Integrated Corridor Management Initiative: Demonstration Phase Evaluation

Dallas Technical Capability Analysis Test Plan

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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 Dallas U.S. 75 Integrated Corridor Management (ICM) Initiative Demonstration. The ICM projects being deployed in Dallas include a suite of strategies aimed at balancing U.S. 75 corridor transportation supply and demand to promote overall corridor efficiency and safety. Operational strategies to be deployed in the Dallas U.S. 75 highway corridor include: simulations to predict travel conditions for improved incident response, interdependent response plans among agencies, traffic diversion to frontage roads and strategic arterials, traveler mode shift to the light rail system during major freeway incidents, and comparative travel time information to the public and operating agencies for freeway, HOV lanes, frontage roads, arterial streets, and light-rail transit lane. 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, parking management systems, transit signal priority 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.

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LIST OF ABBREVIATIONS

AMS	Analysis, Modeling and Simulation
DART	Dallas Area Rapid Transit
DMS	Dynamic Message Sign
DSS	Decision Support Systems
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GUI	Graphical User Interface
HOT	High-Occupancy Tolling
HOV	High-Occupancy Vehicle
I-15	Interstate-15
I-635	Lyndon B. Johnson Freeway
ICM	Integrated Corridor Management
ICMS	Integrated Corridor Management System
ITS	Intelligent Transportation Systems
KTT	Knowledge and Technology Transfer
LRT	Light Rail Transit
MOE	Measure of Effectiveness
NCTCOG	North Central Texas Council of Governments
NTTA	North Texas Tollway Authority
RITA	Research and Innovative Technology Administration
TEARS	Targeted Event Accelerated Response System
TMC	Transportation Management Center
TTI	Texas Transportation Institute
TxDOT	Texas Department of Transportation
UMD	University of Maryland
U.S. DOT	U.S. Department of Transportation
VMT	Vehicle-Miles Traveled
Volpe Center	John A. Volpe National Transportation System Center

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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 Dallas 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 Dallas, 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 develop 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 stages:
    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., assumptions related to the percentage of travelers who change routes or modes in response to ICM traveler information. Second, 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 Dallas ICM deployment and briefly contrasts it with the San Diego deployment.

1.2.1 Overview of the Dallas ICM Deployment

The U.S. 75 ICM project is a collaborative effort led by Dallas Area Rapid Transit (DART) in collaboration with U.S. DOT; the cities of Dallas, Plano, Richardson, and University Park; the town of Highland Park; North Central Texas Council of Governments (NCTCOG); North Texas Tollway Authority (NTTA); and the Texas Department of Transportation (TxDOT).

U.S. 75 is a north-south radial corridor that serves commuter, commercial, and regional trips, and is the primary connector from downtown Dallas to the cities to the north. Weekday mainline traffic volumes reach 250,000 vehicles, with another 30,000 vehicles on the frontage roads. The corridor (travelshed) has 167 centerline-miles (269 kilometers) of arterial roadways.

Exhibited in Figure 1-1, the U.S. 75 corridor has two concurrent flow-managed, high-occupancy vehicle (HOV) lanes, light rail, bus service, and park & ride lots. The corridor sees recurring congestion and a significant number of freeway incidents. Light rail on the DART Red Line is running at 75 percent capacity, and arterial streets are near capacity during peak periods and are affected by two choke points at the U.S. 75/Lyndon B. Johnson Freeway (I-635) interchange and U.S. 75/President George Bush Turnpike interchange.

DART and the regional stakeholders will contribute $3 million to the $8.3 million ICM deployment. The Dallas ICM deployment focuses on the four primary ICM goals shown in Table 1-1: improve incident management, enable intermodal travel decisions, increase corridor throughput, and improve travel time reliability. The Dallas site team intends to utilize a variety of coordinated, multimodal operational strategies to achieve these goals, including:

- Provide comparative travel times between various points of interest to the public via the 511 system for the freeway, strategic arterial streets (i.e., Greenville Ave.), and light-rail transit line, as well as real-time and planned events status and weather conditions. Operating agencies plan to have real time status of all facilities within the ICM corridor.
- Use simulations to predict travel conditions for improved operational response.
- Implement interdependent response plans among agencies.

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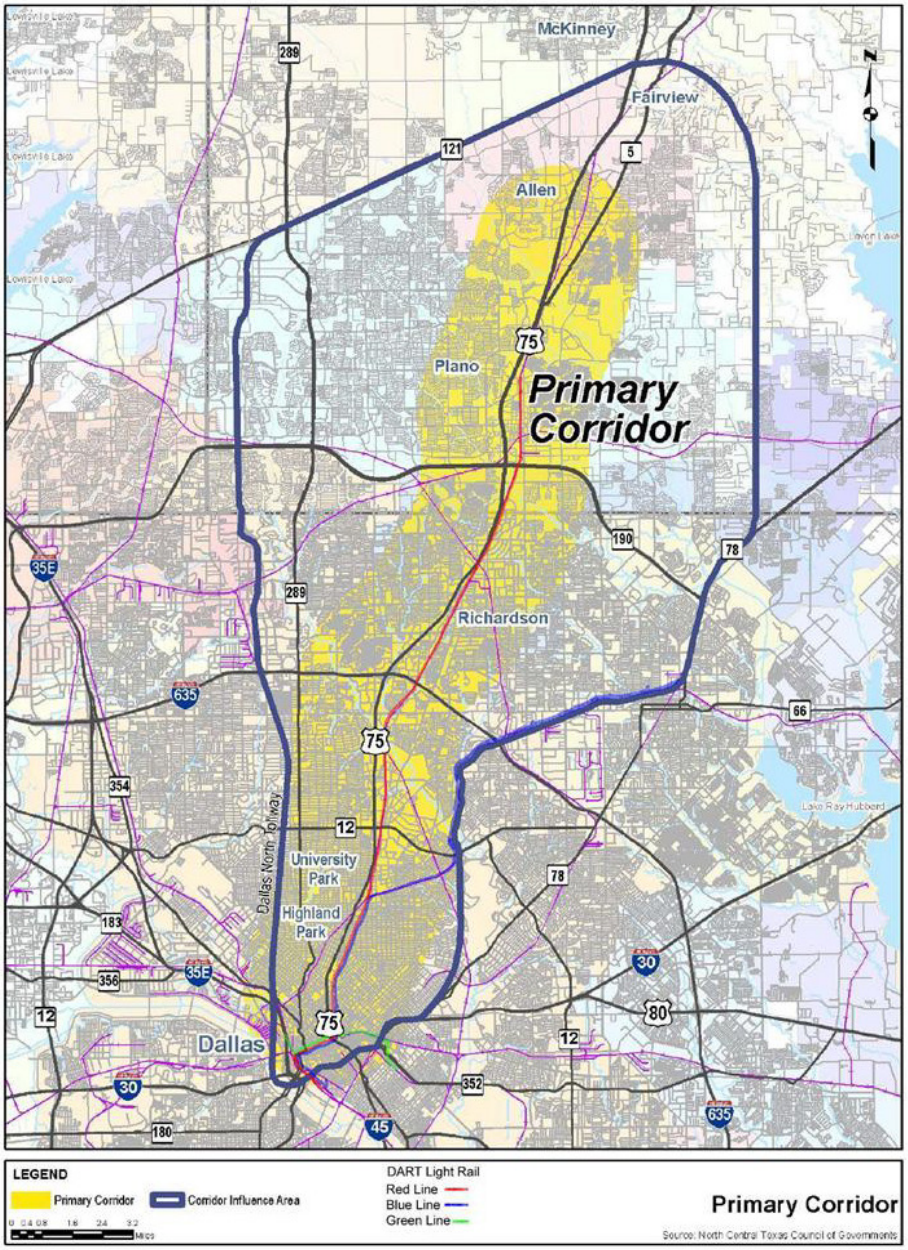
[2] Information in this section has been excerpted from "Integrated Corridor Management," published in the November/December 2010 edition of Public Roads magazine. The article was authored by Brian Cronin (RITA), Steve Mortensen (FTA), Robert Sheehan (FHWA), and Dale Thompson (FHWA). With the consent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

- Divert traffic to strategic arterials and frontage roads with improved, event-specific traffic signal timing response plans.
- Shift travelers to the light-rail system during major incidents on the freeway.



DART and their ICM partners, June 30, 2010

Figure 1-1. U.S. 75 Corridor Boundaries of Dallas ICM Deployment

Table 1-1. Dallas ICM Project Goals

Goal #1	Improve Incident Management • Provide a corridor-wide and integrated approach to the management of incidents, events, and emergencies that occur within the corridor or that otherwise impact the operation of the corridor, including planning, detection and verification, response and information sharing, such that the corridor returns back to "normal."
Goal #2	Enable Intermodal Travel Decisions • Provide travelers a holistic view of the corridor and its operation through the delivery of timely, accurate and reliable multimodal information, to allow travelers to make informed choices regarding departure time, mode and route of travel. In some instances, the information will recommend travelers to utilize a specific mode or network. Advertising and marketing to travelers over time will allow a greater understanding of the modes available to them.
Goal #3	Increase Corridor Throughput • Agencies within the corridor have worked to increase throughput on their individual networks from supply and operations points of view, and will continue to do so. The ICM perspective builds on these network initiatives, managing delays on a corridor basis, utilizing any spare capacity within the corridor, and coordinating the junctions and interfaces between networks in order to optimize the overall throughput of the corridor.
Goal #4	Improve Travel Time Reliability • The transportation agencies within the corridor have done much to increase the mobility and reliability of their individual networks, and will continue to do so. The integrated corridor perspective builds on these network initiatives, managing delays on a corridor basis, utilizing any spare capacity within the corridor, and coordinating the junctions and interfaces between networks, thereby providing a multimodal transportation system that adequately meets customer expectations for travel time predictability.

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Technology investments that are being implemented as part of the ICM deployment in Dallas 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 1-2 summarizes expected Dallas DSS functionality.
- Enhancement of the SmartNET regional information exchange network, a system that was recently implemented using non-ICM funding and which is being enhanced using ICM funding, including expanding the number of agencies able to exchange data through the system. SmartNET is a commercial data integration and dissemination tool with a common graphical user interface (GUI). SmartNet provides a conduit for input, fusion and shared, multi-agency access to a variety of transportation condition data.
- A 511 telephone and web-based traveler information system for the region.
- Development of new, event-specific traffic signal timing plans to support traffic diversions onto Greenville Avenue (termed the "Targeted Event Accelerated Response System," or TEARS).
- Arterial street monitoring system, including additional travel time detectors (Bluetooth).
- Using non-ICM funds, various supporting transit improvements including mobile data terminals and automatic vehicle location system replacement.
- Parking management systems for key park & ride lots.

Table 1-2. Summary of Dallas DSS Functionality

Functionality	Summary
Modularization of Response Plan Recommendation Functionality and Predictive Functionality	Dallas has explicitly separated the functionality required to select candidate response plans based on real-time conditions from the functionality associated with predicting future conditions. The former functionality resides in the Expert System DSS subsystem and the latter resides in the Prediction subsystem. These functions have been modularized so that the DSS will still be able to recommend response plans in the event that the mesoscopic traffic model used in the Prediction sub-system is not able to run faster than real-time, that is, to not only monitor current conditions but also to forecast conditions X minutes into the future. Dallas is anticipating their Predictive subsystem will ultimately be capable of running faster than real-time but they need to complete the design and testing phases of Stage 3. The decision to separate response plan selection functionality from prediction functionality was also based on prediction accuracy considerations. Another important part of the DSS Expert System module is the periodic (most likely monthly or if feasible every 2 weeks) post-review of action plans implemented and modifying them as needed.
Real-time Monitoring of Transportation System Conditions	The real-time data is collected by the ICMS Data Fusion subsystem. The Expert System subsystem of the Dallas DSS will monitor conditions from the Data Fusion subsystem in real-time and, based on key real-time system performance indicators, select one or more pre-defined, proposed response plans for consideration by the ICM Coordinator.
Prediction and Prioritization of Emerging Transportation System Problems	The Dallas ICMS will continuously monitor conditions. This will be augmented with the deployment of Bluetooth readers for a real-time arterial monitoring system. When events such as significant changes in demand, incidents (planned or not planned), or inclement weather occur, the Dallas DSS will initiate an analysis for possible operational strategies to improve corridor operation. The analysis of operational strategies is planned to include a prediction of future conditions under possible strategies. The Dallas ICMS is not currently planned to continuously predict future conditions. The Predictive subsystem is only executed as part of an evaluation of possible strategies. Although it is possible that the Dallas ICMS may be used in such a capacity at some point within or beyond the evaluation period, it is not an explicit design objective of the Dallas DSS to continuously predict conditions or anticipate developing problems. The Dallas ICMS, will however, have to account for multiple events occurring in the corridor and be able to prioritize which events need to be addressed or assess the interaction of strategies to different events.
Prediction of the Impact/Performance of Response Plans	The Prediction subsystem of the Dallas DSS will be capable of being used at regular time intervals or “on the fly” during an event to determine whether the net impacts/benefits of a candidate response plan recommended to the ICM Coordinator by the Expert System will be positive given current transportation system conditions and expected travel demand X minutes into the future. That is, prediction of the impacts of a response plan will be used in the decision of whether to recommend a candidate response plan by the Expert System. Further, if it is found that the Prediction subsystem is able to operate in faster-than-real-time mode—that is predict conditions X minutes into the future—the recommendation of response plans by the Expert System subsystem (and potentially the refinement or re-selection of response plans over the course of a long event) will incorporate predictions of transportation conditions and/or response plan impacts X minutes into the future.

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It is expected that the various Dallas 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. 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 system will be applied in at least the following general contexts and timeframes:

1. In "real time" (or near real time), in association with an unplanned event like a traffic incident.
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. These lasting changes may be 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 to other, non-ICM related changes such as regional travel demand.

1.2.2 Dallas ICM Deployment Schedule

Table 1-3 presents the latest, formal, U.S. DOT-approved Dallas ICM deployment schedule. As is often the case with large, complex technology deployments, it is quite possible that this schedule may slip over time. The schedule of data collection and analysis activities presented throughout this test plan reflect the latest schedule but they will be adjusted as necessary in response to any future changes in the deployment schedule.

As indicated in Table 1-3, individual components of the deployment will be completed in a phased manner, with full ICM system operations currently scheduled to commence in early April 2013. The Dallas 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 Dallas site team's utilization of them are expected to evolve as the ICM system design, implementation and shakedown period progress, the approach presented in this test plan may flex somewhat in response.

Table 1-3. Dallas ICM Deployment Schedule

Activity	Completion Date
Complete Planning Phase	December 2010
Complete Design Phase	February 2012
Build Phase (complete unit testing):	
Arterial Street Monitoring System	April 2012
Mobile Web	April 2013
511 Interactive Voice Response (phone)	
My 511 (Web)	
Social Networking	
Transit Signal Priority	August 2012
Event Specific Traffic Signal Timing Plans (Targeted Event Accelerated Response System)	September 2012
DART Data Portal	October 2012
Video Sharing	
SmartNET/Smart Fusion (including all integration of new ICM data) IT Infrastructure	
Decision Support System	November 2012
Complete Integration Testing	January 2013
Complete Acceptance Testing/Operations Go Live	April 8, 2013
Complete Shakedown Period	October 8, 2013
Complete Evaluation One Year Operational Period	October 7, 2014

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1.2.3 Comparison to the San Diego ICM Deployment

The overall objectives of the Dallas ICM deployment are similar to those in San Diego 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 Dallas U.S. 75 corridor includes the Red Line light rail transit (LRT) service whereas the I-15 corridor in San Diego will include extensive bus rapid transit (being implemented separately from and immediately prior to ICM).
- The Dallas U.S. 75 corridor includes concurrent flow HOV lanes whereas the San Diego corridor includes concurrent flow high-occupancy tolling (HOT)/managed 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 responsive traffic signal control. Dallas is not upgrading any traffic signal controllers, but has responsive traffic signal control along the major parallel arterial, Greenville Avenue, through the Cities of Dallas, Richardson and Plano. 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 1-4. 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 1-4. 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.

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* 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." Table 1-5 associates six of those seven analyses with specific U.S. DOT hypotheses; the seventh analysis not shown in Table 1-5 investigates institutional and organizational issues and relates to all of the hypotheses since the ability to achieve any intended ICM benefits depends upon successful institutional coordination and cooperation.

Table 1-5. 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 the 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

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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 1-2 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.

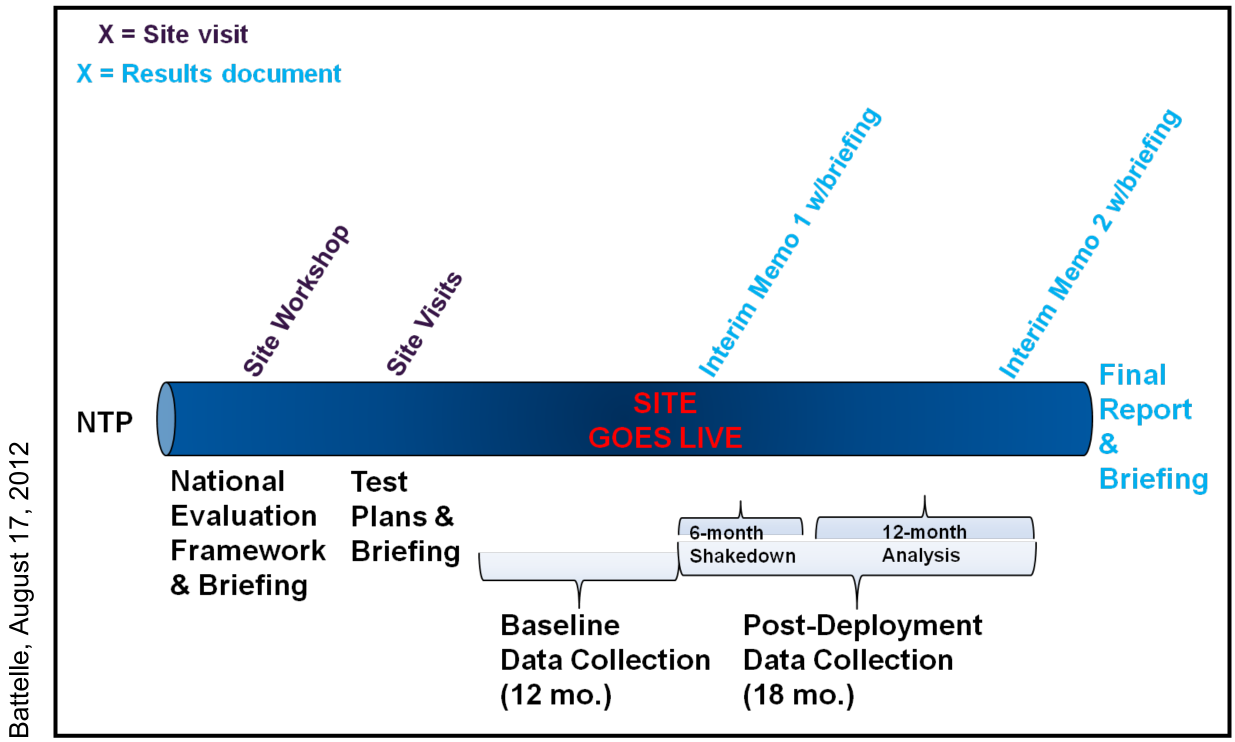

Figure 1-2. Sequence of Evaluation Activities

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

- Finalize test plans – Summer 2012
- Collect baseline (pre-ICM deployment) data – Spring 2012 through Spring 2013
- Complete Interim Technical Memorandum on baseline data – Spring 2013
- Collect post-deployment data – Summer 2013 – Fall 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 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 national evaluation team as well as the Volpe Center and the Dallas 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 Dallas 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 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. In the case of Dallas, the Dallas site team will execute the model runs that will generate the performance measures provided by Cambridge Systematics.

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, Transportation Management Center (TMC) and adjoining corridor agency operators (hereafter referred to as “operators”) surveys and interviews.

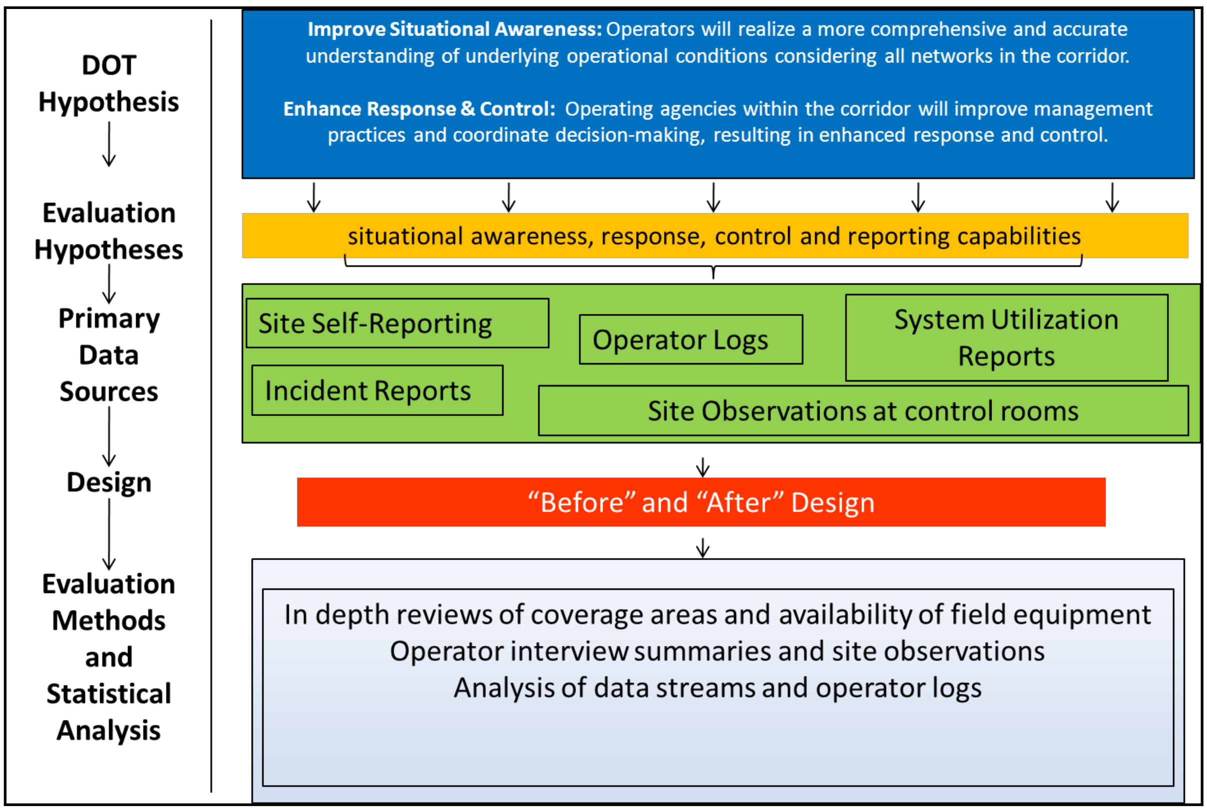

Figure 2-1. Overview of Technical Capability Analysis

Battelle, August 17, 2012

2.1 Hypotheses, Data and Measures of Effectiveness

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.
	ICM will improve operator's ability to facilitate cross-network and modal shifts.
	Improved sharing of construction and maintenance scheduling information among agencies will reduce 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 in the corridor.
	Operators will realize a better and continuous understanding of available system resources and conditions through ICM.
	Data from ICM system will be perceived as high-quality and actionable by the system operators.

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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 (SmartNET) database. The qualitative data elements will be obtained from manually distributed surveys that will track transportation operations staff impressions. 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'[3] DMS messages posted (outside of normal recurring messages such as travel time)	Changes in the number of 'unique' DMS messages executed in response to incidents and other corridor conditions (freeway, tollway and arterial) – may have to be a sampling	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[4]	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 to the pubic received in under 5 minutes from incident identification (across all modes), pre- and post-ICM deployment from the DalTrans TMC	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 SmartNET	Change in the number of incidents being logged into the ICMS from all users	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 all lanes to full operational status, pre- and post-ICM deployment[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 Number of instances (events, not space counts) where parking lot capacity was added when transit parking was deemed at or near capacity.	Change in number of instances where parking lot capacity was added	ICM will improve operator's ability to facilitate cross-network and modal shifts.
1. System Data	1.7 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	Improved data sharing (both real-time data and video) will provide operators with better understanding of mobility conditions in the corridor.

[3] 'Unique' DMS messages will be filtered out of the DMS message log retrieved from SmartNET, identifying event-specific messages that are displayed (e.g., accident ahead, road flooded, etc.) from generic messages (e.g., travel times, safety messages, etc). Only 'unique' DMS messages will be quantified for this MOE.

[4] It is possible that the site may decide not to post travel times of any sort, which would prove this data element to be moot based on the decision made.

[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	1.8 Volume of other traveler information disseminated by telephone, Internet (including transit trip planner), third parties, other media, and social media	Change in the frequency of traveler information being disseminated via telephone (511), internet (including transit trip planner), third parties, and other social media as a result of ICM deployment	Post-ICM, agencies will be able to report corridor conditions in a more timely and actionable manner to travelers.
1. System Data	1.9 Number of centerline miles on arterials with real-time (e.g., active incident) information provided to transportation operators	Change in number of centerline miles of real time arterial information being provided to the transportation operaters pre- and post-ICM deployment	Improved data sharing (both real-time data and video) will provide operators with better understanding of mobility conditions in the corridor.
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 to increase throughput during events	Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.
2. Arterial Data	2.2 Number of active transit signal priority calls (calls per hour)	Change in frequency of active transit signal priority calls	ICM will improve operator's ability to facilitate cross-network and modal shifts.
3. Transit Data	3.1 Number of instances when HOV restrictions were altered	Change in number and duration of instances when HOV lane restrictions were altered	ICM will improve operator's ability to facilitate cross-network and modal shifts.
3. Transit Data	3.2 Number of instances of LRT transit capacity additions	Change in number of instances when temporary (real-time) transit capacity was added	ICM will improve operator's ability to facilitate cross-network and modal shifts.
3. Transit Data	3.3 Time from receiving notification to increased transit capacity	Change in time for DART from receiving notification to increased transit capacity	ICM will improve operator's ability to facilitate cross-network and modal shifts.
3. Transit Data	3.4 Number of parking lots with real-time information	Change in availability of real-time parking lot information, pre- and post-ICM deployment	Operators will realize a better and continuous understanding of available system resources and conditions through ICM.

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

Data Element		MOE	Evaluation Hypotheses
Qualitative Data			
4. Operator Surveys	4.1 Perceptions of 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 ICM system will be perceived as high-quality and actionable by the system operators.
4. Operator Surveys	4.2 Perceptions of 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.
4. Operator Surveys	4.3 Perceptions of operators relative to intervention in altering recommended responses	Level of TMC operator intervention in altering recommended responses	Data from ICM system will be perceived as high-quality and actionable by the system operators.
4. Operator Surveys	4.4 Perceptions of operators relative to capability to monitor and report effectively on the system resources	Change in perceptions of capability to monitor and report effectively on the system resources in the corridor (e.g., road, LRT, ITS equipment)	Data from ICM system will be perceived as high-quality and actionable by the system operators.
4. Operator Surveys	4.5 TMC operator satisfaction levels with inter-organizational coordination	Change in level of 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.
4. Operator Surveys	4.6 Perceptions of 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 reduce the number of instances of simultaneous projects on roads which serve as alternate routes to each other.
5. ICM Operations Committee Surveys	5.1 Perceptions of ICM Operations Committee – relative to incident response plans implemented (**post ICM Deployment only**)	Change in perceived effectiveness of coordinated incident response plans implemented (**post ICM Deployment only**)	Improved intra-agency communications and data sharing will result in quicker response and clearance time for incidents.
5. ICM Operations Committee Surveys	5.2 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.

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

Data Element		MOE	Evaluation Hypotheses
Qualitative Data (Cont.)			
6. ICM Coordinator Survey	6.1 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 reduce the number of instances of simultaneous projects on roads which serve as alternate routes to each other.
6. ICM Coordinator Survey	6.2 Number of times the ICM Coordinator 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 ICM Coordinator has requested additional resources (not available to DART and TxDOT) from the corridor stakeholders based on DSS recommendations	ICM will improve operator's ability to facilitate cross-network and modal shifts.
6. ICM Coordinator Survey	6.3 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.
6. ICM Coordinator Survey	6.4 Bus and LRT routes providing real-time information	Change in the number of transit (bus, LRT) 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.
6. ICM Coordinator Survey	6.5 Number of incident related data feeds available to corridor stakeholder agencies (i.e., CAD, ICMS, etc.)	Change in number of incident data feeds available to each individual agency before and after ICM	Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.
6. ICM Coordinator Survey	6.6 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.
7. Commercial Traveler Information Provider Interviews	7.1 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.

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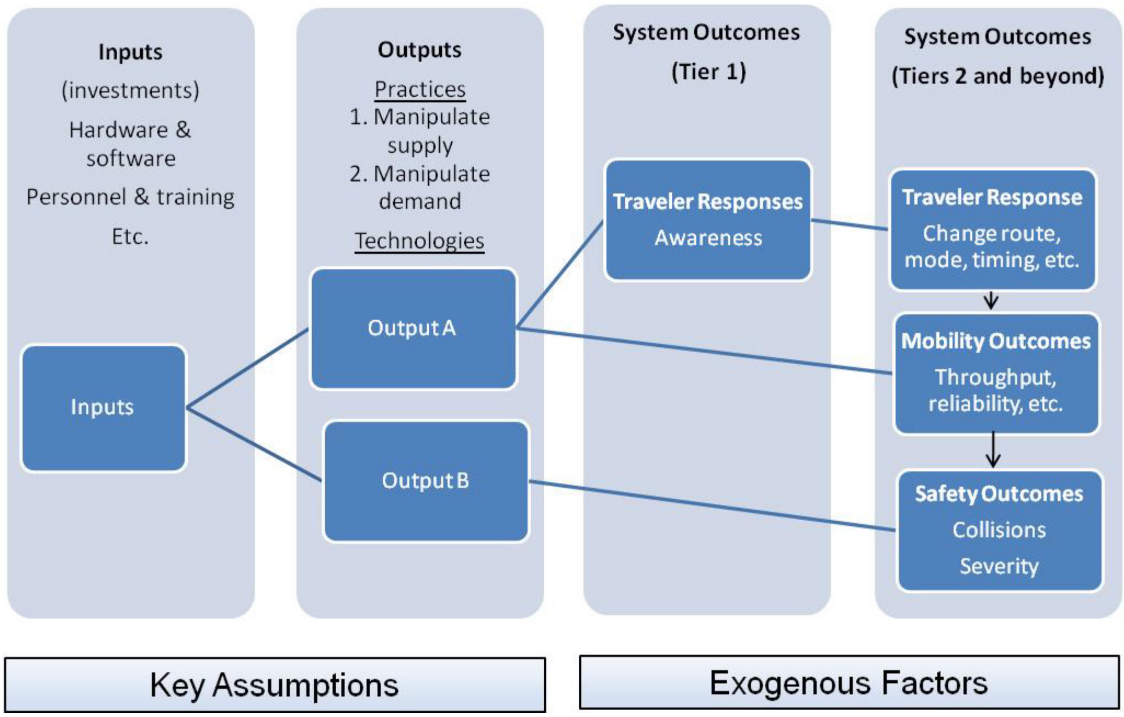
Typically, a test plan such as this one would be drafted after examining samples of most of the required system data. This was not possible in this case because SmartNET, the central collection point for all system data elements, is currently under development. Rather, this test plan reflects discussions between the national evaluation team and the Dallas site team and the national evaluation team's review of the Dallas draft design documentation. During 2012 the national evaluation team expects to begin receiving actual ICM system data and will be able to verify data format and content and adjust if necessary. No significant adjustments are expected.

2.2 Technical Capability Evaluation MOEs and the Logic Model

As noted in section 1.3.2, the ICM evaluation utilizes the "Logic Model" construct for categorizing various evaluation measures of effectiveness and understanding the causal (and typically sequential) relationships among those measures. The logic model categorizes impact MOEs as either "outputs" or "outcomes." Outputs are what the ICM investments ("inputs") generate directly—such as traffic data generated by a new sensor—or which are generated by the system operators using the ICM investments, such as more coordinated responses to incidents or congestion. Outcomes describe the impact of the ICM investments (and the outputs generated by and through those investments) on travelers, the transportation system, and the environment.
In the same way that outcomes are dependent upon preceding investments and outputs, there are causal relationships or dependencies among outcomes. For example, as symbolized by the "tiers" in Figure 2-2, although some transportation system impacts such as mobility or safety may be influenced directly by outputs (e.g., changes in traffic signal timing plans) many of them are at least partially dependent on traveler responses to the ICM system and system operators' actions (inputs and outputs). Finally, as shown in Figure 2-2, there are causal, sequential relationships within the outcome category of "traveler response." That is, changes in traveler behavior based on enhanced ICM traveler information are dependent on the travelers first being aware of the traveler information. In the larger sense, these are still "outcomes"—travelers' awareness and consultation of ICM-enhanced traveler information is certainly an outcome of the ICM system operators' generation and dissemination of that information (outputs)—but within the traveler response tier awareness and use can be seen as a necessary precedents to changes in traveler behavior based on the enhanced traveler information.



Battelle, August 17, 2012

Figure 2-2. The Evaluation Logic Model

The various traveler response MOEs presented in Table 2-2 and used in this Technical Capability Analysis are all, strictly speaking, output MOEs that focus on how the ICM investments operate and are utilized by transportation system operators. Most outcome MOEs are captured in the Traveler Response and Corridor Performance Analyses.

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 data characteristics are discussed in the sections that follow. As requested by the Dallas site team, all data will be coordinated through Dr. Siamak Ardekani of the University of Texas at Arlington.

3.1 System Data

As indicated in Table 3-1, most of the system data will be available via the SmartNET portion of the Dallas ICM system, depicted in Figure 3-1, through the University of Maryland (UMD) data repository. Generally, these data will capture how the ICM Coordinator and operators utilized the ICM tools to monitor, control and report (to agencies and travelers/travel information providers) on ICM corridor conditions. SmartNET system data will be collected by the national evaluation team as part of a real-time, continuous data feed from SmartNET to the UMD ICM national evaluation data repository. Further details for how SmartNET data will be collected are discussed in the DSS Analysis Test Plan.

The Dallas site team's implementation schedule (see Table 1-3) shows SmartNET fully operational—with all new ICM data integrated—by approximately mid-way through the baseline evaluation year, in October 2012. However, based on conversations with the Dallas site team, it is the impression of the national evaluation team that the data required for this analysis will start to be entered into SmartNET well before then. As such, this test plan indicates that both baseline and post-deployment data will be drawn from SmartNET.

The specific data collection source is less certain for system data element 1.7—information capturing how ICM impacts the amount and quality (content richness, e.g., accuracy, specificity, temporal coverage, geographic coverage) of information provided to travelers through various outlets (511 telephone and website, etc.). As reflected in Table 3-1, the local partners have indicated that Dr. Ardekani of the University of Texas at Arlington will provide this data to the national evaluation.

Each system data element will be collected and analyzed during the entirety of the pre- (April 2012 – April 2013) and post- (October, 2013 – October 2014) ICMS deployment periods. System data will also be collected during the shakedown period from April 2013 – October 2013.

Table 3-1. Quantitative Data Summary

Data Element	Location	Data Source	Data Collection Frequency	Data Collection Period (pre-/post-)[6] Start	Data Collection Period (pre-/post-)[6] End	Data Collection Responsible Party	Data Transmittal
System Data							
1.1 Number of 'unique' DMS messages posted (outside of normal recurring messages such as travel time)	Entire ICM Corridor (see Figure 1-1)[7]	ICMS	Continuous	April 2012	Oct 2014	ICMS Data Hub	Continuous (University of Maryland [UMD] Data Feed)
1.2 DMS Travel time update messaging[8]	Entire ICM Corridor (see Figure 1-1)	ICMS	Continuous	April 2012	Oct 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.3 Incident notification times	Entire ICM Corridor (see Figure 1-1)	ICMS	Continuous	April 2012	Oct 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.4 Number of Incident records logged into ICMS	Entire ICM Corridor (see Figure 1-1)	ICMS	Continuous	April 2012	Oct 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.5 Roadway clearance times	Entire ICM Corridor (see Figure 1-1)	ICMS	Continuous	April 2012	Oct 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.6 Number of instances (events, not space counts) where parking lot capacity was added	Entire ICM Corridor (see Figure 1-1)	ICMS	Continuous	April 2012	Oct 2014	ICMS Data Hub	Continuous (UMD Data Feed)

[6] Data will be collected from the start of the pre-deployment and through the entirety of the post-deployment period, including the six months of "shakedown" period data (April-September 2013). The purpose of collecting the shakedown period data is to verify data collection, transmittal and archival processes; it is not expected that the shakedown data will be formally evaluated.

[7] For the purpose of this analysis, the "entire ICM corridor" will consist of the U.S. 75 corridor in the Northeast portion of the region. The corridor includes the high capacity vehicle lanes in the U.S. 75 freeway, extensive frontage roads, parallel arterial streets and light rail transit and bus services.

[8] It is possible that the site may decide not to post travel times of any sort, which would prove this data element to be moot based on the decision made.

Table 3-1. Quantitative Data Summary (Continued)

Data Element	Location	Data Source	Data Collection Frequency	Data Collection Period (pre-/post-)[6] Start	Data Collection Period (pre-/post-)[6] End	Data Collection Responsible Party	Data Transmittal
System Data (Cont.)							
1.7 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)	ICMS	Continuous	April 2012	Oct 2014	ICMS Data Hub	Continuous (UMD Data Feed)
1.8 Volume of other traveler information disseminated by telephone (511), Internet (including transit trip planner), and social media	Entire ICM Corridor (see Figure 1-1)	Dr. Ardekani will facilitate the relay of information from third party sources	Continuous	April 2012	Oct 2014	The University of Texas at Arlington	Monthly
1.9 Number of centerline miles on arterials with real time information being provided to transportation operators	Entire ICM Corridor (see Figure 1-1)	ICMS	Continuous	April 2012	Oct 2014	ICMS Data Hub	Continuous (UMD Data Feed)

Table 3-1. Quantitative Data Summary (Continued)

Data Element	Location	Data Source	Data Collection Frequency	Data Collection Period (pre-/post-)[6] Start	Data Collection Period (pre-/post-)[6] End	Data Collection Responsible Party	Data Transmittal
Arterial Data							
2.1 Instances of coordinated timing plan changes[9]	Entire ICM Corridor's strategic diversion routes	Dr. Ardekani will facilitate the relay of information from third party sources (local agencies bordering the corridor)	Continuous	April 2012	Oct 2014	The University of Texas at Arlington (Dr. Ardekani will facilitate the relay of information from third party sources, i.e., local agencies bordering the corridor)	Monthly
2.2 Number of active transit signal priority calls (calls per hour)[3]	Entire ICM Corridor's strategic diversion routes	Dr. Ardekani will facilitate the relay of information from third party sources	Continuous	April 2012	Oct 2014	The University of Texas at Arlington (Dr. Ardekani will facilitate the relay of information from third party sources)	Monthly
Transit Data							
3.1 Number of instances when HOV restrictions were altered	Entire ICM Corridor (see Figure 1-1)	DART	Continuous	Nov 1, 2011 May 1, 2013	Nov 1, 2012 May 1, 2014	The University of Texas at Arlington (from DART)	Monthly
3.2 Number of instances of transit capacity additions	Entire ICM Corridor (see Figure 1-1)	DART	Continuous	Nov 1, 2011 May 1, 2013	Nov 1, 2012 May 1, 2014	The University of Texas at Arlington (from DART)	Monthly
3.3 Time to notification to increased transit capacity	Entire ICM Corridor (see Figure 1-1)	DART	Continuous	Nov 1, 2011 May 1, 2013	Nov 1, 2012 May 1, 2014	The University of Texas at Arlington (from DART)	Monthly
3.4 Number of parking lots with real time information	Entire ICM Corridor (see Figure 1-1)	DART	Continuous	Nov 1, 2011 May 1, 2013	Nov 1, 2012 May 1, 2014	The University of Texas at Arlington (from DART)	Monthly

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[9] After review of the draft version of this test plan by the Dallas Site Team, it was decided that the Evaluation Team should not remove this Data Element or MOE; however, until the site completes more of the ICM design, it cannot be definitively determined whether these data can be captured.

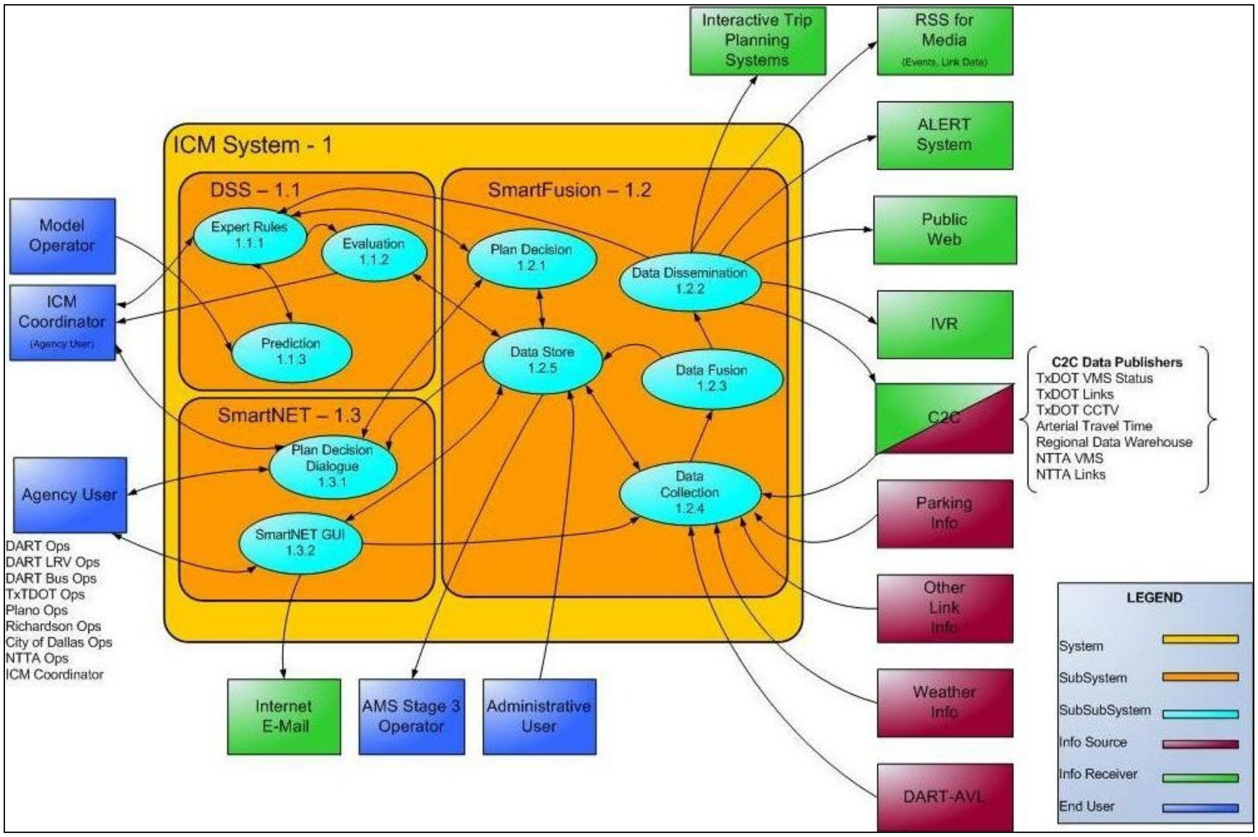

Figure 3-1. Quantitative ICMS Architecture – Dallas

3.2 Arterial Data

A second major category of quantitative evaluation data is data pertaining to arterial streets—traffic signal systems in particular[10]. It is the national evaluation team's understanding that this data may, at some point, reside within SmartNET or SmartFusion (the data engine portion of the Dallas ICM system) 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. Those organizations consist of TxDOT and the municipalities of Dallas, Highland Park, Plano, Richardson and University Park. It is the understanding of the national evaluation team that the University of Texas at Arlington will gather this data and provide it to the national evaluation team. These data will be collected for the entirety of the pre- and post-ICM evaluation periods.

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[10] This statement relates to the data and MOEs associated with elements 2.1 and 2.2, found in table 2-2 on page 2-3.

- 2.1 – Change in the number of instances that arterial signal timing was altered to increase throughput during events.
- 2.2 – Change in frequency of active transit signal priority calls.

3.3 Transit Data

The remaining quantitative data to be used in this analysis—data elements 3.1 through 3.4 in Table 2-2—pertain to transit or HOV lane operations. This data will be provided to the national evaluation team by DART and will provide evidence of any improvements realized in the ICM agencies' ability to take actions to facilitate travel shifts from networks/modes, e.g., from U.S. 75 to LRT. These data also include information that will document the Dallas site team's improved ability to provide park & ride availability data to operators and travelers. The specific formats of these data and the details of how DART will provide them to the national evaluation team are not yet clear. These data will be collected for the entirety of the pre- and post-ICM evaluation periods, recognizing that in some cases the pre-ICM MOE will be zero/none.

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 operators (surveys to be distributed and returned by the DalTrans TMC Operations Manager and key representatives from the local municipalities), the ICM Coordinator (surveys), the DSS Evaluation Subsystem Subcommittee/Operations Committee (surveys), and commercial traveler information providers (interviews). As requested by the Dallas site team, all information gathering to take place at the Transportation Management Center (DART and TxDOT staff) and the local municipalities will be coordinated through Dr. Christopher Poe of Texas Transportation Institute. 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.

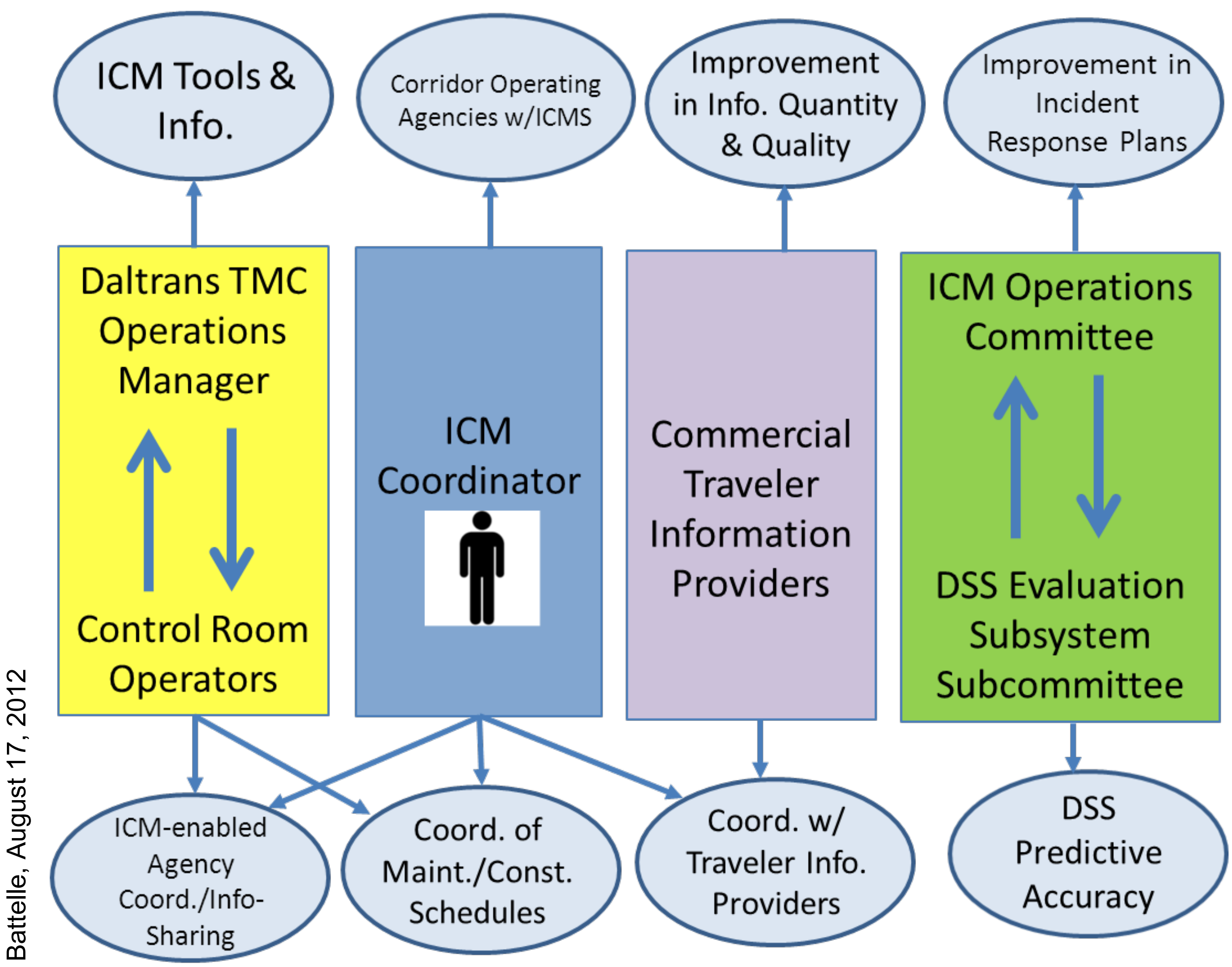

Figure 4-1. Qualitative Evaluation Data Collection Summary

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	August 2012 December 2012 Immediately following several case study events	Nov 2013 (end of shakedown) Feb 2014 (mid-post) June 2014 (late-post) Immediately following several case study events (pulse surveys)	National Evaluation Team via DalTrans TMC Operations Managers	Completed Surveys sent to National Evaluation Team
ICM Operations Committee Survey		X	N/A	Nov 2013 Feb 2014 June 2014 Sept 2014 Immediately following several case study events (pulse surveys)	National Evaluation Team via ICM Operations Committee Chair	Completed Surveys sent to National Evaluation Team
ICM Coordinator Survey	X	X	Either once (July 2012) or Quarterly depending on specific question	Either twice (July 2013 & July 2014) or Quarterly depending on specific question	National Evaluation Team	Completed Surveys sent to National Evaluation Team
Commercial Traveler Info. Provider Interviews		X	N/A	Feb 2014 (mid-post) July 2014 (late-post)	National Evaluation Team	Contact names for Interviewees (Email to National Evaluation Team from Dallas site team)

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4.1 TMC Operator Surveys

4.1.1 Purpose

Operators are the individuals responsible for monitoring corridor conditions, reporting information to agencies and travelers, 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 TXDOT and DART TMC and local municipality operators located on the U.S. 75 corridor, as shown in Table 4-2. The national evaluation team will provide the survey questionnaires to the Dallas site team lead (Dr. Christopher Poe) who will forward it to the relevant Operations Managers who will be responsible for the distribution of the survey and collecting the results that will be provided back to the national evaluation team (thus the two way arrows between the managers and individual operators in Figure 4-1).

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

Involved Parties	Operator Agency	Tentative Survey Participants
Operators at DalTrans TMC	TXDOT	TBD – Andy Oberlander to distribute
	DART	TBD – Koorosh Olyai to distribute
Municipal TMC Operators located adjacent to the corridor	City of Dallas	Ron Patel
	City of Richardson	Robert Saylor
	City of Plano	Lloyd Neal

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Survey questionnaires will be distributed during the baseline and post-deployment periods multiple times, on a 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, Traveler Response, and DSS 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 (collected through this and the DSS Analysis Test Plan) 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 in 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 about August 2012, and the second period will be late in the baseline, about December 2012. The survey will be conducted three times on a set schedule during the post-deployment period: once at the end of the shakedown (about November 2013); once near the middle of the post-deployment period (about February 2014); and once near the end of the post-deployment period (about June 2014).

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 distributed and completed within a week of the event in question. The determination of which incidents or events will be the subject of the pulse surveys will be made by the Volpe Center, who will administer the traveler pulse surveys. The national evaluation team's understanding is that the Volpe Center will alert the Battelle evaluation team when they are planning to administer a traveler pulse survey so that the Battelle evaluation team can administer their ICM agency-related pulse surveys in this Technical Capability Analysis and the DSS Analysis.

4.1.3 Questionnaire

The survey will be presented in a simple document to all of the operators (to include the corridor operating agency operators), with the results being tabulated by the national evaluation team. As shown in Table 4-3, survey questions will utilize a 5-option, Likert response categories which will facilitate the tabulation and quantitative analysis of responses. The questions presented in Table 4-3 are preliminary and 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 Dallas site team so as to make the questions as clear and meaningful to the operators as possible. Also to be added in the questionnaire design is the inclusion of open 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 Operator Survey Questions

Question (Numbers Reference Data Elements from Table 2-2)	Response Options
4.1a 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
4.1b Considering unusually congested traffic conditions, such as during major incidents, please rate the usefulness of the real-time transportation information available to in supporting your decisions.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
4.2a Considering normal peak hour conditions, please rate the usefulness of the information you (the operator) provide to travelers to support their trip-making decisions.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
4.2b 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.	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
4.3a 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. (**Post DSS Deployment Question – ONLY**)	(1) Very good (2) Good (3) Neither good nor bad (4) Poor (5) Very poor
4.3b 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
4.4a 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

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

Question (Numbers Reference Data Elements from Table 2-2)	Response Options
4.4b 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
4.5a 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
4.5b 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
4.6 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

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4.2 ICM Operations Committee Survey

4.2.1 Purpose

The ICM Operations Committee is composed of representatives from a number of corridor stakeholder agencies 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. ICM Operations Committee members are shown in Table 4-4.

Table 4-4. ICM Operations Committee Members

Agency	ICM Operations Committee Member
DART	Koorosh Olyai
	Ravi Gundimeda
	Larry Gaul
	Tim Newby
TXDOT	Andy Oberlander
	Rick Cortez
City of Dallas	Ron Patel
City of Richardson	Robert Saylor
City of Plano	Lloyd Neal
MPO	Marian Thompson
NTTA	Yang Ouyang

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4.2.2 Approach

The national evaluation team will e-mail a survey questionnaire to Dr. Christopher Poe (TTI) who will distribute the surveys to members of the committee, collect their responses and send back the completed survey questionnaires to the Technical Capability Analysis evaluation lead. Surveys will be administered quarterly and during the same few event case studies (pulse surveys) described in Section 4.1.2 (pertaining to the TMC operator surveys). As with the TMC operator surveys, the quarterly questionnaires will focus on general perceptions over a period of a few months and the event case study pulse surveys will focus on the specific events.

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 Dallas site team so as to make the questions as clear and meaningful to the committee members as possible.

Table 4-5. Preliminary ICM Operations Committee Survey Questions

Question (Numbers Reference Data Elements from Table 2-2)	Response Options
5.1a 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
5.1b 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
5.2 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

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4.3 ICM Coordinator Survey

4.3.1 Purpose

The ICM Coordinator will be stationed at the DalTrans TMC and work cooperatively with the DART, TxDOT TMC, and corridor operating agency transportation operators. This position is responsible for the TMC's utilization of ICMS principles in the response to incidents. The ICM Coordinator will evaluate the DSS-generated response plans, decide which if any to pass along to specific transportation operators for implementation, and relay those recommendations to the operators. The purpose of the survey of the ICM coordinator 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.

4.3.2 Approach

The ICM Coordinator, Ravi Gundimeda will be surveyed once during the baseline period, in about July 2012. That survey will focus only quantitative, factual transportation system information such as the number of U.S. 75 corridor agencies sharing video feeds with one another. During the post-deployment period, the ICM Coordinator will be surveyed twice regarding quantitative, factual transportation system information: once near the end of the shakedown period (about July 2013) and once near the end of the one-year post-deployment period (about July 2014). The ICM Coordinator 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. The national evaluation team will email the survey questionnaire to the Dallas site team lead (Dr. Christopher Poe), who will review it and forwarded it to the ICM Coordinator. The ICM Coordinator will complete the questionnaire and return it to the national evaluation team.

4.3.3 Questionnaire

Table 4-6 presents the proposed ICM Coordinator 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. Preliminary ICM Coordinator Survey Questions

Question Type	Questions (Numbers refer to data element numbers in Table 2-1)
Perceptual Questions on ICM Tool and Information Utilization	6.1 Over the last 3 months, how many construction/maintenance events have shifted as a result of shared information between agencies?
	6.2 Over the last 3 months, how many times has the TMC requested additional corridor resources based on incident response plan (DSS and otherwise) recommendations?
Quantitative/Factual Transportation System Questions	6.3 What is currently the number of agencies sharing video feeds along the US75 ICM corridor?
	6.4 How many transit (LRT) routes in the corridor provide real time info to ICMS (vehicle location, LRT vehicle capacity, and schedule adherence)?
	6.5 Number of incident related data feeds available to corridor stakeholder agencies?
	6.6 Number of agencies using a common incident report system?

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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 U.S. 75 corridor public agencies, post-ICM deployment. Along with travelers themselves, the media and other traveler information providers 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 (around February 2014) and again near the end (around July 2014). The Dallas site team has requested that baseline interviews not be conducted so as to avoid creating unwanted publicity that may challenge the deployment.

The specific interviewees will be finalized in consultation with the Dallas team, a tentative list has been provided by the Dallas site team in Table 4-7. 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 Dallas area at the time of the interviews.

Table 4-7. Potential Commercial Traveler Information Providers from which to Seek Interviewees

Involved Parties	Agency or Company of Potential Interviewees
Local Commercial Traveler Information Providers	Metro Networks NAVTEQ
Local Television Stations	CH 4 (Fox) CH 5 (NBC) CH 8 (ABC) CH 11 (CBS) CH 23 (Univision) CH 33 (Tribune)

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4.4.3 Questionnaire

Interview questions will be e-mailed to interviewees in advance. The questionnaire will be finalized in consultation with the Dallas 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 extent to which the information is sufficient to support travelers' decisions about the timing, route and mode of their trip; that is, how "actionable" is the information?

d. 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, LRT lines)?

e. 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 U.S. 75 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?

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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.

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 such as opening temporary, supplemental LRT station parking or responding more quickly and effectively to traffic incidents. This portion of the analysis will test the following three evaluation hypotheses that serve as the derivatives of the U.S. DOT ICM Hypotheses defined on page 1-11:

- Improved intra-agency communications and data sharing will result in more timely notification and validation of incidents in the corridor.
- ICM will improve operator's ability to facilitate cross-network and modal shifts.
- Improved sharing of construction and maintenance scheduling information among agencies will reduce the number of instances of simultaneous projects on roads which serve as alternate routes to another.

A variety of quantitative and qualitative data will be considered. Quantitative data will come from SmartNET, from agencies responsible for operating traffic signal systems, and from DART. 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 SmartNET and other Dallas 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 Dallas 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 TMC operator surveys, ICM Committee surveys and ICM coordinator 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, tabulated and reported on; 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. 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 (DMS) postings and the change in the volume and/or content of traveler information disseminated through other channels, such as 511 telephone and website. The national evaluation team will parse through the SmartNET 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: TMC 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, cameras, and parking spaces. 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 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 include SmartNET and DART system data. Qualitative data consists of results from the TMC operator and ICM Coordinator 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.

- **TMC operator turnover** 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 TMC operator performance will also be considered through interfacing with the TMC operator's immediate supervisor, providing the national evaluation team with a sense as to whether the TMC operator will make a dependable, knowledgeable and willing participant in the evaluation.
- **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.

5.5 Application of the Logic Model

Overall conclusions regarding technical capability will be based on consideration of not only the results associated with each of the MOEs collected and analyzed through this test plan but will also take into consideration the "input" (ICM investments) findings that will be gleaned from throughout the evaluation, especially the Institutional and Organizational Analysis. For example, in any cases where it may be found that the Dallas ICM system did not generate the expected outputs related to monitoring, controlling and reporting, these findings will be compared against the documentation of ICM investments to understand the extent to whether and how the investments were made influenced the ultimate generation of outputs, or lack thereof. That is, this analysis will seek to understand why the various output results were observed and that will include consideration of the inputs (investments).

In this way, this Technical Capability and other evaluation analyses will utilize the inherent power of the logic model to help explain findings (e.g., whether they are related to ICM or not and the specifics ICM strategies to which they are related) based on the overall pattern of findings along the length of the logic model. Table 5-1 illustrates, at a conceptual level, this notion of how specific combinations of input, output and outcome findings from across the logic model and from across the evaluation can aid in understanding various ICM strategies as well as understanding the potential influence of exogenous factors.

Table 5-1. Interpreting Results from Across the Logic Model

Strategy	Evaluation Results: Input	Evaluation Results: Output	Evaluation Results: Outcome	Outcome Linked Only to this Strategy?	Conclusion
A	+	+	+	Yes	Strategy responsible for all ICM-related impacts but exogenous factors may also have contributed
B	-	-	+	Yes	ICM not responsible for impact because investment not made; exogenous factors responsible for outcomes
C	+	+	-	No	ICM not responsible for impact because practices and technologies did not translate to traveler behavior and/or capacity changes OR exogenous factors obscured impact
D	+	+	+	No	Strategy responsible for at least some impacts (other strategies and/or exogenous factors also possible)

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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 Dallas site team to definitively identify data sources, formats and limitations.

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