with eight Pioneer Sites to deploy and test various ICM components such as standards, interfaces and management schemes.
- Phase 3: Corridor Site Development, Analysis and Demonstration – This phase includes three activities:
    1) Concept Development – Eight ICM Pioneer Sites developed concepts of operation and requirements documents.
    2) Modeling – U.S. DOT selected Dallas, Minneapolis and San Diego to model their proposed ICM systems.
    3) Demonstration and Evaluation – Dallas and San Diego will demonstrate their ICM strategies; data from the demonstrations will be used to refine the analysis, modeling and simulation (AMS) models and methodology.
- Phase 4: Outreach and Knowledge and Technology Transfer (KTT) – U.S. DOT is packaging the knowledge and materials developed throughout the ICM Initiative into a suite of useful multimedia resources to help transportation practitioners implement ICM.

An on-going ICM Initiative activity, AMS is very relevant to the evaluation. AMS tools were developed in Phase 2 and used by the sites to identify and evaluate candidate ICM strategies. In Phase 3, the proposed Dallas and San Diego ICM deployments were modeled. As sites further refine their ICM strategies, AMS tools continue to be used and iteratively calibrated and validated, using key evaluation results, in part. The AMS tools are very important to the evaluation for two reasons. First, the evaluation will produce results that will be used to complete validation of the AMS tools, e.g., updating the AMS assumptions related to the percentage of travelers who change routes or modes in response to ICM traveler information. Second, the calibrated AMS tools will serve as a source of some evaluation data, namely the corridor-level, person-trip travel time and throughput measures that are difficult to develop using field data.

1.2 ICM Demonstration Phase Deployments[2]

This section summarizes the San Diego ICM deployment and briefly contrasts it with the Dallas deployment.

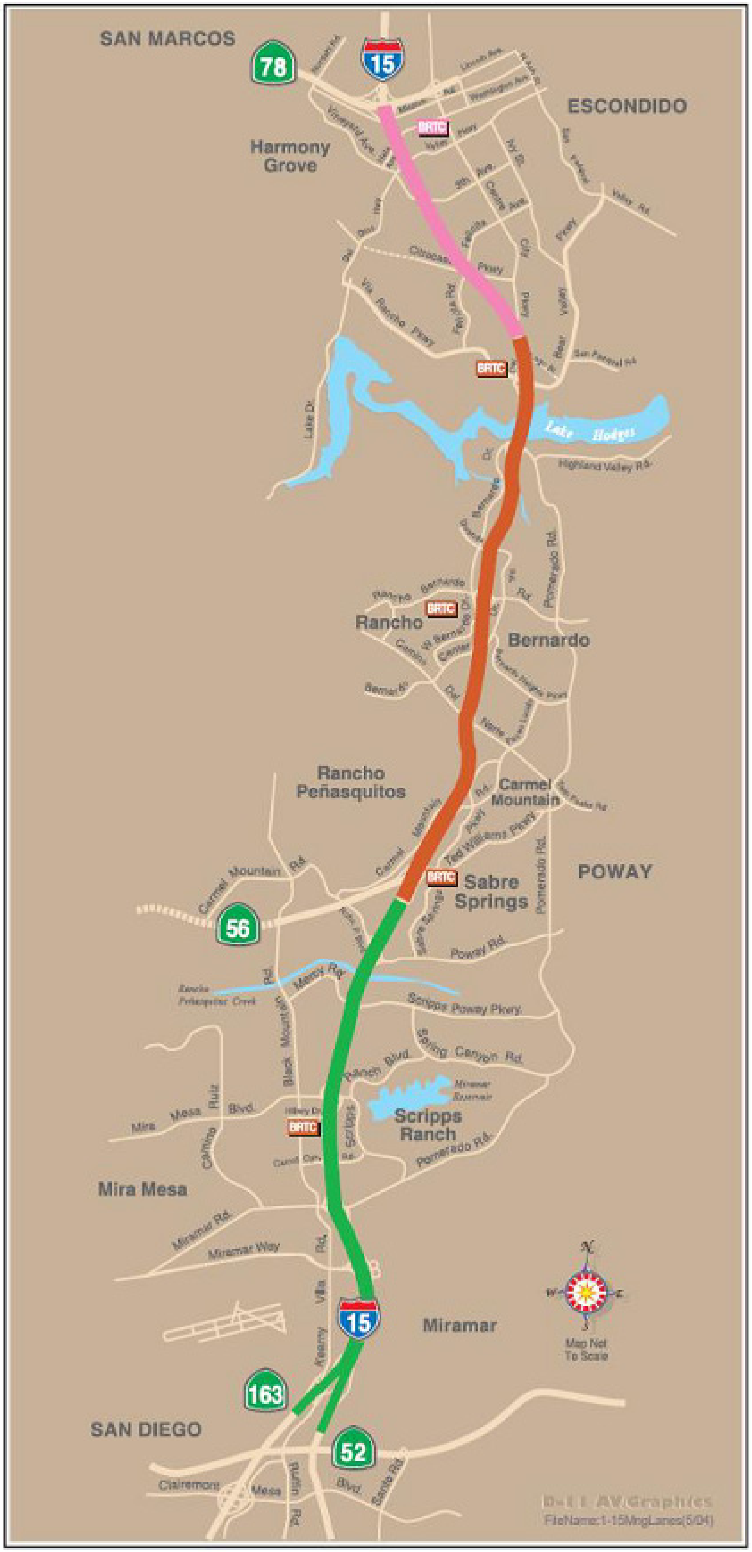
1.2.1 Overview of the San Diego ICM Deployment

The I-15 project is a collaboration led by the San Diego Association of Governments (SANDAG), along with U.S. DOT; the California Department of Transportation; Metropolitan Transit System (MTS); North County Transit District (NCTD); the cities of San Diego, Poway, and Escondido; San Diego County Service Authority for Freeway Emergencies (SD SAFE); County of San Diego Office of Emergency Services (OES); and California Highway Patrol (CHP), in addition to private sector support.

The San Diego ICM corridor includes the portion of I-15, a north-south facility, from State Route (S.R.) 78 in the north to the S.R. 163 interchange in the south, as shown in Figure 1-1. I-15 is a primary artery for the movement of commuters, goods, and services from inland northern San Diego County to downtown San Diego. Weekday traffic volumes range from 170,000 to 290,000 vehicles on the general purpose (GP) lanes.

The corridor currently has a 20-mile, four-lane concurrent flow high-occupancy toll/managed lanes facility with two reversible center lanes, the “I-15 Express Lanes.” Approximately 30,000 vehicles use the I-15 Express Lanes during weekdays, and the corridor experiences recurring congestion.

[2] Information in this section has been excerpted from “Integrated Corridor Management,” published in the November/December 2010 edition of Public Roads magazine. The article was authored by Brian Cronin (RITA), Steve Mortensen (FTA), Robert Sheehan (FHWA), and Dale Thompson (FHWA). With the consent of the authors, at the direction of U.S. DOT some updates or corrections have been made to this material.



San Diego Association of Governments, January 2011

Figure 1-1. I-15 Corridor Boundaries of San Diego ICM Deployment

The San Diego ICM focuses on five primary ICM goals to augment technical management, software and systems development, and cutting-edge innovation:

1. The corridor's multimodal and smart-growth approach shall improve accessibility to travel options and attain an enhanced level of mobility for corridor travelers.
2. The corridor's safety record shall be enhanced through an integrated multimodal approach.
3. The corridor's travelers shall have the informational tools to make smart travel choices within the corridor.
4. The corridor's institutional partners shall employ an integrated approach through a corridor-wide perspective to resolve problems.
5. The corridor's networks shall be managed holistically under both normal operating and incident/event conditions in a collaborative and coordinated way.

To achieve these goals, SANDAG and its partnering agencies will contribute $2.2 million for the $10.9 million project. San Diego will use investments in ITS to implement a "smart" transportation management system that combines road sensors, transit management strategies, video, and traveler information to reduce congestion. The smart system will deliver information to commuters via the Internet and message signs, and will enable managers to adjust traffic signals and ramp meters to direct travelers to high-occupancy vehicle (HOV) and high-occupancy tolling (HOT) lanes, bus rapid transit (BRT), and other options. Specific examples of practices the San Diego site team intends to employ include the following:

- Provide corridor users with the operational condition of all corridor networks and components, such as comparative travel times, incident information, and expected delays.
- Use a decision support system with real-time simulation, predictive algorithms, and analysis modeling.
- Establish, improve, and automate joint agency action plans for traveler information, traffic signal timing, ramp metering, transit and Express Lanes.
- Identify means of enhancing corridor management across all networks, including shared control multi-jurisdictional coordination of field devices such as lane controls, traveler information messages, traffic signal timing plans, and transit priority.

Technology investments that are being implemented as part of the ICM deployment in San Diego and which will be used to carry out ICM operational strategies include:

- A Decision Support System (DSS) that will utilize incoming monitoring data to assess conditions, forecast conditions up to 30 minutes in the future, and then formulate recommended response plans (including selecting from pre-approved plans) for consideration by operations personnel. Table 1-1 summarizes expected San Diego DSS functionality.

- Enhancement of the Intermodal Transportation Management System (IMTMS) regional information exchange network, a system previously implemented using non-ICM funding and which is being enhanced using ICM funding, depicted in Figure 1-2.
- Adjustments to ramp meter timing to support diversions to or from the freeway
- Lane use modifications, namely the four configurable, managed (variably priced high-occupancy toll) lanes in the I-15 median.
- Upgrades to selected traffic signal systems, including new traffic signal coordination timings and responsive traffic signal control on two arterial streets paralleling I-15.
- Arterial street monitoring system, including additional traffic detectors.

Table 1-1. Summary of San Diego DSS Functionality

Functionality	Summary
Expert-System Based DSS	The Expert System combines a rule base using incident response parameters with knowledge base information on roadway geometry and field device locations to automatically generate response plans consisting of strategies such as dynamic message sign (DMS) signing, signal timing, and ramp metering and incident checklists. The heart of the DSS subsystem within the ICMS is the ability to analyze collected data, ascertain abnormal or scheduled events, determine appropriate responses, and suggest a set of actions that collectively form a "Response Plan." The Response Plan may be manually or automatically generated, but if automatically generated, will include the capability for human operator review and modification. This is particularly critical for field device (i.e., DMS and camera) control actions.
Real-Time Monitoring of Transportation System Conditions through the DATA-HUB (IMTMS)	The DSS – DATA HUB takes the data received from participating agencies and provides fused data to participating agencies as XML data feeds and to the general public through the regional 511 system. The DSS – DATA HUB will provide for a dynamic, Web-based Graphical User Interface (GUI) to selected agencies for the monitoring of corridor performance and operations. This portion of DSS functionality is the Intelligent NETworks (iNET) program
Real-Time Simulation modeling to help assess impacts of response plans	The DSS will use a micro/meso scale modeling tool to assess the impact of short-term responses to the planned and unplanned events in the corridor (such as the recent wildfires in San Diego). The real-time modeling component will use the DATA-HUB inputs, along with the DSS-Response Plans to generate corridor level impact assessments of response plans.
Offline simulation and modeling to help fine-tune response plans	Response plans will be reviewed periodically using offline simulation and modeling approaches to make changes to the rules of practices, generate modified rules of practice, and assess the performance retroactively of the DSS
DSS-Network prediction	DSS includes a network prediction capability that looks at capacity and demand conditions across the corridor up to an hour in advance in 15 minute slices. The network prediction looks at estimating demand and the consequent travel conditions across the various modes in the corridor. This information is shared with the corridor operators. The prediction will be refreshed every 3-5 minutes.

Battelle

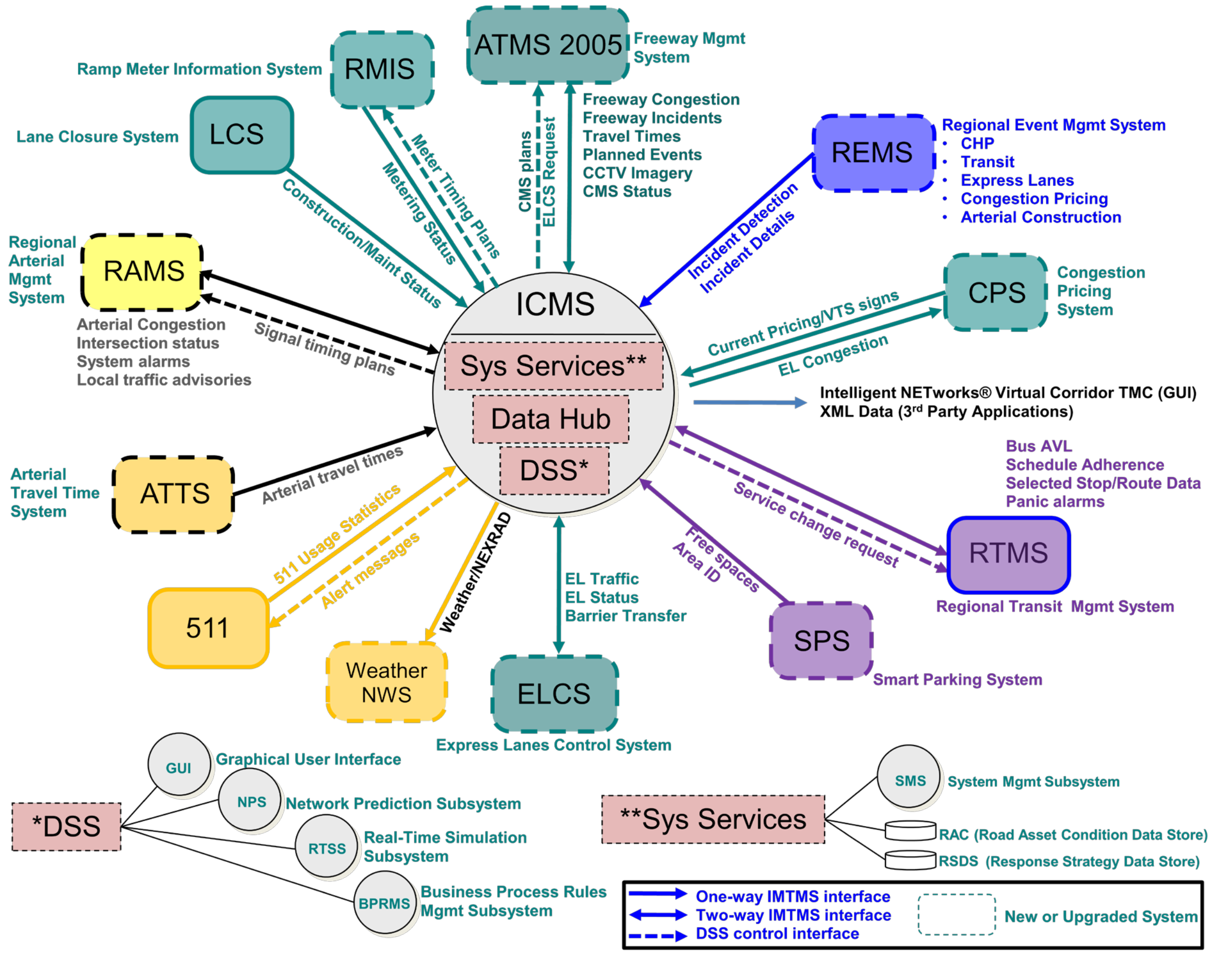


Figure 1-2. Context of San Diego ICM System Data Inputs and Outputs

It is expected that the various San Diego ICM system capabilities and strategies will be utilized in several different contexts and timeframes. These contexts and timeframes are expected to become more definitive and elaborated as the sites proceed with the design and implementation of their systems; various scenarios have been explored that consider the use of the ICM system as a response strategy for wildfires, a crash involving hazardous materials, and heavy congestion at different locations along the corridor. Further, these uses are expected to evolve as the sites work through their six-month "shakedown" periods following the initial system go-live dates, and possibly, continuing to some extent into the 12-month post-deployment data collection period. Currently, it is expected that the ICM systems will be applied in at least the following general contexts and timeframes:

1. In "real time" (or near real time), based on congestion levels.
2. In advance, e.g., pre-planned:
    a. Anticipating a specific, atypical event, such as major roadway construction or a large sporting event; and

b. Periodic or cyclical (e.g., seasonal) adjustments to approaches based on lessons learned and evolution of the ICM strategies and/or in response to lasting changes in transportation conditions either directly related to ICM strategy utilization (e.g., drivers who may have switched to transit during a specific ICM-supported traffic incident choosing to continue to use transit on a daily basis) or other, non-ICM related changes such as regional travel demand.

1.2.2 San Diego ICM Deployment Schedule

Table 1-2 presents the San Diego ICM deployment schedule. As indicated in Table 1-2, individual components of the deployment will be completed in a phased manner, with full ICM system operations currently scheduled to commence in February 2013. The San Diego site team has indicated that they do expect, to at least some degree, to begin using individual components and associated ICM strategies as they become available prior to the overall system go-live. The approach to this analysis attempts to take that phasing into consideration. Since both the completion dates of the individual ICM components and the San Diego site team's utilization of them are expected to evolve as the ICM system design, implementation and shakedown periods progress, the approach presented in this test plan may flex somewhat in response.

Table 1-2. San Diego ICM Deployment Schedule

Activity	Completion Date
Complete Planning Phase	November 2010
Design/Build Phase (complete unit testing):	
Iteration 1: Intelligent NETworks (iNET) Integrated Corridor Management System (ICMS) configuration, new datahub interfaces, Traffic Management Data Dictionary (TMDD) v3.0 conversion, error-checked real-time (R/T) Traffic model, response plan data store design	April 2012
Iteration 2: R/T traffic model with response plans, iNET updates for response plan and event management	August 2012
Iteration 3: Predictive modeling, iNET update for predictive modeling, integration of all DSS capabilities in all subsystems	January 2013
Additional field element construction	January 2013
Complete Acceptance Testing	January 2013
Operations Go Live	February 2013
Complete Shakedown Period	July 2013
Complete Evaluation One Year Operational Period	July 2014

Battelle

1.2.3 Comparison to the Dallas ICM Deployment

The overall objectives of the San Diego ICM deployment are similar to those in Dallas and many of the same general operational strategies are planned, focusing on improving the balance between travel supply and demand across multiple modes and facilities, including highways, arterial streets and transit. The major distinctions in the ICM strategies to be utilized by each site generally flow from the differences in their transportation systems:

- The San Diego corridor includes extensive bus rapid transit whereas the U.S. 75 corridor in Dallas includes the Red Line Light Rail Transit (LRT) service.
- The San Diego corridor includes concurrent flow HOT/managed lanes whereas the Dallas corridor includes HOV lanes:
  - The San Diego corridor includes a recently expanded four-lane managed lane system in the I-15 median that is variably priced high occupancy tolling and includes two reversible center lanes. The San Diego site team does not expect ICM to impact their variable pricing decisions but it will impact their use of the four configurable managed lanes.
  - The Dallas U.S.75 corridor includes access-controlled, HOV lanes located in the median, although, like San Diego with the HOT lanes, they do not expect ICM to impact their occupancy requirement decisions.
  - Both sites currently lift HOV restrictions during major incidents.
- Both sites include major arterials that run parallel with the freeways. However, while the arterial in Dallas is continuous for the length of the corridor, there is no single continuous arterial running parallel to I-15 in San Diego; Black Mountain Road, Pomerado Road, and Centre City Parkway are parallel arterials in the I-15 corridor.
- The Dallas corridor includes an extensive frontage road system, while the San Diego I-15 corridor includes auxiliary lanes between most freeway interchanges that function similarly, though with less capacity.
- The San Diego corridor includes ramp meters on I-15 and so their traffic signal timing strategies include ramp meter signals. Dallas does not use ramp meters.
- Both sites include changes to traffic signal timing plans during heavy demand and/or incidents. The Dallas deployment includes improved traffic signal timing response plans to adjust signal timing in response to real-time traffic demands along the major parallel arterial. The San Diego deployment includes responsive traffic signal control along Black Mountain and Pomerado Roads, both of which are major arterials that parallel I-15.

1.3 National Evaluation Objectives and Process

This section summarizes key aspects of the overall ICM national evaluation. A more comprehensive discussion is contained in the National Evaluation Framework document and the details of individual analyses are documented in this and other test plans.

1.3.1 U.S. DOT Hypotheses

The U.S. DOT has established the testing of eight "hypotheses" as the primary objective and analytical thrust of the ICM demonstration phase evaluation, as shown in Table 1-3. There are a number of cause-effect relationships among the U.S. DOT hypotheses; for example, enhanced response and control is dependent on enhanced situational awareness. These relationships will be examined through the evaluation in addition to testing the individual hypotheses. Another important relationship among the hypotheses is that DSS is actually a component of enhanced response and control and, depending on the specific role played by the DSS, may also contribute to improved situational awareness.

Table 1-3. U.S. DOT ICM Evaluation Hypotheses

Hypothesis	Description
The Implementation of ICM will:	
Improve Situational Awareness	Operators will realize a more comprehensive and accurate understanding of underlying operational conditions considering all networks in the corridor.
Enhance Response and Control	Operating agencies within the corridor will improve management practices and coordinate decision-making, resulting in enhanced response and control.
Better Inform Travelers	Travelers will have actionable multi-modal (highway, arterial, transit, parking, etc.) information resulting in more personally efficient mode, time of trip start, and route decisions.
Improve Corridor Performance	Optimizing networks at the corridor level will result in an improvement to multi-modal corridor performance, particularly in high travel demand and/or reduced capacity periods.
Have Benefits Greater than Costs	Because ICM must compete with other potential transportation projects for scarce resources, ICM should deliver benefits that exceed the costs of implementation and operation.
The implementation of ICM will have a positive or no effect on:	
Air Quality	ICM will affect air quality through changes in Vehicle Miles Traveled (VMT), person throughput, and speed of traffic, resulting in a small positive or no change in air quality measures relative to improved mobility.
Safety	ICM implementation will not adversely affect overall safety outcomes, and better incident management may reduce the occurrence of secondary crashes.
Decision Support Systems*	Decision support systems provide a useful and effective tool for ICM project managers through its ability to improve situational awareness, enhance response and control mechanisms and provide better information to travelers, resulting in at least part of the overall improvement in corridor performance.

Battelle

* For the purposes of this hypothesis, the U.S. DOT considers DSS functionality to include both those carried out by what the sites have labeled their "DSS" as well as some related functions carried out by other portions of the sites' ICM systems.

1.3.2 Evaluation Analyses

The investigation of the eight U.S. DOT evaluation hypotheses have been organized into seven evaluation "analyses," shown in Table 1-4, which generally correlate with the hypotheses. A separate analysis investigates institutional and organizational issues, which relate to all of the hypotheses since the ability to achieve any intended ICM benefits depends upon successful institutional coordination and cooperation.

Table 1-4. Relationship Between U.S. DOT Hypotheses and Evaluation Analyses

U.S.DOT Hypotheses	Evaluation Analysis Area
• Improve Situational Awareness • Enhance Response and Control	Technical Assessment of Operator Capability to Monitor, Control, and Report on the Status of the Corridor
• Better Inform Travelers	Traveler Response (also relates to Enhance Response and Control)
• Improve Corridor Performance	Quantitative Analysis of the Corridor Performance – Mobility
• Positive or No Impact on Safety	Quantitative Analysis of the Corridor Performance – Safety
• Positive or No Impact on Air Quality	Air Quality Analysis
• Have Benefits Greater than Costs	Benefit-Cost Analysis
• Provide a Useful and Effective Tool for ICM Project Managers	Evaluation of Decision Support Systems

Battelle

The evaluation features a "logic model" approach in which each link in the cause-effect sequence necessary to produce the desired impacts on transportation system performance is investigated and documented, beginning with the investments made ("inputs"), the capabilities acquired and their utilization ("outputs") and traveler and system impacts ("outcomes").

Collectively, the results of the eight evaluation analyses will provide a comprehensive understanding of the ICM demonstration phase experience:

- What ICM program-funded and other key ICM-supporting investments did the Dallas and San Diego site teams make, including hardware, software, and personnel (inputs)?
- What capabilities were realized through those investments; how were they exercised and to what extent did they enhance previous capabilities (outputs)?
- What were the impacts of the ICM deployments on travelers, transportation system performance, safety and air quality (outcomes)?
- What institutional and organizational factors explain the successes and shortcomings associated with implementation, operation and effectiveness (inputs, outputs and outcomes) of ICM and what are the implications for U.S. DOT policy and programs and for transportation agencies around the country (Institutional and Organizational Analysis)?

- How well did the DSS perform (DSS Analysis)?
- What is the overall value of the ICM deployment in terms of benefits versus costs (Benefit-Cost Analysis)?

1.3.3 Evaluation Process and Timeline

Figure 1-3 shows the anticipated sequence of evaluation activities. The evaluation will collect 12 months of baseline (pre-ICM deployment) data and, following a 6-month shakedown period, 12 months of post-deployment data.

The major products of the evaluation are two interim technical memoranda after the end of the baseline and post-deployment data collection efforts and a single final report documenting the findings at both sites as well as cross-cutting results. Two formal site visits are planned by the national evaluation team to each site: as part of evaluation planning during national evaluation framework development and test planning-related visits. Additional data collection trips will be made by various members of the national evaluation team during baseline and post-deployment data collection.

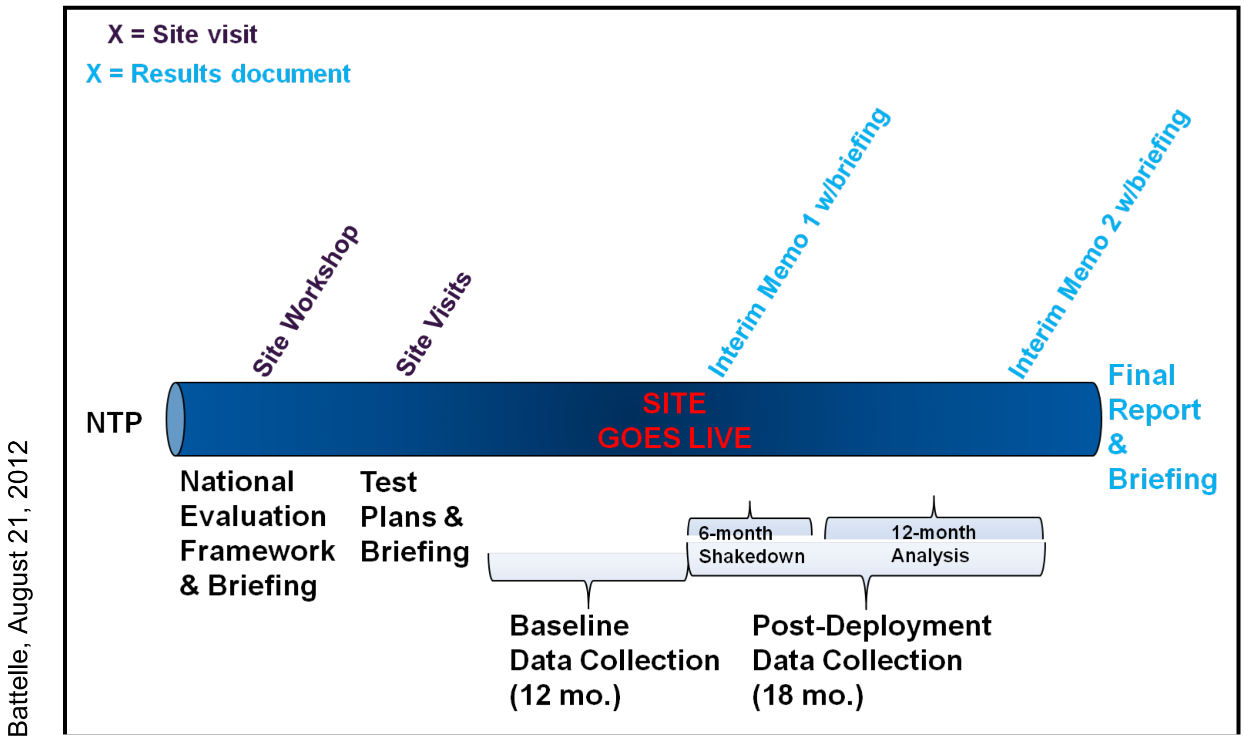


Figure 1-3. Sequence of Evaluation Activities

Based on current deployment schedules for both Dallas and San Diego, the anticipated schedule for major evaluation activities in San Diego is as follows:

- Finalize test plans – Summer 2012
- Collect baseline (pre-ICM deployment) data – Winter 2012 through Winter 2013
- Complete Interim Technical Memorandum on baseline data – Spring 2013
- Collect post-deployment data – Winter 2013 – Summer 2014
- Complete Interim Technical Memorandum on evaluation results – Fall 2014
- Complete Final Report – Spring 2015

1.3.4 Roles and Responsibilities

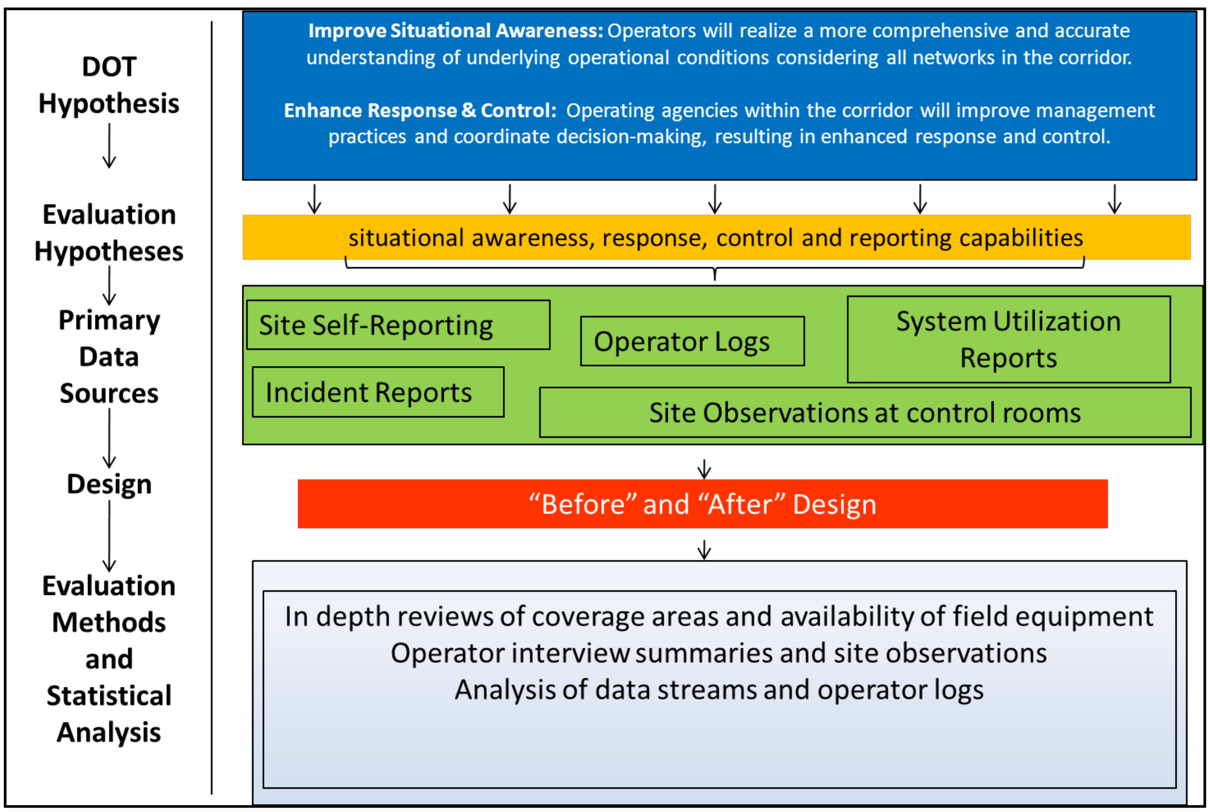
The U.S. DOT ICM Management Team is directing the evaluation and is supported by the Volpe National Transportation Systems Center (Volpe Center), Noblis and ITS America. The Battelle national evaluation team is responsible for leading the evaluation consistent with U.S. DOT direction and is responsible for collecting certain types of evaluation data—namely partnership documents and conducting workshops and interviews. The national evaluation team is also responsible for analyzing all evaluation data—including that collected by the Battelle national evaluation team as well as the Volpe Center and the San Diego site team—preparing reports and presentations documenting the evaluation results, and archiving evaluation data and analysis tools in a data repository that will be available to other researchers. The San Diego site team is responsible for providing input to the evaluation planning activities and for collecting and transmitting to the national evaluation team most of the evaluation data not collected directly by the national evaluation team. The Battelle national evaluation team will create and disseminate surveys to the San Diego site team, who will assist and coordinate with logistics. The Volpe Center is providing technical input to the evaluation and will carry out the traveler survey activities discussed in the Traveler Response Test Plan. The U.S. DOT Analysis, Modeling and Simulation contractor, Cambridge Systematics, will provide key AMS modeling results to the evaluation, namely person-trip measures that cannot be feasibly collected in the field, and will utilize certain evaluation outputs, such as those related to traveler response, to calibrate the AMS tools post-ICM deployment.

This page intentionally left blank

2.0 ANALYSIS OVERVIEW

This chapter provides a high-level overview of the approach to the Technical Capability Analysis, including a discussion of evaluation hypotheses to be tested and measures of effectiveness (MOEs).

Figure 2-1 graphically summarizes the approach to analyzing these hypotheses. The ability of each ICM site to integrate systems and resources, monitor the conditions and capacity of the corridor, implement management strategies, control ITS devices and resources, and report on the status of the corridor in an integrated and cooperative manner is critical to the effectiveness and success of the ICM system. The Technical Capability analysis will thoroughly investigate and document these foundational capabilities, comparing conditions pre- and post-ICM deployment. This analysis will use quantitative and qualitative information, including system data, TMC operator surveys and interviews.



Battelle, August 21, 2012

Figure 2-1. Overview of Technical Capability Analysis

The U.S. DOT has identified two, broad hypotheses related to ICM Technical Capability:

- **Improve Situational Awareness** – Operators will realize a more comprehensive and accurate understanding of underlying operational conditions considering all networks in the corridor.
- **Enhance Response and Control** – Operating agencies within the corridor will improve management practices and coordinated decision making, resulting in enhanced response and control.

U.S. DOT evaluation objectives also reference improvements in the ability of the ICM partners to report on the status of the transportation system to the public and thereby influence cross-network and modal shifts to better balance travel demand loads. The two main U.S. DOT evaluation hypotheses have been decomposed for testing into the evaluation hypotheses shown in Table 2-1. The evaluation hypotheses are organized into three areas, corresponding to the two U.S. DOT broad hypotheses and a third area related to reporting.

Table 2-1. Technical Capability Evaluation Hypotheses

Evaluation Hypothesis Area	Evaluation Hypothesis
Enhance Response and Control	Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.
	Improved understanding of conditions and improved response plans will allow operators to more effectively modify ramp metering rates as part of ICM strategies
	Improved sharing of construction and maintenance scheduling information among agencies will increase the awareness of the number of lane closures on roads which serve as alternate routes to each another.
Improve Ability to Report	Post-ICM, agencies will be able to report corridor conditions in a more timely and actionable manner to travelers.
Improve Situational Awareness	Improved data sharing (both real-time data and video) will provide operators with better understanding of mobility conditions and demand conditions in the corridor.
	Operators will realize a better and continuous understanding of available system resources and conditions through ICM.
	Data from ICMS system will be perceived as high-quality and actionable by the system operators.

Battelle

Table 2-2 identifies the data elements that will be used in this analysis and associates them with MOEs and the evaluation hypotheses they will be used to test. The data elements are categorized as quantitative and qualitative. The majority of the quantitative data elements will be collected from the ICMS data fusion engine (the ICMS Data Hub). The qualitative data elements will be obtained from manually distributed surveys and interviews that will track transportation operations staff impressions pre- and post-IC deployment. Discussions of quantitative and qualitative data elements are presented in Chapters 3 and 4, respectively. In Table 2-2 all references to "change" pertain to pre- versus post-ICM deployment with the understanding that some pre-ICM values will be zero.

Table 2-2. Technical Capability Analysis Hypotheses, MOEs, Data, and Sources

Data Element		MOE	Evaluation Hypotheses
Quantitative Data			
1. System Data	1.1 Number of 'unique' DMS messages posted (outside of normal recurring messages such as travel time)	Changes in the number of DMS messages executed in response to incidents and other corridor conditions (freeway, express lanes and arterial).	Post-ICM, agencies will be able to report corridor conditions in a more timely and actionable manner to travelers.
1. System data	1.2 DMS Travel time update messaging[3]	Update frequency (over a period of time) of travel time messaging in particular, across all modes of travel.	Post-ICM, agencies will be able to report corridor conditions in a more timely and actionable manner to travelers.
1. System Data	1.3 Incident notification times	Change in percent of incident notifications sent to the public within 15 minutes from incident identification (when identified by the TMC operator) across all modes), pre- and post-ICM deployment.	Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.
1. System Data	1.4 Number of incident records logged into ICMS	Change in the number of incident being logged pre- and post-ICMS deployment.	Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.
1. System Data	1.5 Roadway clearance times	Change in time from incident awareness to the restoration of lanes to full operational status, pre- and post-ICM deployment[4,5]	Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.
1. System Data	1.6 Duration (number of hours) that comparative travel times on arterials, transit, and freeways are available and accessible to (1) travelers and (2) TMC	Change in percentage of peak periods with the availability of multimodal comparative travel times via the 511 traveler information service or other future (new) traveler information systems (i.e., website)	Improved data sharing (both real-time data and video) will provide operators with better understanding of mobility conditions and demand conditions in the corridor.

[3] Per Peter Thompson on the SD ICM Eval Test Plan Call #1, March 30, 2012, the site "may decide not to" post travel times of any sort. Therefore, this Data Element may prove to be moot based on the decision made.

[4] The San Diego Site Team has advised that this data is also available not only via the ICMS, but the SANDAG Freeway Service Patrol (FSP) Operator Logs as well.

[5] For the purpose of this MOE, the evaluation team is using the FHWA definition of roadway clearance times, defined in the 2010 Traffic Incident Management Handbook as "the time between awareness of an incident and restoration of lanes to full operational status" (meaning all lanes are open for traffic).

Table 2-2. Technical Capability Analysis Hypotheses, MOEs, Data, and Sources (Continued)

Data Element		MOE	Evaluation Hypotheses
Quantitative Data (Cont.)			
1. System Data	1.7 Frequency of traveler information disseminated by the 511 Traveler Information service	Change in number of updates to the 511 system as a result of the ICM deployment	Post-ICM, agencies will be able to report corridor conditions in a more timely and actionable manner to travelers.
1. System Data	1.8 Number of centerline miles on arterials in the corridor with real-time (i.e., active incident) information provided to transportation operators[6]	Change in number of centerline miles of real time arterial information being provided to the transportation operations pre- and post-ICM deployment	Improved data sharing (both real-time data and video) will provide operators with better understanding of mobility conditions and demand conditions in the corridor.
1 System Data	1.9 Number of times arterial metering rates have been modified with a flush plan	Number of times traffic is re-routed over an arterial and the ramp meter controller is overridden with a flush plan	Improved understanding of conditions and improved response plans will allow operators to more effectively modify ramp metering rates as part of ICM strategies
1 System Data	1.10 Bus routes providing real-time information (vehicle locations, capacity, schedule adherence)	Change in the number of BRT routes in corridor providing real time info to ICMS (vehicle locations, capacity, schedule adherence)	Operators will realize a better and continuous understanding of available system resources and conditions through ICM.
2. Arterial Data	2.1 Number of instances of coordinated timing plan changes	Change in the number of instances that arterial signal timing was altered in response to corridor events (including recurring and non-recurring congestion)	Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.

[6] This information may also be available via the "local agency encroachment permit application logs", per San Diego Site Team.

Table 2-2. Technical Capability Analysis Hypotheses, MOEs, Data, and Sources (Continued)

Data Element		MOE	Evaluation Hypotheses
Qualitative Data			
3. Operator Surveys	3.1 Perceptions of transit, local agency and TMC operators relative to usefulness of real-time information	Change in perceived usefulness of real-time information (data) provided to operators for interpretation and decision making	Data from ICMS system will be perceived as high-quality and actionable by the system operators.
3. Operator Surveys	3.2 Perceptions of transit, local agency and TMC operators relative to usefulness of travel information being provided to the public	Change in operators perceived usefulness of travel information being provided to the public	Post-ICM, agencies will be able to report corridor conditions in a more timely and actionable manner to travelers.
3. Operator Surveys	3.3 Perceptions of transit, local agency and TMC operators relative to intervention in altering recommended responses	Level of operator intervention in altering recommended responses[7]	Data from ICMS system will be perceived as high-quality and actionable by the system operators.
3. Operator Surveys	3.4 Perceptions of transit, local agency and TMC operators relative to capability to monitor and report effectively on the system resources	Change in operator's perceptions of capability to monitor and report effectively on the system resources in the corridor (e.g., road, ITS equipment)	Data from ICMS system will be perceived as high-quality and actionable by the system operators.
3. Operator Surveys	3.5 Transit, local agency and TMC operator satisfaction levels with inter-organizational coordination	Change in level of operator satisfaction with inter-organizational coordination measures	Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.
3. Operator Surveys	3.6 Perceptions of transit, local agency and TMC operators (relative to schedule coordination of maintenance and construction activities)	Change in perceived effectiveness of coordination of maintenance and construction schedules	Improved sharing of construction and maintenance scheduling information among agencies will increase the awareness of the number of lane closures on roads which serve as alternate routes to each other
4. PDT Committee Surveys	4.1 Perceptions of PDT (Project Development Team) – relative to response plans implemented (**post ICM Deployment only**)	Change in perceived effectiveness of coordinated response plans implemented (**post ICM Deployment only**)	Improved intra-agency communications and data sharing will result in quicker response and clearance time for incidents.

[7] This MOE applies to those response plans which require operator approval and intervention. As part of the site's design, there will be response plans which do not require operator intervention, mostly relating to ramp metering changes and traffic signal changes. They will be captured through the MOEs listed as part of Data Element 1.9 and 2.1.

Table 2-2. Technical Capability Analysis Hypotheses, MOEs, Data, and Sources (Continued)

Data Element		MOE	Evaluation Hypotheses
Qualitative Data (Cont.)			
4. PDT Committee Surveys	4.2 Usefulness (perceived value)of incident related data feeds available to corridor stakeholder agencies pre and post ICM deployment (**post ICM Deployment only**)	Change in perceived value of incident related data feeds available to corridor stakeholders (**post ICM Deployment only**)	Improved intra-agency communications and data sharing will result in quicker response and clearance time for incidents.
5. San Diego Site Team Lead Surveys	5.1 Number of instances of shifted plans	Number of construction/maintenance events shifted as a result of shared construction and maintenance information among agencies	Improved sharing of construction and maintenance scheduling information among agencies will increase the awareness of the number of lane closures on roads which serve as alternate routes to each other
5. San Diego Site Team Lead Surveys	5.2 Number of times the TMC has requested additional resources (beyond what they would typically request in the absence of ICM) from corridor stakeholders based on DSS recommendations	Change in times the operator has requested additional resources (not available to SANDAG, Caltrans or other local corridor relevant municipalities – such as arrow boards and portable DMS) from the corridor stakeholders based on DSS recommendations	Operators will realize a better and continuous understanding of available system resources and conditions through ICM.
5. San Diego Site Team Lead Surveys	5.3 Number of agencies with access to real-time video feeds	Change in the number of agencies sharing video feeds pre- and post-ICM deployment	Operators will realize a better and continuous understanding of available system resources and conditions through ICM.
5. San Diego Site Team Lead Surveys	5.4 Consumers using data from ICMS	Identify users of the new data being made available via ICMS. This will be a qualitative response.	Data from ICMS system will be perceived as high-quality and actionable by the system operators
5. San Diego Site Team Lead Surveys	5.5 Number of agencies with access to corridor-wide real time data	Change in the number of agencies getting real time data as a result of ICMS deployment, pre- and post-ICM deployment comparison	Operators will realize a better and continuous understanding of available system resources and conditions through ICM.
5. San Diego Site Team Lead Surveys	5.6 Number of agencies manually using the common incident reporting system	Change in number of agencies using the common incident reporting system	Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.
6. Commercial Traveler Information Provider Interviews	6.1 Perceptions of, and changes in, the quality and quantity of information available them (**post ICM Deployment only**)	Perceived improvement in traveler information available as a result of the ICM deployment (**post ICM Deployment only**)	Post-ICM, agencies will report corridor conditions in a more timely and actionable manner to travelers.

Battelle

Typically, a test plan such as this one would be drafted after examining samples of most of the required system data. This was not possible in this case because ICMS, central collection point for all system data elements, is currently under development and not anticipated to be functional before the second quarter of 2012. As such, the San Diego site team will not able to provide the specific details regarding ICMS data formats or content as of test plan development. The San Diego site team will provide the national evaluation team an ICMS user account at the conclusion of the software development iteration, in which details regarding the ICMS data formats and content will be more clearly defined.

This page intentionally left blank

3.0 QUANTITATIVE DATA

This chapter describes the quantitative data elements to be used in the Technical Capability analysis. Table 3-1 summarizes the data requirements for the Technical Capability Analysis Test Plan. The details associated with the source, timing, and other details are discussed in the sections that follow.

3.1 System Data

As indicated in Table 3-1, most of the system data (apart from data element 1.6, which will be collected via Caltrans Performance Measurement System [PeMS]) will be available via the ICMS Data Hub, depicted in Figure 3-1. A connection from the ICMS Data Hub through the University of Maryland (UMD) data repository will serve as the primary means of communicating the data from the site to the national evaluation team. Generally, these data will capture how the transit, local agency and TMC operators utilized the ICM tools to monitor, control and report (to agencies and travelers/travel information providers) on ICM corridor conditions. The collection of ICMS data includes a real-time, continuous data feed from the ICMS Data Hub to the UMD ICM national evaluation data repository.

The San Diego site team implementation schedule (see Table 1-2) shows ICMS fully operational—with all new ICM data integrated—by approximately mid-way through the baseline evaluation year, in August 2012. However, based on conversations with the San Diego site team, it is the impression of the national evaluation team that the data required for this analysis will begin being entered into ICMS well before then. As such, this test plan indicates that both baseline and post-deployment data will be drawn from ICMS.

Table 3-1. Quantitative Data Summary

Data Element	Location	Data Source	Data Collection Frequency	Data Collection Period (pre-/post-)		Data Collection Responsible Party	Data Transmittal
				Start	End		
System Data							
1.1 Number of DMS messages posted (outside of normal recurring messages such as travel time)	Entire ICM Corridor (see Figure 1-1)	ICMS Data Hub	Continuous	Feb 2012	July 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.2 DMS Travel time update messaging	Entire ICM Corridor (see Figure 1-1)	ICMS Data Hub	Continuous	Feb 2012	July 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.3 Incident notification times	Entire ICM Corridor (see Figure 1-1)	ICMS Data Hub	Continuous	Feb 2012	July 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.4 Number of Incident records logged into ICMS[8]	Entire ICM Corridor (see Figure 1-1)	ICMS Data Hub	Continuous	Feb 2012	July 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.5 Roadway clearance times	Entire ICM Corridor (see Figure 1-1)	ICMS Data Hub	Continuous	Feb 2012	July 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.6 Duration (number of hours) that comparative travel times on arterials, transit, and freeways are available and accessible to (1) travelers and (2) TMC	Entire ICM Corridor (see Figure 1-1)	PeMS	Continuous	Feb 2012	July 2014	National Evaluation Team will collect through Performance Measurement System (PeMS)	N/A

[8] SANDAG Freeway Service Patrol (FSP) Operator Logs may be additional data source for this element.

Table 3-1. Quantitative Data Summary (Continued)

Data Element	Location	Data Source	Data Collection Frequency	Data Collection Period (pre-/post-)		Data Collection Responsible Party	Data Transmittal
				Start	End		
System Data (Cont.)							
1.7 Frequency of traveler information (updates) provided to the 511 Traveler Information service	Entire ICM Corridor (see Figure 1-1)	ICMS	Continuous	Feb 2012	July 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.8 Number of centerline miles on arterials with real time information being provided to transportation operators	Entire ICM Corridor (see Figure 1-1)	ICMS	Continuous	Feb 2012	July 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.9 Number of times arterial metering rates have been modified with a flush plan	Entire ICM Corridor (see Figure 1-1)	ICMS	Continuous	Feb 2012	July 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.10 Bus Routes providing real-time information	Entire ICM Corridor (see Figure 1-1)	ICMS	Continuous	Feb 2012	July 2014	ICMS Data Hub	Continuous (UMD Data Feed)
Arterial Data							
2.1 Instances of coordinated timing plan changes	Entire ICM Corridor (see Figure 1-1)	San Diego Site Team Lead	Continuous	Feb 2012	July 2014	ICMS Data Hub	Continuous (UMD Data Feed)

Battelle

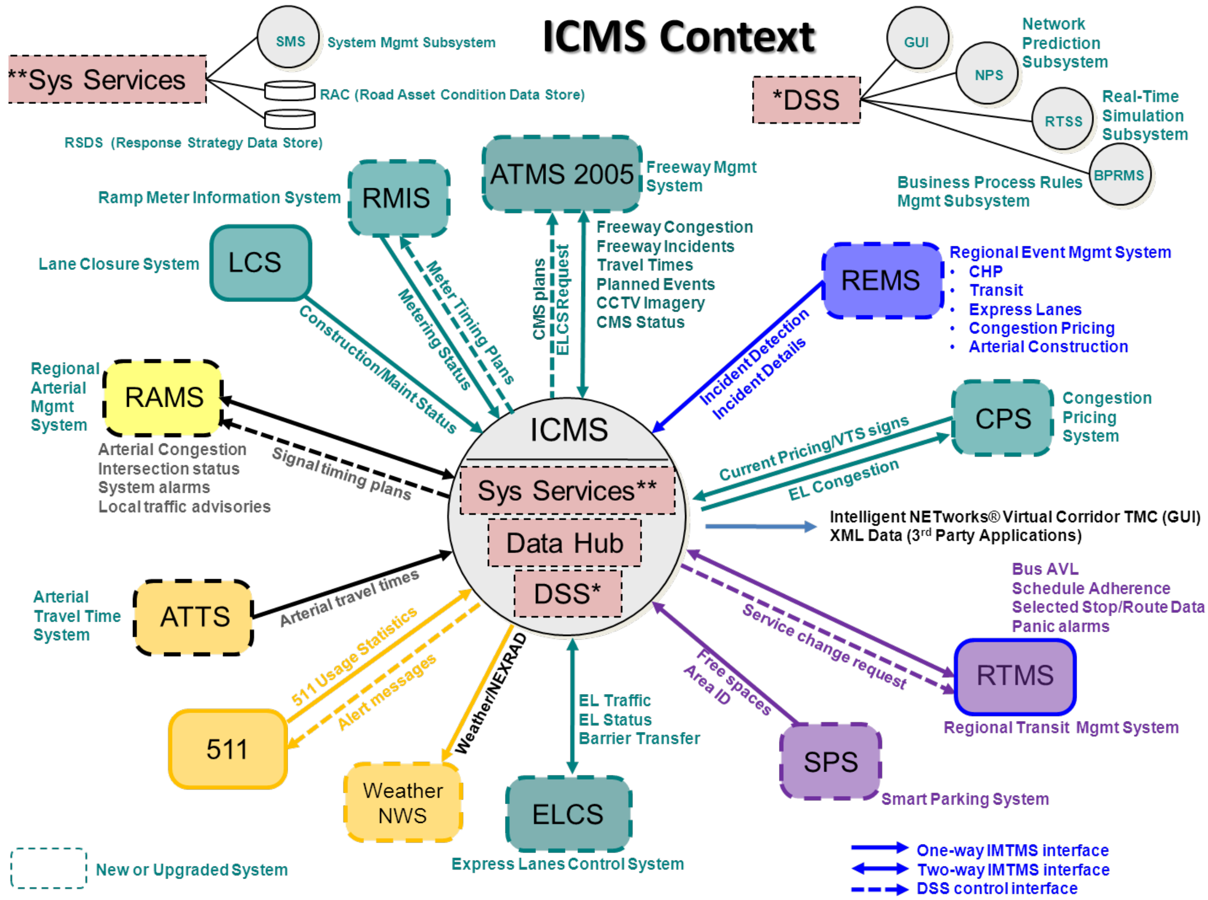


Figure 3-1. Quantitative ICMS Architecture – San Diego

Each system data element will be collected during the entirety of the pre- (February 2012 through February 2013) and post- (August 2013 – July 2014) ICMS deployment periods. System data will also be collected during the shakedown period from February 2013 – July 2013.

3.2 Arterial Data

The second category of quantitative evaluation data is pertaining to arterial streets – traffic signal systems in particular. Some of this data may, at some point, reside within ICMS Data Hub post deployment but that, for now, it should be assumed that these data will come from the individual organizations that participate in the operation of the ICM corridor traffic signal systems or through other studies conducted by the San Diego site team. Those organizations consist of Caltrans, the City of San Diego, the City of Poway, and the City of Escondido.

4.0 QUALITATIVE DATA

This chapter describes the qualitative data elements to be used in the Technical Capability analysis. Figure 4-1 highlights the relationship between qualitative data sources (the rectangles) and the types of perception information (ovals) to be collected by the national evaluation team. As reflected in Figure 4-1, perception data will be collected from four sources: the various agency and municipal operators (surveys to be distributed electronically and returned by the national evaluation team), the San Diego site team lead (surveys), the Project Development Team (surveys), and commercial traveler information providers (interviews). Table 4-1 summarizes the timing and responsible parties for the various qualitative data elements and the sections that follow provide additional detail for each activity, including survey and interview questions.

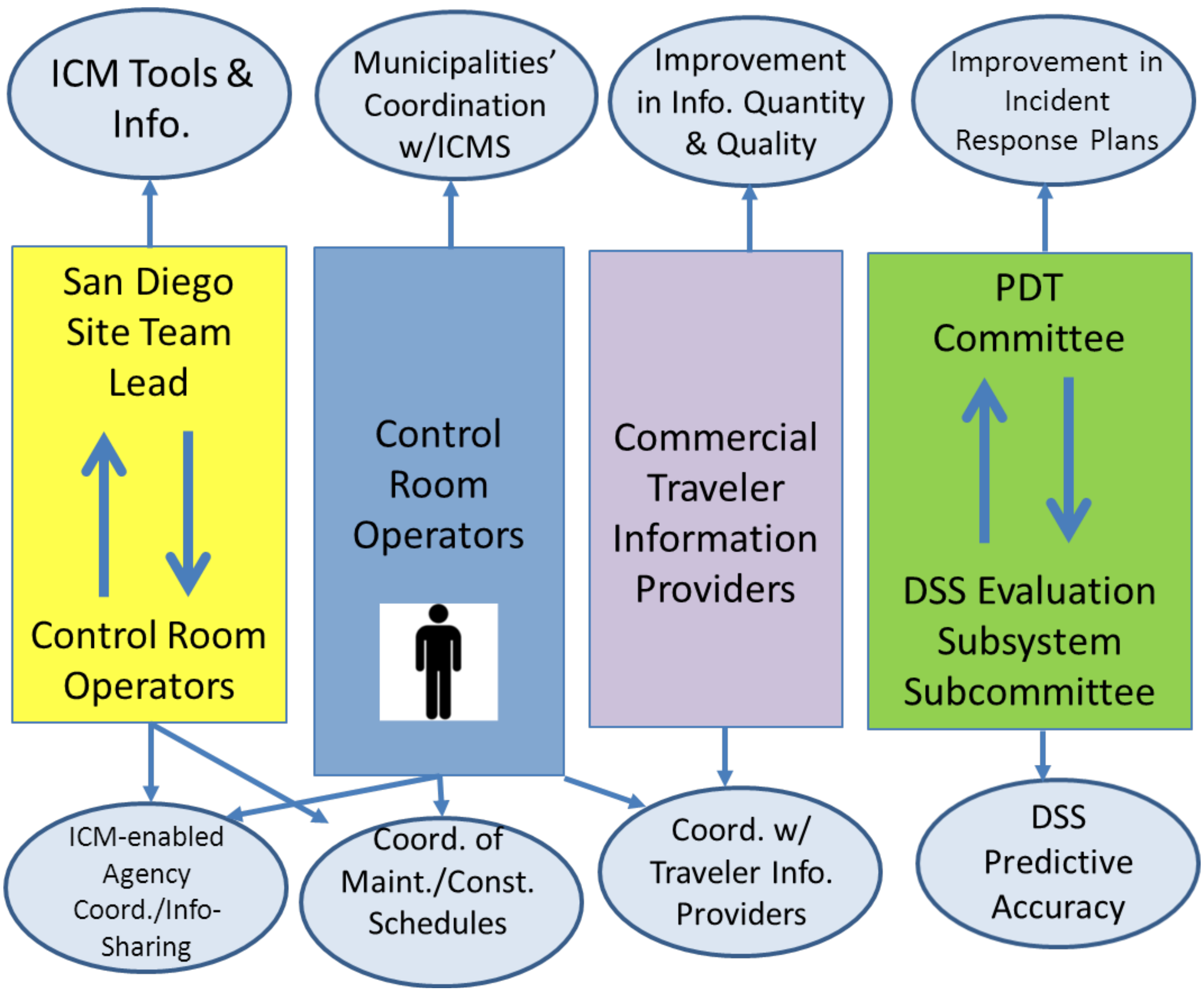


Figure 4-1. Qualitative Evaluation Data Collection Summary

Table 4-1. Qualitative Data Summary

Data Collection Activity	Data Collection Periods		Data Collection Schedule		Data Collection Responsible Party	Data Transmittal
	Baseline	Post-Deployment	Baseline	Post-Deployment		
TMC Operator Surveys	X	X	Aug 2012 Jan 2013 Immediately following several case study events	Sept 2013 (end of shakedown) Jan 2014 (mid-post) July 2014 (late-post) Immediately following several case study events	National Evaluation Team via the San Diego Site Team Lead[9]	Completed Surveys sent to National Evaluation Team
PDT Operations Committee Survey		X	N/A	Sept 2013 Jan 2014 April 2014 July 2014	National Evaluation Team via the PDT Committee Chair[10]	Completed Surveys sent to National Evaluation Team
San Diego Site Lead Survey	X	X	Either once (Feb 2013) or Quarterly depending on specific questions	Either twice (Aug 2013 & July 2014) or Quarterly depending on specific question	National Evaluation Team	Completed Surveys sent to National Evaluation Team
Commercial Traveler Information Provider Interviews[11]		X	N/A	Dec 2013 (mid-post) July 2014 (late-post)	National Evaluation Team	Contact names for Interviewees (Email to National Evaluation Team from SANDAG)

Battelle

[9] The role of the San Diego Site Lead and the PDT Committee Chair will be primarily to coordinate and encourage responses from their constituents. The national evaluation team will create an electronic survey instrument and provide the appropriate information to the survey respondents.

[10] See previous footnote.

[11] The National Evaluation Team will interview commercial data providers but SANDAG will assist in identifying the appropriate traveler information sources.

4.1 TMC Operator Surveys

4.1.1 Purpose

Transit, local agency and TMC operators are the individuals responsible for monitoring corridor conditions and implementing control actions. The purpose of these surveys is to gather operators' perceptions, before and after ICM implementation, of their ability to perform these functions.

4.1.2 Approach

This survey will be administered to the transit, local agency and TMC operators associated with the corridor operations. A tentative list of survey participants is shown in Table 4-2. The national evaluation team will provide the survey questionnaires via an electronic format, directly to the recipients for completion and on-line return to the national evaluation team.

Table 4-2. Tentative List of TMC Operator Survey Participants

Involved Parties	Agency	Tentative Survey Participant
Transit Operators	MTS	Devin Braun
		Mike Daney
	Veolia (contractor)	TBD
TMC Operators	Caltrans	Lima Kopitch
		Paul English
		Valerie Pekarek
		Mike Egan
Local Agency Operators	City of Poway	Zoubir Ouadah
	City of San Diego	Duncan Hughes
		Eddie Flores
	City of Escondido	Ali Shahzad
		Chris Landis

Battelle

Electronic survey questionnaires will be distributed during the baseline and post-deployment periods multiple times, on both a set schedule and on an ad hoc or "pulse" schedule synchronized with a few "event case studies" (e.g., major incidents) that will also be considered in the Corridor Performance and Traveler Response Analyses. The surveys distributed on a set schedule will ask for the operators to base their responses on their experience with ICM in general, over a period of many months. The ad hoc or pulse surveys will ask the operators to focus specifically on individual case study events. The operators' perceptions corresponding to the event case studies will compliment data for the same events that will be collected from travelers (see the Traveler Response Analysis Test Plan) and quantitative traffic and transit data (see the Corridor Performance Analysis Test Plan). Having all three types of data will provide the evaluation powerful, "360-degree" insights into ICM impacts, reflecting how ICM was utilized (operator surveys), how travelers responded, and the implications for "on-street" system performance. Every survey will include an open ended 'comments' section, allowing the operators to submit any feedback that may not be captured by the close ended questions presented.

The set schedule for the baseline period includes two survey periods—not because conditions are expected to evolve significantly during the baseline but rather to provide two, corroborating data points for the entirely perceptual information that will be collected through these surveys. The first scheduled baseline survey period will be early in the baseline and the second period will be late in the baseline. The survey will be conducted three times on a set schedule during the post-deployment period: once at the end of the shakedown; once near the middle of the post-deployment period; and once near the end of the post-deployment period (refer to Figure 1-3).

For the few ad hoc, event case study surveys in both the baseline and post deployment periods, it will be important that the surveys be electronically distributed and completed within a week of the event in question. The Corridor Performance Analysis Test Plan identifies "profiles" of the types of event case studies that the San Diego site team will be asked to watch for and alert the national evaluation team. The San Diego site team lead will have the responsibility of notifying the national evaluation team analysis lead for the Technical Capability Analysis within 72 hours of the event. This timeframe will allow the analysis lead to coordinate the survey through the either the San Diego site team lead or their designate for administration to the operators.

4.1.3 Questionnaire

The survey will be presented in a link to an online survey that will be emailed to the operators, with the results being tabulated and analyzed by the national evaluation team. As shown in Table 4-3, survey questions will utilize a 5-option, Likert-scale response categories which will facilitate the tabulation and quantitative analysis of responses. The questions presented in Table 4-3 are intended to illustrate the type of information of interest to the national evaluation team. Finalization of the survey questions, as well as developing standardized explanations or elaborations for questions, will be closely coordinated with the San Diego site team so as to make the questions as clear and meaningful to the operators as possible. Also to be included in the questionnaire design are open-ended response questions that would allow respondents to explain the rationale for their ratings and/or identify how tools and practices could be approved.

Table 4-3. Preliminary TMC Operator Survey Questions

Question (Numbers Reference Data Elements from Table 2-2)	Response Options
3.1a Considering normal peak hour conditions, please rate the usefulness of the real-time transportation information available to you in supporting your decisions.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
3.1b Considering unusually congested traffic conditions, such as during major incidents, please rate the usefulness of the real-time transportation information available in supporting your decisions.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor

Table 4-3. Preliminary TMC Operator Survey Questions (Continued)

Question (Numbers Reference Data Elements from Table 2-2)	Response Options
3.2a Considering normal peak hour conditions, please rate the usefulness of the information you (the operator) provide to travelers to support their trip-making decisions via the DMS.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
3.2b Considering unusually congested traffic conditions, such as during major incidents, please rate the usefulness of the information you (the operator) provide to travelers to support their trip-making decisions via the DMS.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
3.3a Considering normal peak hour conditions, please rate the quality of the pre-defined or ICM system-recommended incident/event response plans in terms of how much you have to modify them in order to implement them during a specific incident or event.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
3.3b Considering unusually congested traffic conditions, such as during major incidents, please rate the quality of the pre-defined or ICM system-recommended incident/event response plans in terms of how much you have to modify them in order to implement them during a specific incident or event.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
3.4a Considering normal peak hour conditions, please rate your ability to effectively report transportation conditions and the status of transportation assets (e.g., message signs, CCTV cameras), to other transportation operators, emergency responders, and the media.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
3.4b Considering unusually congested traffic conditions, such as during major incidents, please rate your ability to effectively report transportation conditions and the status of transportation assets (e.g., message signs, CCTV cameras), to other transportation operators, emergency responders, and the media.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
3.5a Please rate the effectiveness of inter-agency coordination that takes place during minor incidents.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
3.5b Please rate the effectiveness of inter-agency coordination that takes place during major incidents.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
3.6 Please rate the extent to which agencies coordinate scheduling of construction and maintenance with one another to minimize impacts on travelers?	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor

Battelle

4.2 PDT Operations Committee Survey

4.2.1 Purpose

The PDT Committee is composed of representatives from a number of corridor stakeholder agencies, as shown in Table 4-4, and is tasked with overseeing the successful deployment of the ICMS relative to its functional capabilities. This survey focuses on one committee responsibility in particular: to review the effectiveness of the ICM response plans as recommended/pre-defined and as implemented. The committee, as described to the national evaluation team, is tasked with reviewing a sampling of incidents and determining what level of success the control room experienced in utilizing DSS-recommended response plans. It is expected that these deliberations will result in modifications to pre-defined response plans throughout the shakedown period and potentially continuing through the post-deployment evaluation period. The purpose of surveying this committee is to gather the perceptions pertaining to the quality of the response plans in a formal manner.

Table 4-4. PDT Operations Committee Members

Agency	PDT Operations Committee Member
MTS	Devin Braun
Caltrans	Lima Kopitch
City of Poway	Zoubir Ouadah
City of San Diego	Duncan Hughes
City of Escondido	Ali Shahzad
Caltrans D11	Tim Bouquin
	Everett Townsend
	Cindee Feaver
	Lawrence Emerson
	Shahin Sepassi
SANDAG	Ingrid Weisenbach

Battelle

4.2.2 Approach

The national evaluation team will electronically distribute a survey questionnaire to the members of the committee, collecting their responses and sending back the completed survey questionnaires to the Technical Capability Analysis evaluation lead. Surveys will be administered quarterly in conjunction with the quarterly review meeting. As with the operator surveys, the quarterly questionnaires will focus on general perceptions over a period of a few months.

4.2.3 Questionnaire

Proposed questions are shown in Table 4-5. Finalization of the survey questions, as well as developing standardized explanations or elaborations for questions, will be closely coordinated with the San Diego site team so as to make the questions as clear and meaningful to the committee members as possible.

Table 4-5. Preliminary PDT Operations Committee Survey Questions

Question (Numbers Reference Data Elements from Table 2-2)	Response Options
4.1a Please rate the effectiveness of the responses to transportation conditions such as incidents and high traffic demand.	(1) Very good
	(2) Good
	(3) Neither good nor bad
	(4) Poor
	(5) Very poor
4.1b Please rate the effectiveness of inter-agency coordination in responding to transportation conditions such as incidents and high traffic demand.	(1) Very coordinated
	(2) Coordinated
	(3) Intermittently coordinated
	(4) Not very coordinated
	(5) Not at all coordinated
4.2 Change in perceived value of incident related data feeds available to corridor stakeholders	(1) Very good
	(2) Good
	(3) Neither good nor bad
	(4) Poor
	(5) Very poor

Battelle

4.3 San Diego Site Team Lead Survey

4.3.1 Purpose

The San Diego site team lead[12] will work cooperatively with the national evaluation team acting as the conduit with the transit, Caltrans and local agency transportation operators. The purpose of the survey of this position is to gather both quantitative information on the ICM system (e.g., extent of data collection coverage) as well as perceptual information on utilization of ICM tools and capabilities.

[12] It should be noted that the San Diego site team lead, as referenced in this section alone, is a combination of Alex Estrella, Functional Manager and Peter Thompson, Technical Manager, although this survey will only require one of them to respond.

4.3.2 Approach

The San Diego site team lead will be surveyed/interviewed once during the baseline period. That survey will focus on only quantitative, factual transportation system information such as the number of I-15 corridor agencies sharing video feeds with one another. During the post-deployment period, the San Diego site team lead will be surveyed twice regarding quantitative, factual transportation system information: once near the end of the shakedown period and once near the end of the one-year post-deployment period. The San Diego site team lead will be surveyed quarterly on perceptual information on the utilization of the ICM tools and capabilities. The two quantitative/ factual surveys will be synchronized with two of the quarterly perceptual surveys so that all questions are on a single questionnaire. The reason that the quantitative information will be collected less often is because it is not expected to change much over time whereas the perceptual information may change considerably over time.

An electronic survey will be emailed to the San Diego site team lead by the national evaluation team. The San Diego site team lead will complete the questionnaire and return it to the national evaluation team.

4.3.3 Questionnaire

Table 4-6 presents the proposed San Diego Site Team Lead Survey Questions for both types of surveys (the less frequent, quantitative questions and the quarterly perceptual questions). All responses will be open field; that is, there will not be pre-defined, multiple choice responses. Other questions about the assets in the corridor may be added as necessary.

Table 4-6. San Diego Site Team Lead Survey Questions

Question Type	Questions (Numbers refer to data element numbers in Table 2-1)
Quantitative/Factual Transportation System Questions	5.1 Over the last 3 months, how many construction/maintenance events have shifted as a result of shared information between agencies?
	5.2 Over the last 3 months, how many times has the TMC requested additional corridor resources based on incident response plan (DSS and otherwise) recommendations?
	5.3 What is currently the number of agencies sharing video feeds along the I-15 ICM corridor?
	5.4 Identify what users are currently taking advantage of the new data being made available via ICMS
	5.5 What is the change in the number of agencies getting real time data as a result of ICMS deployment, pre- and post-ICM deployment comparison
	5.6 Number of agencies using a common incident report system?

Battelle

4.4 Commercial Traveler Information Provider Interviews

4.4.1 Purpose

The purpose of these interviews is to gather commercial traveler information providers' perceptions of any changes in the quality or quantity of the information available to them via the I-15 corridor public agencies, post-ICM deployment. Along with travelers themselves, the media and other traveler information providers (e.g., PeMS and Cal-IT^2) are an important consumer of traveler information. The information gathered through these interviews will help test the hypothesis that ICM will result in more timely and actionable traveler information.

4.4.2 Approach

Two rounds of telephone interviews will be conducted with three to five commercial traveler information providers during the one-year post-deployment evaluation period, once about halfway through and again near the end.

The specific interviewees will be identified in consultation with the San Diego site team. The interviewees will include major radio, television and internet traveler information providers as well as possibly providers using any more innovative or emerging methods that may be available in the San Diego area at the time of the interviews.

4.4.3 Questionnaire – Discussion Guide

Interview questions will be e-mailed to interviewees in advance. The questionnaire will be finalized in consultation with the San Diego site team and are not likely to be completely final until shortly before the interviews are conducted so as to allow for developments in the ICM deployment and operation. Preliminary interview questions are as follows:

1. Please describe the role your organization plays in providing information to travelers?
    a. What information do you provide travelers?
    b. How do you provide the information; that is, through what channels, such as radio, television, the Internet, etc.?
2. Where do you obtain your information?
    a. What information do you obtain from public agencies and how do you obtain it?
3. I'm going to ask you to rate various aspects of the quality and quantity of the traveler information that is currently available to you from public agencies on a scale of 1 to 5 with 5 being excellent and 1 being very poor.
    a. First, how would you rate the timeliness of information; that is, how current is the information?
    b. Next, how would you rate the accuracy of the information; for example, are the locations of collisions reported accurate, is the level of traffic congestion reported accurately and is the status of an incident (e.g., cleared or not cleared) reported accurately?

c. Now please rate the geographic coverage of the information; for example is information available on a sufficient number of transportation facilities (e.g., freeways, arterials, bus routes)?

d. Finally, please rate the temporal coverage of the information; that is, is the information available for all times of day and days of the week when it is needed?

4. In terms of quality, quantity or accessibility, is the information available from transportation agencies now any different than it was six months ago?
   a. If it's different, how is it different; is it better or worse?
   b. If it's better or worse, how is it better or worse; that is, is it more accurate, more timely or what?
   c. If it's improved or is worse, what do you think would explain the change?
5. Have any transportation agencies approached you to solicit your opinion on how the information available to you could be improved?
6. Do you have any suggestions for how the information available to you from transportation agencies could be improved?
7. Do you have any questions for the transportation agencies about their information or how they disseminate it?
8. Are you aware of the I-15 Integrated Corridor Management system project?
   a. If so, how did you become aware of it?
   b. If so, do you feel it has had any impact on the quality, quantity or accessibility of traveler information that is available to you? If so, how?

5.0 DATA ANALYSIS

This chapter describes how the data described in Chapter 4 will be analyzed to test various hypotheses. The data analysis approach is presented in three sections corresponding to the three areas of evaluation hypotheses discussed in Chapter 2: Enhance Response and Control; Improve Ability to Report; and Improve Situational Awareness. For the most part, the analysis features a before-after design, comparing data pre- and post-ICM. As a prelude to the analysis proper, all data will be quality-checked, including looking for any obvious out-of-range values in the quantitative data, clear indications that survey respondents misinterpreted survey questions, and other anomalies apparent through visual inspection of the data.

5.1 Enhance Response and Control

This area of the analysis focuses on understanding how ICM impacts the agencies' ability to respond to transportation conditions, including implementing specific response plans and executing various control actions. This portion of the analysis will test the following three evaluation hypotheses:

- Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.
- Improved intra-agency communications and data sharing will result in quicker response and clearance time for incidents.
- Improved sharing of construction and maintenance scheduling information among agencies will increase the awareness of the number of lane closures on roads which serve as alternate routes to each other (this will also improve general response to avoid facilities/routes that are degraded)

A variety of quantitative and qualitative data will be considered. All quantitative data will come from ICMS. These data records are expected to be large databases containing records of each of a variety of actions taken by transportation operators. The national evaluation team will parse through those data records, categorizing each record into its appropriate MOE, tabulate totals by MOE, and then compare baseline and post-deployment totals. Standard statistical practices shall be used in all calculations to ensure consistent comparisons across all MOEs. When changes are detected, statistical significance of the change shall be calculated to ensure the national evaluation team does not misrepresent the change as meaningful when it is not.

As the quantitative data is tabulated, attempts will be made to categorize each record according to the general prevailing transportation system condition, e.g., normal peak hour conditions, major incidents, minor incidents, or severe weather events. To the extent that the data supports that sort of categorization, this analysis will also examine how ICM response and control impacts may vary according to the complexity of the transportation condition. In the case of weather events, the national evaluation team can cross-reference information in the ICMS and other San Diego agency records with National Weather Service data.

In cases where it is found that any of the various analysis categories used here, e.g., major incident, normal peak hour conditions, etc. may be found to closely resemble any of the various AMS scenarios (e.g., high demand, low demand, major incident), then this will be noted, thus allowing U.S. DOT, the AMS contractor, the San Diego site team or others to compare the results of this analysis with the AMS results.

The qualitative data to be analyzed to test response and control hypotheses will come from Transit, Local Agency and TMC Operator Surveys, San Diego Site Team Lead Surveys, PDT discussions, and Commercial Traveler Information Provider Surveys. As indicated in Chapter 4, the operator surveys will explicitly parse perceptions pertaining to both regular peak hour conditions as well as unusually heavily congested periods such as major incidents. That information will provide the means to examine how perceived response and control effectiveness may vary by transportation system complexity.

Survey results will be cleaned and tabulated; use of 5-point Likert rating scales will allow average responses to be calculated and reported, along with the high and low range for each question. Survey results will be reported in tables and charts. Comparative MOEs shall be calculated as a percentage of change between pre- and post-deployment of the ICM. Standard statistical practices shall be used in all calculations to ensure consistent comparisons across all MOEs. When changes are detected, statistical significance of the change shall be calculated to ensure the national evaluation team does not misrepresent the change as meaningful when it is not.

5.2 Improve Ability to Report

This area of the analysis will test one evaluation hypothesis: post-ICM, agencies will be able to report corridor conditions in a more timely and actionable manner to travelers.

Conclusions related to this hypothesis will be drawn based on the combined evidence from both quantitative and qualitative data. Measures of effectiveness developed from quantitative data consist of the change in the number of non-routine (that is, incident related) dynamic message sign postings and the change in the volume and/or content of traveler information disseminated through other channels, such as 511 and its related website. The national evaluation team will parse through the ICMS data—collected in its entirety through the DSS Analysis—classify each incidence of DMS message posting as either routine or non-routine, and then tabulate the change (baseline versus post-deployment) in the number of non-routine messages.

Analysis approaches associated with changes in the volume and quality of traveler information disseminated through other channels are less certain at this time as it is not yet clear exactly what this data will look like.

Testing of this hypothesis will also utilize two types of qualitative data: operator perceptions of the information they provide to travelers and commercial traveler information providers' perceptions of the information available to them from ICM corridor transportation agencies. Survey results will be analyzed as described in Section 5.1. Commercial traveler information provider interview results will be analyzed subjectively, carefully reviewing the results from each interview and noting areas of agreement and disagreement and overarching themes. The hypothesis testing will draw overall conclusions based on both the operator survey and provider interview results and will focus in particular on areas of agreement and differences in perspective.

5.3 Improve Situational Awareness

This portion of the analysis will be focusing on understanding how ICM impacts agencies' awareness of transportation situations, including demand levels and performance on various roadway and transit facilities and services as well as the status and availability of system resources like signs, and cameras. This portion of the analysis will test these three specific evaluation hypotheses:

- Improved data sharing (both real-time data and video) will provide operators with better understanding of mobility conditions and demand conditions in the corridor.
- Operators will realize a better and continuous understanding of available system resources and conditions through ICM.
- Data from ICMS will be perceived as high-quality and actionable by the system operators.

These hypotheses will be tested using a variety of quantitative and qualitative data. Quantitative data will come almost entirely through the ICMS. Qualitative data consists of results from the operator and San Diego site team lead surveys. Data analysis methods for the respective types of data will be essentially the same as described in Sections 5.1 and 5.2. Quantitative analysis will focus on tabulating MOEs based on individual system data records; qualitative analysis will entail typical survey analysis techniques such as calculation of average responses and response ranges. Results will be presented graphically and in hybrid graphical/report formats where key findings and outliers are highlighted and elaborated as appropriate.

5.4 Exogenous Factors

The following factors could have an impact on not only the collection of data, but the ability of the national evaluation team to analyze the data in relationship to the MOE and associated hypotheses.

- **Unrelated software/system upgrades** over the course of the analysis could have an impact on data availability. Prior to each data collection point, monthly for most of the quantitative data and quarterly for most of the qualitative data, the national evaluation team will inquire as to the possibility of any data shifts based on technical upgrades or modifications to the software being used.

  Should these data altering circumstances present themselves, an approach to screening and normalization of affected data will be developed before the data are used in the analysis or such data will need to be excluded from the analysis if data normalization cannot resolve the data quality issue.

- **Operator turnover and experience** between pre- and post-deployment could have an impact on data collection. The national evaluation team will minimize this factor by selecting operators who have had a longer history in association with their current positions and corridor operations. Historical operator performance will also be considered through interfacing with the operator's immediate supervisor, providing the national evaluation team with a sense as to whether the operator will make a dependable, knowledgeable and willing participant in the evaluation. The operator survey instrument will also carefully identify the levels of experience for the operators.
- **Non-ICM transportation system changes** and construction or maintenance projects outside of the ICM corridors may reduce corridor capacity or change demand and, therefore, have an adverse effect on the measures associated with DMS messaging, changes in average incident response times, and changes in operators' perceived quality of information. The national evaluation will collect data on construction and maintenance projects through the Corridor Performance Analysis. Information on any transit fare increases or other policy changes will also be monitored as part of the general evaluation monitoring which will occur over the course of the entire evaluation. These data will be consulted in this analysis to attempt to ensure that those activities do not skew conclusions.

6.0 RISKS AND MITIGATIONS

Table 6-1 identifies the risks associated with this analysis and the national evaluation team's response plan for each risk.

Table 6-1. Risks and Mitigations

Risk	Mitigation Strategy
1. The inherent subjectivity in perceptual (survey) data could limit the ability to draw strong conclusions. This could also be impacted by the relatively small sample size (e.g., operators).	• Use of carefully worded, written survey questions with well-defined multiple-choice response categories. • Avoid using only qualitative data to test any given hypothesis; instead use a combination of quantitative and qualitative data. • Conduct surveys at multiple points in time so that changes unrelated to ICM may be more apparent and factored out.
2. Development of this test plan without having examples of various data.	• Review data and adjust plans as appropriate as data samples become available.
3. Influence of non-ICM (exogenous) factors.	• Attempt to track these factors and take into consideration during data analysis (see Section 5.4).
4. Lack of certainty in what traveler information "volume and quantity" data will look like for non-DMS dissemination channels and what can be inferred from it.	• Further work with the San Diego site team to definitively identify data sources, formats and limitations.

Battelle

This page intentionally left blank

U.S. Department of Transportation
ITS Joint Program Office-HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free "Help Line" 866-367-7487
www.its.dot.gov

Publication Number FHWA-JPO-13-044

U.S. Department of Transportation