Integrated Corridor Management Initiative: Demonstration Phase Evaluation

Dallas Traveler Response Analysis Test Plan

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16. Abstract

This report presents the test plan for conducting the Traveler Response 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/event 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/events, 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 Traveler Response Analysis Test Plan is based on the ICM Initiative Demonstration National Evaluation Framework. This test plan provides an overview of the traveler response analysis and describes the specific survey, information usage, and network performance 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 Signs
DSS	Decision Support Systems
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GLM	General Linear models
GP	General Purpose
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
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 Traveler Response 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 traveler surveys, administered by the John A. Volpe National Transportation System Center (Volpe Center) and their survey contractor, will be analyzed and reported by the national evaluation team and constitute a very large and important proportion of the overall Traveler Response Analysis. This test plan includes the most comprehensive information currently available from the Volpe Center on the traveler survey. However, as the Volpe Center has not yet completed their development of the survey, this test plan omits certain details—such as the full survey questionnaires—that would typically be included in a test plan. Such details will be available in the Volpe Center methodology plan.

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 Traveler Response Analysis overall. Chapter 3 describes the traveler survey data utilized in this analysis and Chapter 4 describes the traveler information usage and network performance data. Chapter 5 describes the data analysis approach. Chapter 6 presents the risks and mitigations associated with traveler response 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.

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[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.

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.

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:

- <u>Phase 1: Foundational Research</u> – This phase researched the current state of corridor management in the United States as well as ICM-like practices around the world; conducted initial feasibility research; and developed of technical guidance documents, including a general ICM concept of operations to help sites develop their own ICM concept of operations.
- <u>Phase 2: Corridor Tools, Strategies and Integration</u> – 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.
- <u>Phase 3: Corridor Site Development, Analysis and Demonstration</u> – 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.

[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.

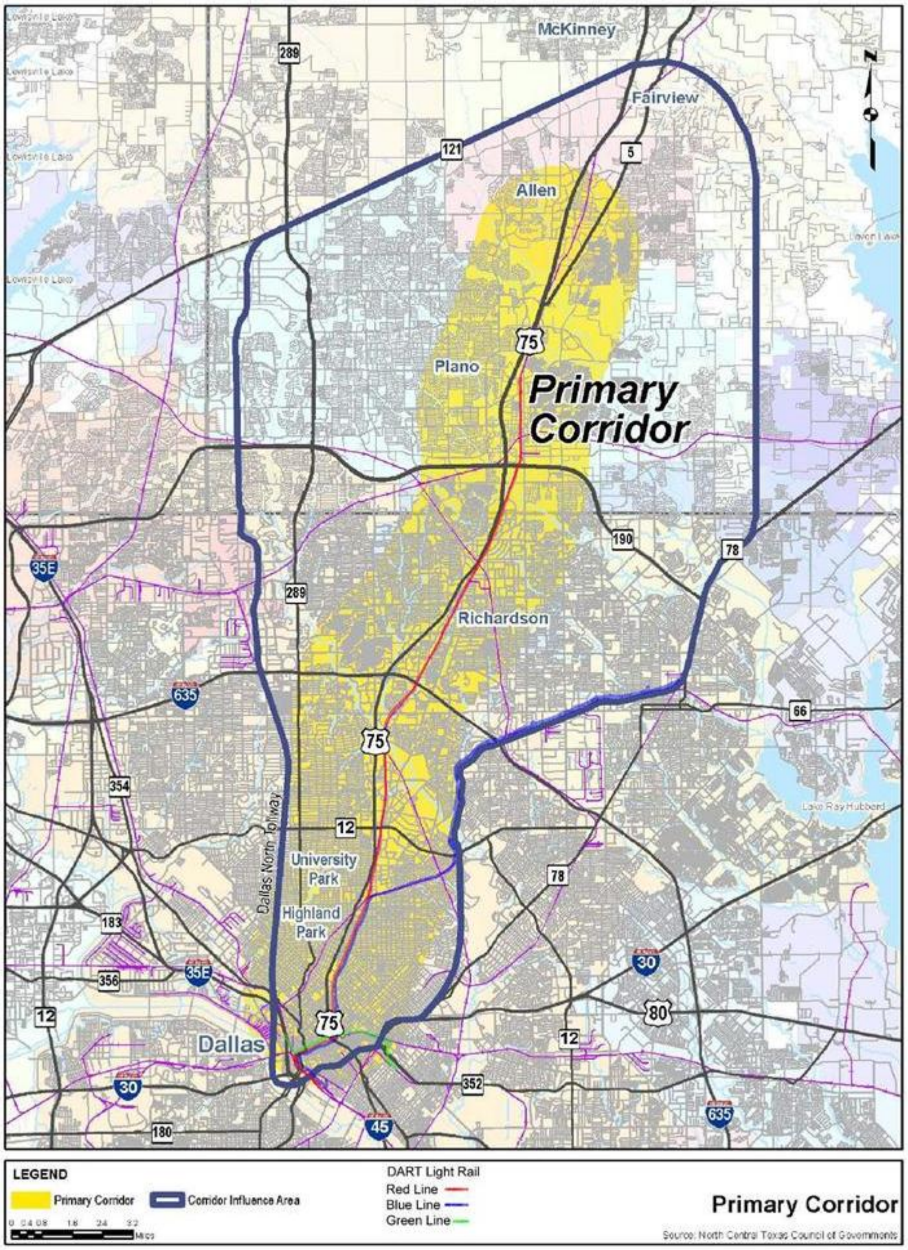

Figure 1-1. U.S. 75 Corridor Boundaries of Dallas ICM Deployment

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/event 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, 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.
- 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.

Table 1-1. Dallas ICM Project Goals

Goal #1	Improve Incident/Event 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.

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 systems 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/event choosing to continue to use transit

on a daily basis) or to other, non-ICM related changes such as regional travel demand.

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. When events such as significant changes in demand, incidents/events (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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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 in San Diego corridor 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/events.
- 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 multimodal (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 multimodal 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 (Traveler Response 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.

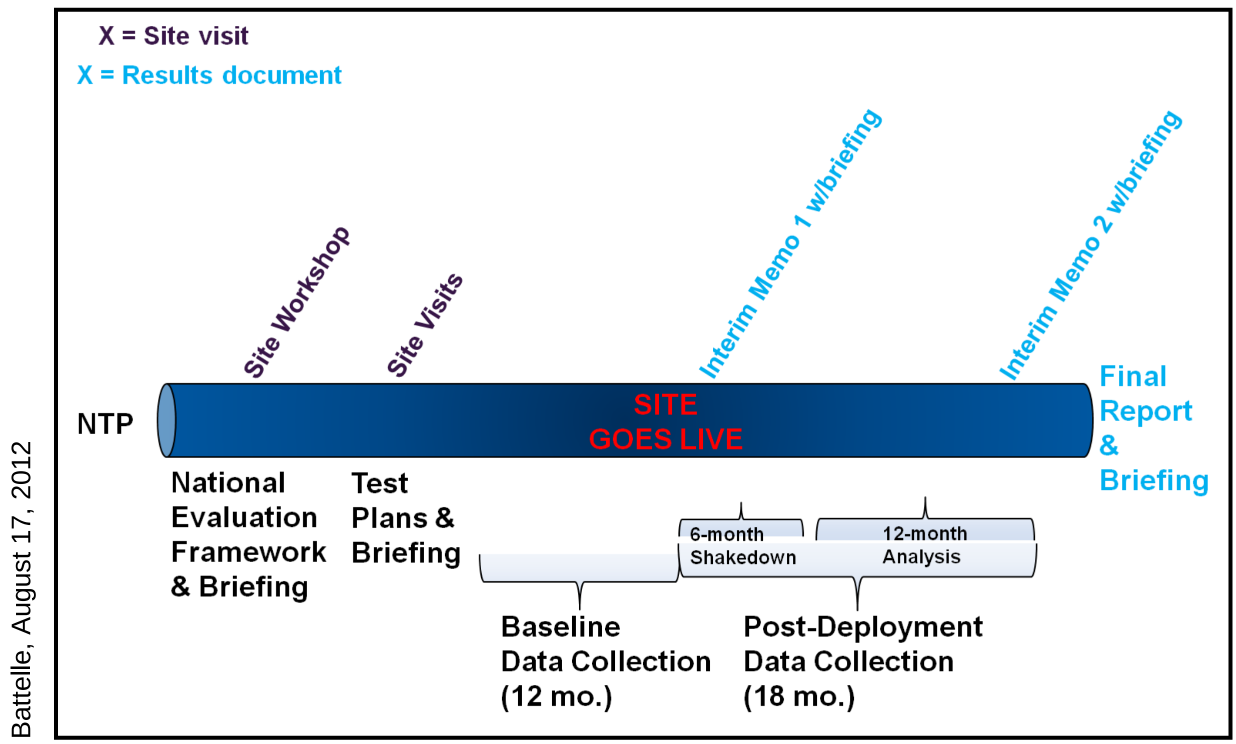

Figure 1-2. Sequence of Evaluation Activities

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 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.

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2.0 ANALYSIS OVERVIEW

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

One of the core tenets of the ICM Initiative is that better informed travelers will utilize this information to optimize their personal travel. This, in turn, will have the resulting impact of improving travel and performance characteristics across the entire corridor. Travelers' response to system perturbations with and without ICM, including (to the extent feasible) their response to specific strategies, is therefore integral to ICM success and is a key aspect of this evaluation, supporting both the evaluation findings report and the AMS model validation efforts.

Within the context of ICM, the response of travelers can be influenced by many factors including those that can be attributed to the ICM strategies as well as other factors that are exogenous to the ICM deployment (e.g., weather). Traveler response can be viewed both as an outcome of ICM strategies, as well as an input to network performance that can lead to system-wide benefits. For example, for there to be system-wide mobility improvements, a significant portion of the traveling public will need to be aware of and change behavior as the traffic conditions change. In other terms, traveler response is important to evaluate not only in the context of its impact to the individual traveler in outcomes such as total travel time and travel time reliability, but also within the context of the larger system outcomes such as increased person throughput, resources utilization, and safety benefits.

Both of these outcome and input aspects of traveler response, i.e., impacts on individual travelers and cumulative impacts (among many travelers) on the performance of the transportation system will be examined as part of the evaluation. The analysis described in this section, however, focuses more on the impact on individuals or groups of travelers as a result of implementing one or more ICM strategies, rather than examining system-wide changes for which a change in traveler response is a necessary prerequisite. These systemic changes are implicitly included in the other evaluation areas, such as the analyses related to mobility, and are, therefore, not discussed in detail in this analysis section. However, it is important to note that a significant portion of the data collected through the mechanisms discussed in this analysis will also be important in the other analyses (e.g., Corridor Performance) to provide a context for observed system/corridor/facility impacts.

2.1 Evaluation Hypotheses

As illustrated in Figure 2-1, U.S. DOT has defined an overall hypothesis for assessing Traveler Response as:

> *"Travelers will have actionable multimodal (highway, arterial, transit, parking, etc.) information resulting in more personally efficient mode, time of trip start, and route decisions."*

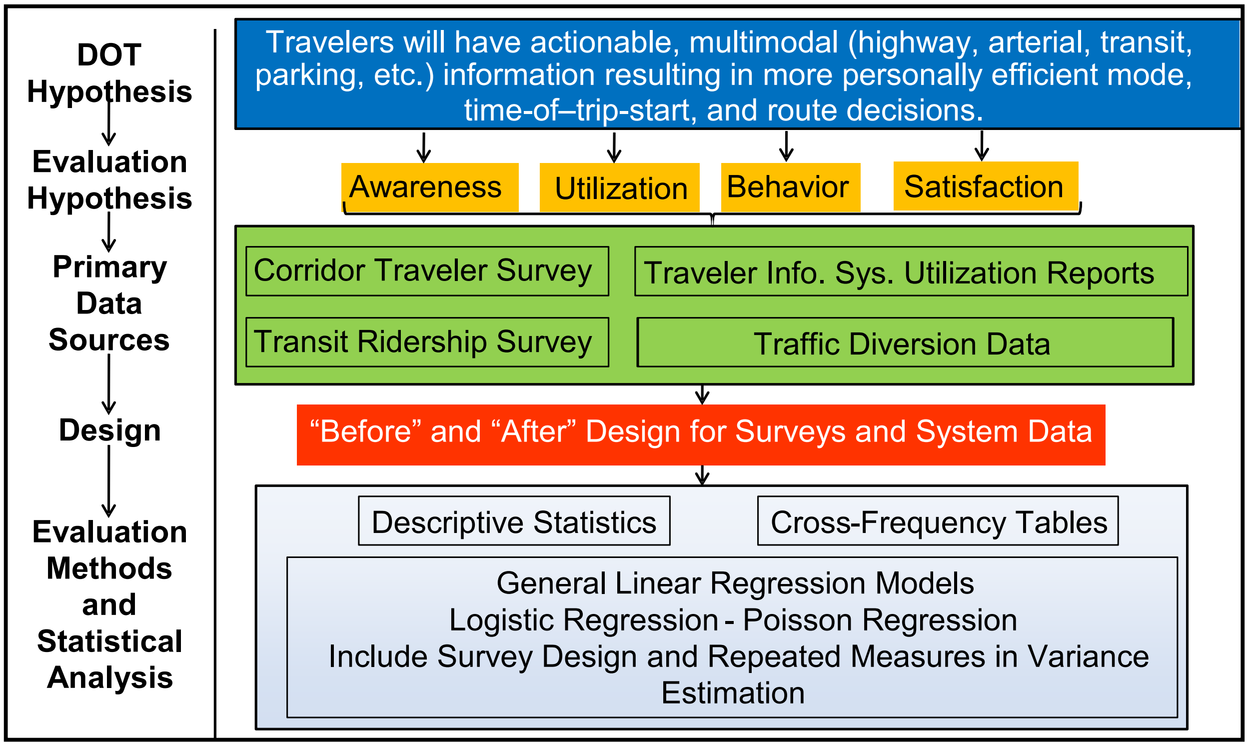

Figure 2-1. Overview of Traveler Response Analysis

The evaluation approach described in this section builds upon the specific U.S. DOT hypothesis by partitioning it into a series of hypotheses that can be individually and collectively tested. For convenience, these hypotheses are grouped into four general categories focused upon:

- **Awareness.** This group of hypotheses assesses the extent to which the general traveling public is aware of ICM delivery mechanisms (e.g., 511 service, dynamic message signs [DMS], social media applications) being employed. Additionally, this set of hypotheses also seeks to address whether the public is aware of the actual information that is being provided (e.g., aware of travel options).
- **Utilization.** Utilization in this context means that the traveler somehow *uses* the information obtained through the ICM strategies or other sources to make a travel decision. Use in this context does not imply any actual change in behavior, which is assessed through different hypotheses, just the extent to which the traveling public is a consumer of the information provided.
- **Behavior.** Ultimately, changing the behavior of travelers through the implementation of ICM strategies is one of the major goals of the ICM deployment as this change is a primary mechanism for achieving gains in system performance. These hypotheses assess whether the enhanced information provided through the implementation of ICM strategies results in changes in traveler behavior.

- **Satisfaction.** This set of hypotheses is focused upon assessing how satisfied the traveling public is with traveler information and their overall traveling experience and whether that satisfaction has changed as a result of ICM strategies.

Specific evaluation hypotheses within each of these four areas have been linked to one or more MOEs. Table 2-1 identifies specific evaluation hypotheses for each of the hypothesis category areas of awareness, utilization, behavior, and satisfaction. Table 2-2 then expands on these evaluation hypotheses by associating them with the specific data and MOEs that will be used to test them. The particulars of each data type are elaborated in Chapters 3 (Traveler Information Usage and Network Performance Data) and 4 (Traveler Surveys). Wherever possible, the overall analytical design of this analysis is a comparison of outcomes after ICM deployment compared to before.

Table 2-1. Traveler Response Evaluation Hypotheses

Evaluation Hypothesis Area	Evaluation Hypotheses
Awareness	Self-reported traveler awareness of traveler information sources will increase post deployment of ICM.
	Transit users will report awareness of traveler information enabled or enhanced by deployment of ICM.
Utilization	The deployment of the ICM will result in a greater number of travelers using information systems.
	Transit users will report utilization of traveler information enabled or enhanced by deployment of ICM.
Behavior	Travelers will be more likely after ICM deployment to have used added or enhanced ICM assets to change mode, route, or timing of trips.
	Transit travelers will report after ICM deployment having used added or enhanced ICM assets to change mode, route, or timing of trips.
Satisfaction	Travelers will be more satisfied with the type and reliability/accuracy of the travel information that they receive from sources after ICM deployment.
	Transit user satisfaction with travel information after ICM deployment will be reported.
	Travelers will be more satisfied with their travel experience (e.g., predictability of travel time and travel speed) after the ICM deployment.
	Transit user satisfaction with overall travel experience after ICM deployment will be reported.

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Table 2-2. Traveler Response Data, MOEs, and Evaluation Hypotheses

Data Element		MOE	Evaluation Hypotheses Area	Evaluation Hypotheses
Traveler Information Usage and Network Performance Data				
1. Traveler Information Usage Statistics	1.1 Legacy phone and web (including Facebook, Twitter) traveler information statistics (TxDOT) pre and post-ICM	Changes in the number of calls, accesses, and registrations related to the corridor over time.	Utilization	The deployment of the ICM will result in a greater number of travelers using information systems.
1. Traveler Information Usage Statistics	1.2 511 DFW phone, web (including Facebook, Twitter) traveler information statistics pre and post-ICM	Changes in the number of calls, accesses, and registrations related to the corridor over time.	Utilization	The deployment of the ICM will result in a greater number of travelers using information systems.
1. Traveler Information Usage Statistics	1.3 DART Trip Planner statistics pre and post-ICM	Changes in the number of calls, accesses, and registrations related to the corridor over time.	Utilization	The deployment of the ICM will result in a greater number of travelers using information systems.
2. Traffic Diversion Data	2.1 U.S. 75 traffic volumes upstream and downstream of a diversion point pre and post-ICM	Change in the percentage of drivers diverting to avoid an incident/event location in response to DMS message	Behavior	Travelers will be more likely after ICM deployment to have used added or enhanced ICM assets to change mode, route, or timing of trips.
2. Traffic Diversion Data	2.2 Incident/event data related to a diversion scenario pre and post-ICM	Change in the percentage of drivers diverting to avoid an incident/event location in response to DMS message	Behavior	Travelers will be more likely after ICM deployment to have used added or enhanced ICM assets to change mode, route, or timing of trips.

Table 2-2. Traveler Response Data, MOEs, and Evaluation Hypotheses (Continued)

Data Element		MOE	Evaluation Hypotheses Area	Evaluation Hypotheses
Traveler Response Surveys				
3. Corridor Traveler Surveys	3.1 Survey responses pre- and post-ICM	Change in awareness of travel information sources	Awareness	Self-reported traveler awareness of traveler information sources will increase post deployment of ICM.
3. Corridor Traveler Surveys	3.2 Survey responses pre- and post-ICM	Reported utilization to include frequency, method, and timing of uses by source	Utilization	The deployment of the ICM will result in a greater number of travelers using information systems.
3. Corridor Traveler Surveys	3.3 Survey responses pre- and post-ICM	Changes in satisfaction profile	Satisfaction	Travelers will be more satisfied with the type and reliability/accuracy of the travel information that they receive from sources after ICM deployment.
3. Corridor Traveler Surveys	3.4 Survey responses pre- and post-ICM	Changes in satisfaction profile	Satisfaction	Travelers will be more satisfied with their travel experience (e.g., predictability of travel time and travel speed) after the ICM deployment.
3. Corridor Traveler Surveys	3.5 Survey responses pre- and post-ICM	Change in behavior with regard to selection of mode, route, or timing	Behavior	Travelers will be more likely after ICM deployment to have used added or enhanced ICM assets to change mode, route, or timing of trips.
4. Pulse Surveys	4.1 Survey responses pre- and post-ICM	Change in awareness of travel information sources related to conditions	Awareness	Self-reported traveler awareness of traveler information sources will increase post deployment of ICM.
4. Pulse Surveys	4.2 Survey responses pre- and post-ICM	Reported utilization to include frequency, method, and timing of uses by source related to incident/event conditions	Utilization	The deployment of the ICM will result in a greater number of travelers using information systems.
4. Pulse Surveys	4.3 Survey responses pre- and post-ICM	Changes in satisfaction profile related to incident/event conditions	Satisfaction	Travelers will be more satisfied with the type and reliability/accuracy of the travel information that they receive from sources after ICM deployment.
4. Pulse Surveys	4.4 Survey responses pre- and post-ICM	Changes in satisfaction profile related to incident/event conditions	Satisfaction	Travelers will be more satisfied with their travel experience (e.g., predictability of travel time and travel speed) after the ICM deployment.
4. Pulse Surveys	4.5 Survey responses pre- and post-ICM	Change in behavior with regard to selection of mode, route, or timing related to incident/event conditions	Behavior	Travelers will be more likely after ICM deployment to have used added or enhanced ICM assets to change mode, route, or timing of trips.

Table 2-2. Traveler Response Data, MOEs, and Evaluation Hypotheses (Continued)

Data Element		MOE	Evaluation Hypotheses Area	Evaluation Hypotheses
Traveler Response Surveys (Cont.)				
5. Transit Surveys	5.1 Survey responses post-ICM	Transit user awareness of travel information sources	Awareness	Transit users will report awareness of traveler information enabled or enhanced by deployment of ICM.
5. Transit Surveys	5.2 Survey responses post-ICM	Reported utilization to include frequency, method, and timing of uses by source	Utilization	Transit users will report utilization of traveler information enabled or enhanced by deployment of ICM.
5. Transit Surveys	5.3 Survey responses post-ICM	Perceived change in satisfaction	Satisfaction	Transit user satisfaction with travel information after ICM deployment will be reported.
5. Transit Surveys	5.4 Survey responses post-ICM	Perceived change in satisfaction	Satisfaction	Transit user satisfaction with overall travel experience after ICM deployment will be reported.
5. Transit Surveys	5.5 Survey responses post-ICM	Perceived change in behavior with regard to selection of mode, route, or timing	Behavior	Transit travelers will report after ICM deployment having used added or enhanced ICM assets to change mode, route, or timing of trips.

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2.2 Traveler Response 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/events 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 many 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.

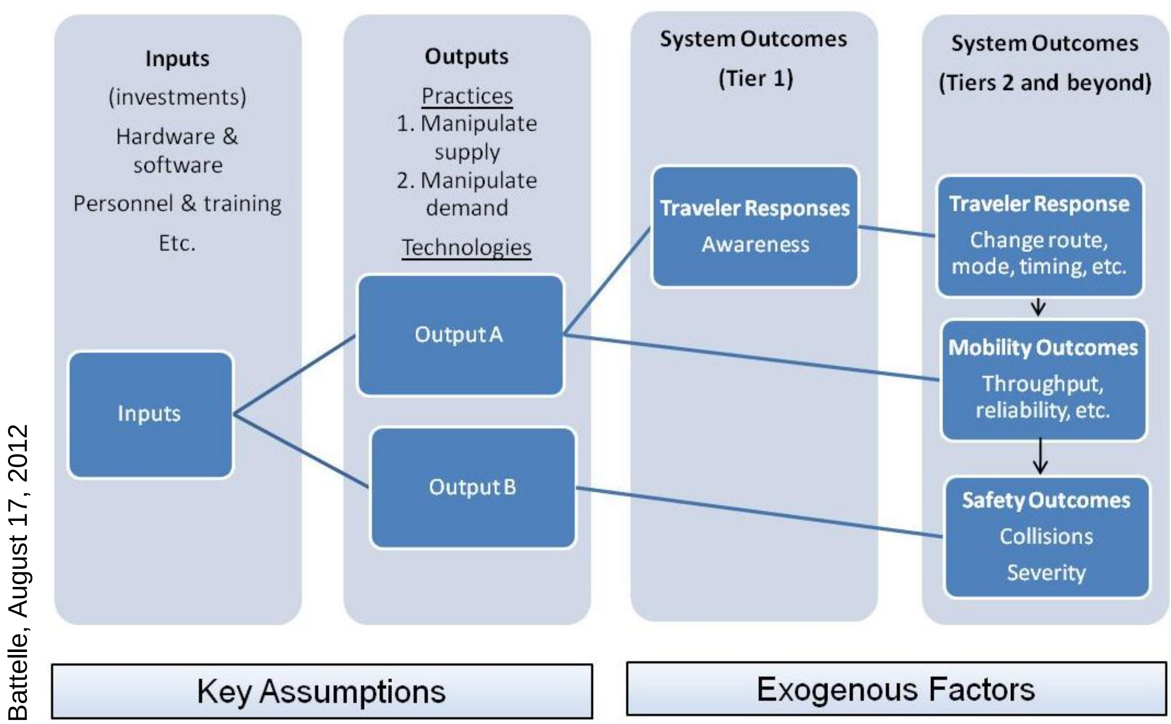

Figure 2-2. The Evaluation Logic Model

The various traveler response MOEs presented in Table 2-1 and used in this Traveler Response Analysis are all, strictly speaking, outcome MOEs. Most output MOEs are captured in those evaluation analyses, such as "Technical Capability to Monitor, Control and Report," that focus on how the ICM investments operate and are utilized by transportation system operators. However, this Traveler Response Analysis does explicitly recognize the causal and sequential relationships within the broad category of traveler response outcomes and there are MOEs that focus on the various links in the traveler response chain, from traveler awareness through changes in traveler behavior.

3.0 TRAVELER INFORMATION USAGE AND NETWORK PERFORMANCE DATA

This chapter identifies the traveler information usage and network performance data elements to be used in the Traveler Response Analysis. Table 3-1 summarizes the traveler information usage data requirements and the traffic diversion data requirements to evaluate network performance in the Traveler Response Analysis Test Plan. The details associated with the source, timing, and other aspect of each data element are discussed in the sections that follow.

3.1 Traveler Information Usage Statistics

The Volpe Center traveler surveys will provide the richest understanding of travelers' awareness, usage, behavior change, and satisfaction associated with ICM-created and ICM-enhanced corridor traveler information. However, the survey will only reach a relatively small sample of all travelers and will rely upon travelers' self-reporting. To provide a more comprehensive and externally verifiable understanding of travelers' consultation of traveler information (that is, "usage" in the sense of consulting the information but not in the sense of whether and how it impacts the traveler's behavior) it is useful to analyze available traveler utilization system data from the various ICM-created or enhanced dissemination outlets. Although it is possible that the ICM deployment may improve the quantity and/or quality of traveler information disseminated through a wide variety of channels, including by the media and commercial traffic information services, this analysis must focus only on those channels for which system usage data is available and can be readily collected and analyzed. Therefore, this analysis focuses on public agency telephone and web-based traveler information systems as well as the Dallas site team's planned Twitter and Facebook dissemination strategies. It should be noted, however, that the traveler surveys will include questions which may include responses regarding uses of commercial and media information. Therefore, these 3rd party traveler information sources will have some opportunity for inclusion in the traveler response test plan evaluation.

ICM traveler information system utilization data will be made available through the ICMS Data Feed. The national evaluation team and the Dallas site team will coordinate to identify the specific data, formats and sources. The approach proposed here assumes that typical data such as number of calls/user sessions by month, number of page hits to specific parts of websites, number of telephone menu selections for specific information, and number of unique users/subscribers will be available.

Table 3-1. Traveler Information Usage and Network Performance Data Summary

Data Element	Location		Data Collection Frequency	Data Collection Period		Data Collection Responsible Party	Data Transmittal
	Start	End		Baseline	Post-Deployment		
Traveler Information Usage Statistics							
1.1 TxDOT web and phone traffic information	Web site and Phone		Continuous	Apr 2012-Apr 2013	Apr 2013-Oct 2014	TxDOT	Monthly
1.2 511 website/ My 511	Web site		Continuous	Apr 2012-Apr 2013	Apr 2013-Oct 2014	ICMS Data Feed	Continuous (University of Maryland [UMD] Data Feed)
1.2 511 telephone system	Phone		Continuous	Apr 2012-Apr 2013	Apr 2013-Oct 2014	ICMS Data Feed	Continuous (UMD Data Feed)
1.2 511 personal traveler services/ alerts	Web site		Continuous	Apr 2012-Apr 2013	Apr 2013-Oct 2014	ICMS Data Feed	Continuous (UMD Data Feed)
1.3 DART trip planner	Web site		Continuous	Apr 2012-Apr 2013	Apr 2013-Oct 2014	ICMS Data Feed	Continuous (UMD Data Feed)
Traffic Diversion Data							
2.1 U.S. 75 General Purpose (GP) Lane Volume	U.S. 75 N of Exit 28	U.S. 75 S of Exit 28	1-min	Apr 2012-Apr 2013	Apr 2013-Oct 2014	ICMS Data Feed	Continuous (UMD Data Feed)
2.1 U.S. 75 HOV Lane Volume	U.S. 75 N of Exit 28	U.S. 75 S of Exit 28	1-min	Apr 2012-Apr 2013	Apr 2013-Oct 2014	ICMS Data Feed	Continuous (UMD Data Feed)
2.2 Incident/Event Records	Northern boundary of corridor	Southern boundary of corridor	By incident/event	Apr 2012-Apr 2013	Apr 2013-Oct 2014	ICMS Data Feed	Continuous (UMD Data Feed)

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Increased usage of travel information is expected once the Dallas regional 511 network is implemented (anticipated to commence July 2012). On-line information about traffic conditions including incidents/events, lane closures, speeds, cameras, and message signs that encompass the evaluation corridor are currently available through TxDOT (http://www.txdot.gov/local_information/dallas_district/). Telephone information is similarly available through TxDOT toll-free at (800) 452-9292. Starting in July 2011 and extending to July 2012 to represent the pre-ICM deployment, and from July 2012 to October 2014 for post-ICM deployment, usage statistics will be obtained for each of these travel information sources. With the implementation of the 511 system, expanded information will become available to include multiple travel modes, weather, ride sharing, and trip planning. Most importantly, existing information from multiple agencies will be combined into a single source. Also, the system will be customizable to individuals, and will allow for new capabilities like personal travel alerts. Both the existing TxDOT web access and the newly implemented 511 system will have Facebook and Twitter access. The number of people who "like" the Facebook page or followers for Twitter will provide opportunities to quantify information usage.

For transit users, DART provides an On-Line Transit Trip Planner. This currently existing service will be better linked to other traveler information after the ICM deployment, potentially expanding its usage. Statistical evaluation of ICM baseline versus post-ICM deployment for the DART information should consist of the number of times 511 users utilize the transit link, as well as tracking the historical use of the transit trip planner. The usage trend will be shown with annotations indicating the timing of any ICM-relevant enhancements that could inform the trend.

For the existing traveler information sources of web, phone, Facebook, and Twitter, these data will be provided for the periods July 2011 to July 2012, and July 2012 to October 2014, or whenever they terminate (if for instance the toll-free number were discontinued as a service in favor of 511). After the 511 components come on line (anticipated to be starting by July 2012) 511 usage statistics will be collected from July 2012 to October 2014. Counts for usage could include number of times the asset is accessed. It also might include a number of subscribers. In the latter case, the number of individuals unsubscribing might provide further insight into the level of satisfaction with the information provided. The evaluation objective will be to compare usage statistics of these assets both before and after ICM-deployment. To maximize the value of these comparisons, it will be necessary to subset the statistics of usage to only include those uses impacting on the corridor. For instance, we would want to subset the number of times a person accesses the toll-free number and asks for traffic conditions on a road in the corridor. At a minimum, the national evaluation team anticipates that route specific usage statistics will be available for the legacy and ICM (511) phone systems.

There are many other channels, both public and private, that can provide traveler information on the corridor. Freeway and arterial dynamic message signs, television and radio, and a number of commercial travel information products regularly provide traveler information for the corridor. Directly assessing the ICM-related impact in usage for these assets is beyond the capability of this analysis. However, the panel surveys will permit identification of what additional sources of traveler information are utilized by travelers in the corridor.

3.2 Traffic Diversion Data

To validate the outcomes of the changes in traveler behavior, it would be beneficial to go beyond the traveler survey which self-reports behavior and have a measure to objectively demonstrate ICM-influenced changes in behavior, especially for en-route changes. While all possible reasons for a route change cannot be tested, an evaluation method is proposed that may be able to demonstrate a behavioral change directly attributable to ICM messaging on DMS:

- Assume there is an incident/event on the corridor freeway (e.g., U.S. 75) that would ultimately lead to long delays.
- A DMS deployed at a point sufficiently upstream can warn travelers of the incident/event and the attendant back-up in enough time that drivers would be able to divert to an alternate route (e.g., frontage road, arterials) to continue their trip by car, or divert to an alternative route that leading to a Red Line LRT station where they would finish their trip by transit.
- The proportion of freeway traffic that passes the DMS can be separated into the group that elects to exit the main freeway and the group that elects to stay on the freeway. Those that leave the freeway are said to have been diverted.
- If the rate of diversion is greater after implementation of the ICM, it will provide some evidence that the DMS message is directly linked to drivers changing their behavior in response to an ICM enhancement.

This evaluation scenario provides a strong linkage between an ICM-related cause (DMS message to re-route in response to an incident/event) and a behavior change (diversion). The behavior change could occur as a result of other ICM assets (e.g., 511 mobile alerts), but the certainty of the contributions of these are not readily measurable, whereas it is reasonable to suppose that a sizable majority of drivers passing a DMS will be aware of it. For this reason, this scenario is posited to have a reasonable chance of confirming the evaluation hypothesis of a differentially higher change in behavior after ICM deployment (if one exists).

There are many challenges associated with identification of a suitable location for the measurements. Some of these include:

- A suitable scenario for diversion must exist in the first place. The Dallas site team provided four potential scenarios; either a minor or major incident/event on SB U.S. 75 at either Plano Parkway or Beltline Road. In each case, traffic could be diverted to either the frontage road or to a significant arterial.
- The diversion scenario needs to occur multiple times both before and after ICM deployment so the comparative diversion can be observed. This also implies that the incident/event is of sufficient seriousness that a substantial number of drivers could be induced to divert.
- There must be a means to measure the proportion of the traffic volume that has been diverted in the scenario. This might be achieved if the main freeway and all entrance and exit ramps were instrumented for traffic counts, but this will not be the case in Dallas.

Instead, the most favorable scenario appears to be one with traffic volumes on the freeway upstream and downstream of a diversion point where the diversion point acts as a traffic sink and where no other entrances exist between the two traffic count locations.

- A DMS must be in place upstream of the diversion point, preferably close to the upstream traffic counter so it can be certain that no new drivers entered the freeway after the DMS and before the diversion since such drivers could not be assumed to be informed of the scenario.
- The DMS must provide enhanced information after the ICM deployment as compared to before. To get the greatest sensitivity, a blank or non-traffic condition related message pre-deployment would be best.

With all the challenges presented, it is possible that this analysis will ultimately prove impossible. However, one of the four diversion scenarios provided by the Dallas site team has been examined in some detail and appears to be potentially workable:

- Major incidents/events have historically occurred on U.S. 75 SB at Beltline Road
- Backups from such incidents/events can extend 4 miles north to Plano Parkway
- There is a DalTrans DMS deployed at Park Boulevard, North of Plano Pkwy
- Given the Beltline incident scenario, the DMS may warn travelers of long delays on U.S. 75 and suggest the frontage road, a Greenville Avenue diversion, or diversion to LRT at the Red Line Bush Turnpike station
- The diversions can all occur by leaving the freeway at Exit 28
- There appear to be traffic counters on U.S. 75 SB upstream and downstream of Exit 28 (this needs to be verified by the Dallas site team as the maps provided to the national evaluation team were not detailed enough to pinpoint the detector locations relative to on and off ramps).

Suppose in the pre-deployment scenario of an incident/event at this location, it is found that 20 percent of the U.S. 75 SB traffic before Exit 28 is no longer on the freeway after Exit 28 due to self-selected diversion. In a similar incident/event after ICM-deployment, a DMS message recommending diversion results in 30 percent of the U.S. 75 SB traffic diverting at Exit 28. This represents an ICM-related post deployment increase of 10 percent of traffic diverted from the freeway.

This sample diversion scenario is the one that is anticipated to be utilized as it is the only known one that appears to potentially meet all the required criteria to be able to attribute diversion to ICM. However, other sites would also be utilized if appropriate data can be gathered from them. The diversion analysis will ideally be executed at least three times in each of the baseline and post-ICM deployment periods, assuming that suitable incidents/events occur. The DSS system data will provide the identification of suitable incidents/events to include in the analysis. Note that such incidents/events could be the same ones used in the pulse survey evaluations, but need not be as this analysis will stand alone. Some of the incident elements to be documented include:

- Location of the incident
- Date and time of incident identification, response, clearance, and restoring traffic to normal operating conditions
- Impacts on traffic conditions (e.g., 1 lane blocked)
- ICM strategies implemented during post-deployment period; specifically the DMS message displayed.

This diversion analysis by traffic counts appears to be a reasonable, efficient way to gauge the ICM-related behavior change that is the objective of the traveler behavior evaluation hypothesis. Other scenarios for evaluation are possible and were also considered. For instance, assuming (as is expected) that once the ICMS is operational DMS messages with Red Line LRT park & ride parking availability information will be posted during incidents/events (but not during "normal" peak hour conditions), then DMS message posting logs coupled with park & ride lot use data could be used in a before and after evaluation to measure incremental mode diversion directly relatable to ICM. Although evaluation resources are insufficient to support the analysis of both the U.S. 75 traffic and the park & ride analyses, if the U.S. 75 diversion assessment proves impossible the park & ride analysis may serve as an alternative. It is not necessary to definitively identify which analysis (U.S. 75 traffic versus park & ride lot utilization) will be pursued in advance because the national evaluation team expects that the required data will be collected and preserved by the Dallas site team regardless.

The timing for these analyses includes a pre-deployment period that extends from April 2012 through April 2013. This date range includes a full one year period which can be assumed to be relatively free of any ICM component integration, and therefore able to serve as a baseline. The post-ICM deployment date range would be April 2013 through October 2014, during which the ICM assets should have already been deployed. Note that the first six months of this period are considered post-ICM, though they are the six month shakedown period. However, it is important to establish that the post-deployment incidents/events, rather than just falling into the required time period, also have an arguable ICM deployment benefit. For instance, the scenario identified above would only be included if it could be established that ICM deployment had resulted in improved DMS messaging that provided diversion information. If the DMS did not provide that information, or was not operational during a particular incident, even though the correct type of incident had occurred and was within the post-deployment time period, it would not be used for the evaluation.

4.0 TRAVELER SURVEYS

This chapter describes the traveler behavior surveys (administered by the Volpe Center) that will be used in Traveler Response Analysis. Some of the final details of the surveys will be provided in separate communications from the Volpe Center, but the following section provides an overview of the surveys. Survey activities will include a panel survey of drivers (including "regular use" and specific traffic incident-related "pulse" surveys) and transit users. Each of these is described in the sections that follow.

4.1 Panel Survey (Drivers)

4.1.1 Overall Design

The overall design is a panel survey of drivers to capture changes due to ICM. The survey will be administered in waves, with a baseline survey during the pre-deployment period, currently anticipated to be in September 2012, and a final survey of the same respondents (to the extent feasible) in the post-deployment period, currently anticipated to be in winter 2014.

Additionally, the Volpe Center approach to the traveler surveys includes "pulse" surveys in which the same panel members will be surveyed regarding specific traffic incidents/events that occur during peak hours and that impact travel in the corridor. The surveys will be conducted within a short time after the incident/event occurs. Those surveys are part of a larger evaluation strategy in which the same limited number of incidents/events will be examined from multiple perspectives: via the analysis of traffic and transit impacts in the Corridor Performance Analysis; via the analysis of traveler responses through the Volpe Center pulse surveys; and via surveys of ICM system operating agencies in the Technical Capability Analysis. Both the traveler pulse surveys and the operating agency surveys will need to be carried out within a day after the incident/event and therefore it will be important for the Dallas site team to alert the national evaluation team within 4-8 hours after the occurrence of any types of incidents/events that have been predetermined to be of interest. The national evaluation team is in the process of working with the Dallas site team to identify a pre-determined "watch list" of candidate event case studies. The Dallas site team has identified two locations on southbound U.S. 75—at Beltline Road and Plano Parkway—as being the likely locations for such events, including both "major" and "minor" traffic incidents/events, though others may be identified during the evaluation.

The pulse surveys are planned to be administered at multiple times in the pre and post deployment phases, with the ultimate goal of obtaining two pulse surveys per respondent in the pre phase and two pulse surveys from each respondent in the post-deployment phase.

4.1.2 Study Population

The population of interest is regular, peak hour users of the corridor (i.e., 3-4 days/week). The population is defined as individual drivers and not households. While occasional or one-time travelers may well benefit from the ICM deployment, it is these regular users expected to provide the greatest sensitivity to changes in the corridor that could be attributed to the ICM deployment.

Another reason to focus on these regular, peak hour users is due to the study design, which features the use of pulse surveys. By focusing on regular, peak hour users, the likelihood that respondents are traveling in the corridor when there is an incident/event and thus are able to participate in the pulse survey is maximized. Screening criteria will be used to identify and recruit drivers who tend to drive a significant portion of US 75 – in this way also maximizing the likelihood that respondents are impacted by incidents/events on the corridor.

4.1.3 Sample Frames

Driver sampling is planned to be done by license plate capture on the corridor. Intercepted plates will be sent to the Division of Motor vehicles within the state to obtain the matched names and addresses of the vehicle owners. Those owners will then be invited to participate in the study by a method yet to be finalized. Intercept locations will include U.S. 75, at up to two locations. Possible locations identified include Midpark Bridge, Galatyn, and Plano Parkway. These or other suitable locations will be selected. In addition to the U.S. 75, license plates will be sampled off of Greenville Avenue, a key arterial and diversion route in the corridor. Two possible intercept locations that have been suggested include south or 635 between Buckingham and Walnut Hill or at the intersection with Arapaho Boulevard. These or other suitable locations will be used. A sufficient number of drivers will be recruited in order to obtain a final sample size of approximately 900 freeway drivers and 500 arterial drivers.

The planned sample size is expected to be sufficient to provide results of adequate precision. The precision of reported results is impacted by many factors including the type of survey measure (e.g., categorical vs. continuous measurement), survey weighting, and the observed results. However, a simplified example of the expected level is as follows: Assuming the survey question is a binomial response (e.g., yes or no) with corresponding percentage estimated for each outcome, and the true (but unknown) percentage for each response is near 50 percent, a sample of 500 might result in a margin of error (i.e., result is reported as “x” proportion with 95 percent confidence of (“x”-margin) to (“x”+margin)) of about 4.4 percent. At sample size of 900, the margin of error would be about 3.3 percent. For the combined 1400 samples, the margin of error could be 2.6 percent.

4.1.4 Survey Administration

The surveys will be administered online with a telephone option. Written surveys will be in English, but the telephone option will accommodate Spanish- (and other-) language speakers. Panel maintenance efforts will be undertaken in order to minimize panel attrition and to maximize response rates.

4.1.5 Survey Questionnaire

The specific questions that make up the questionnaires have yet to be determined. However, questions for the baseline and final surveys will include demographics, technology ownership, attitudes and values, schedule flexibility, typical use of the corridor, awareness of traveler information, use of traveler information, travel behavior decision making, and traveler satisfaction. Questions for the pulse surveys will include use of travel information, travel behavior decisions, and traveler satisfaction.

Ideally, this draft test plan would include specific survey questionnaires. However, the survey questionnaires have yet to be finalized. Additional details will be coordinated with U.S. DOT and the Dallas site team and documented in the separate Volpe Center methodology plan prepared by the Volpe Center survey team.

4.2 Transit Survey (Riders)

4.2.1 Overall Design

Post-deployment surveys of transit riders will be performed to capture changes due to ICM. An initial intercept survey focusing on habits will be administered, followed by pulse surveys associated with incidents/events. The pulse surveys are planned to be administered at multiple times in the post-deployment phase, with the ultimate goal of obtaining two pulse surveys per respondent. The pulse surveys will be aligned to driver pulse survey incidents/events if possible, tentatively planned for Summer/Fall of 2013.

4.2.2 Study Population

The study population is regular, peak hour users of the DART LRT Red Line.

4.2.3 Sample Frames

The transit survey panel will come from an initial intercept survey. The sampling locations are Red Line LRT stations. A sufficient number of transit riders will be recruited in order to achieve a final sample size of approximately 500 riders. This sample size is expected to provide adequate precision for reported results. As discussed in Section 4.1.3, a sample of 500 is adequate to produce a maximum 4.4 percent margin of error for a common binomial proportion result (e.g., yes or no).

4.2.4 Survey Administration

The transit survey will begin with an intercept survey. Participants may be asked a limited number of questions en route, but the main survey will be administered on-line with a telephone option. Subsequent pulse surveys will also be administered on-line with a telephone option. Surveys will primarily be conducted in English, except that the telephone option may accommodate Spanish- (and other-) language speakers. Panel maintenance efforts will be undertaken in order to minimize panel attrition and to maximize response rates.

4.2.5 Survey Questionnaire

The specific questions that make up the questionnaires have yet to be determined. However, questions will include demographics, technology ownership, attitudes and values, schedule flexibility, typical use of the corridor transit and reason for use, awareness of traveler information, use of traveler information, travel behavior decision making, and traveler satisfaction. Questions for the pulse surveys will include use of travel information, travel behavior decisions, and traveler satisfaction.

As with the driver surveys, this draft test plan does not include specific transit rider survey questionnaires. These will be provided in the separate Volpe Center methodology plan prepared by the Volpe Center survey team.

5.0 DATA ANALYSIS

This section describes how the gathered traveler response data will be analyzed. Specifically, for each data category, the approach to testing the hypotheses and/or drawing conclusions will be discussed, including statistical and analytical processes and tools.

5.1 Hypothesis Testing

Table 5-1 summarizes the four traveler response hypotheses as discussed in Chapter 2 into three hypothesis areas, provides the MOE categories they link to, and identifies the section where data analysis testing methods are detailed for each.

Table 5-1. Traveler Response Analysis Hypothesis Areas, Data Source and Testing Methods

Hypothesis Areas	Data Source	Testing Method
Awareness, Utilization, Behavior, and Satisfaction	Corridor Traveler Surveys, Pulse Surveys and Transit Surveys	Section 5.2.1
Utilization	Phone and Web usage statistics	Section 5.2.2
Behavior	Traffic Diversion Data	Section 5.2.3

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5.2 Performance Measure Calculation Procedures

The input data sources and the procedures around calculation of the MOEs are described in this section.

5.2.1 Statistical Analysis of Traveler Surveys

The primary data sources for assessing the hypotheses associated with Traveler Response are the traveler surveys being conducted by the Volpe Center. These surveys will be a pre- and post-deployment panel survey with pulses for corridor drivers and a post-deployment only with pulses intercept survey for transit riders. Under the panel survey design, a sample of travelers will be recruited and surveyed initially, and then in multiple pulse surveys around incidents/events in the pre- and post-deployment periods (post- only for transit). The use of a panel design provides a mechanism for estimating the "within participant" variability, which is equivalent to having each person serve as their own "control." This technique is particularly useful when attempting to measure relatively small, but meaningful changes in the presence of other exogenous factors that would otherwise tend to overwhelm the change being measured. Statistical analysis of the information collected through the panel surveys will be performed using standard statistical analysis software such as the SAS© system or Stata©. Importantly, all statistical analysis will be conducted using survey weights to ensure that the results can be extrapolated to a larger population as well as reducing sampling and non-response biases. Should it prove infeasible to develop survey weights that are post-stratified to the larger traveling population of the corridor, statistical analysis will be conducted using survey weights that account for the sample selection probability as well as non-response but are calibrated to match the number of surveyed individuals (i.e., the weighted sample size will be equivalent to the actual sample size).

Two different types of statistical analyses will be conducted with the survey data; descriptive statistics and detailed modeling. The descriptive statistics, including frequencies, means, and quartile estimation will be provided for every questionnaire item. This will provide a simple summary for each of the measures of effectiveness. Cross-frequency tables will be prepared to conduct an initial assessment of the relationship between variables such as access of ICM-provided information sources by time of day. Statistical tests using these descriptive statistics will include t-tests as well as Chi-square-tests for cross-tabulation tables. Simple log-linear modeling will be used to conduct additional statistical tests based upon cross-frequency tables so that more sophisticated relationships between various survey responses can be examined (i.e., how the measures of effectiveness change with levels of other factors such as time of day, etc.). For example, we will utilize a log-linear model to understand and quantify the impacts of improved information dissemination as a function of social economic characteristics, geographic location of the driver's household, and length and regularity of the respondent's commute. Although extensive descriptive analyses and log-linear models will be used to produce estimates of changes in the measures of effectiveness, these results will only be considered to be preliminary and will only be produced within the context of leading to statistical analysis techniques that can account for the significant exogenous factors expected to be present during the ICM deployment period.

Controlling for exogenous factors will be conducted through the application of "mixed-models." These models are contained within the larger family of general linear models (GLM) but differ in that they include both "fixed" effects as well as "random or repeated" effects. These models are particularly useful in situations where measurements can be clustered, such as in a panel survey where responses across survey waves are considered to be clustered within a particular respondent (i.e., each respondent provides "repeated" observations across the waves). This model structure allows for partitioning the model-based estimated variance terms to account for "within respondent" and "between respondent" terms. This partitioning enhances the ability to identify statistically significant differences in the fixed effect terms. Within the models that will be developed for these analyses, the fixed effect terms will consist of two separate types of effects; explanatory factors and blocking variables. Explanatory factors are those factors for which estimates of changes are desired (e.g., before/after ICM deployment, ICM strategy in effect, etc.) whereas blocking variables are those exogenous variables that are thought to be related to the outcome of interest and therefore the impact of these variables on the outcome needs to be accounted but these variables are not specifically of interest to the study. The impact of these exogenous effects serves to "block" off or explain a portion of the variability in the outcome, the remainder of which is assumed to be either random variability or explained by the factors of interest. All statistical models developed for this analysis will follow the form of the equation described in Equation 5-1.

Equation 5-1. General Form of Repeated Measures General Linear Model for Estimating Traveler Response

$$Outcome = \alpha \mathrm{X} + \beta \mathrm{Z} + \delta(\mathrm{Respondent}) + \varepsilon$$

where X represents the factors of interest, Z represents a vector of covariates, δ the random effect associated with repeated observations on the same participant, and ε is the unexplained variability.

Depending upon the specific outcome being investigated, different forms of general linear models will be used. In particular, for continuous outcomes such as travel time a normal-theory based model will be used. For outcomes that represent a percentage or binary outcome, logistic regression (binomial-theory based) model will be used. Count-based outcomes will be modeled using Poisson-based models. As many covariates as possible will be included in the model. The same set of covariates will be retained across all of the models. The descriptive statistics will be used to identify those exogenous variables that have a meaningful relationship with the various outcomes of interest. The following covariates will be considered as the initial set of exogenous factors for consideration:

- Demographic information
    - Age
    - Race/ethnicity
    - Gender
    - Income
    - Work status
    - Familiarity with technology
    - Length of time lived in the region
- Presence of Construction
- Seasonality
- Weather
- Availability of Travel Options, especially for routine trips (such as journey to work)
    - Alternative Routes
    - Alternative modes
    - Constraints to options (e.g., vehicle availability, daycare or school-related limitations, job schedule inflexibility).

The traveler behavior survey results will include tabulated sample sizes and proportions of responses by category for each survey question. Results will be reported for the panel as a whole and separately by demographic categories and type of traveler information. Responses in the baseline period will be compared to those in the post-deployment period.

5.2.2 Statistical Analysis of Traveler Information Usage

The analytical evaluation for the test plan will be a tabulation of summary statistics on access to travel information assets during the baseline and post-deployment periods. Travel information will be available from a number of different channels. The 511DFW public web site and 511 telephone system are new components of the ICM and will only be available after deployment. For each, statistics including the number of accesses per month will be tabulated throughout the post-deployment period and will be graphed. These data presentations will be compared to the change in the statistics for the existing toll-free number and TxDOT web site activity throughout the pre- and post-deployment periods. Similar data tabulations and displays will be provided for subscriptions (and unsubscribing) to personal traveler services and alerts and My511. Links or accessing of Facebook and Twitter from the existing and new 511 systems similarly can be compared. The 511DFW site includes a link to the DART trip planner. As this site already exists, a before and after comparison of accesses to it can be performed. In all cases with traveler information, it is assumed the ideal data presentation will have subset statistics to include only those relevant to the corridor.

5.2.3 Statistical Analysis of Traffic Diversion

Diversion will be measured for specific incidents/events where it is assumed that use of ICM technology either could (baseline) or did (post-ICM deployment) result in improved travel efficiency by changing driver behavior to either divert to another route or to move to another mode. Each incident/event will be examined individually to determine timing and location issues that are unique to it.

Diversion percentage is evaluated as follows:

$D = 100 * (V_{upstream} – V_{downstream}) / V_{upstream}$

Where

$V_{upstream}$ is the volume of traffic (vehicles per minute) on the freeway that are seeing their first diversion opportunity

$V_{downstream}$ is the volume of traffic (vehicles per minute) on the freeway that passed the diversion point remaining on the freeway

To properly calculate this statistic, it is critical that no sources of new traffic, or additional exits exist between the location of the upstream and downstream measurements. Furthermore, in the post-deployment period, it is important that any behavior-inducing messages have had the opportunity to be seen by everyone approaching the upstream location. For instance, an entrance ramp on the freeway downstream a DMS but prior to the “upstream” location would be problematic as these entering drivers would not have had access to the DMS and hence be aware that they were driving toward the diversion scenario.

If a sufficient number of diversion statistics can be attained in the pre and post-deployment periods, a nonparametric statistical test will be conducted (one-sided Kolmogorov-Smirnov) against the Null hypothesis that the diversion percentage is less after the ICM deployment. A sufficiently strong observation in the opposite direction, with probability of falsely concluding the alternative at no more than five percent, will result in the conclusion that the ICM deployment did affect behavior relative to the diversion scenario.

5.3 Application of the Logic Model

The Traveler Response Analysis explicitly recognizes the logic model—that is, the casual relationships among various aspects or sequential stages of traveler response—by including separate MOEs and separate hypotheses that focus on each stage, from awareness through behavior change. Overall conclusions regarding traveler response will be based on consideration of not only the results associated with each individual stage of traveler response but will also take into consideration the "input" (ICM investments) and "output" (what the ICM system and system operators produced) findings from throughout the evaluation. For example, in cases where there are changes in traveler behavior that do not seem to be accompanied by traveler awareness of ICM-enhanced traveler information or other ICM operational strategies, the influence of exogenous (non-ICM related) factors will be given particular consideration. Likewise, the traveler response findings overall will be interpreted in light of the results of the Technical Capability and other analyses related to whether, to what extent, and how the ICM system operators actually provided enhanced information to travelers.

In this way, this Traveler Response 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, from inputs to final outcomes. Table 5-2 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 5-2. Interpreting Results from Across the Logic Model

Strategy	Evaluation Results			Outcome Linked Only to this Strategy?	Conclusion
	Input	Output	Outcome		
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 response plan for each risk. Each risk and response is further discussed below.

Table 6-1. Risks and Mitigations

Risk	Mitigation Strategy
1. Volpe Center survey data may be incomplete, invalid and/or not provided in time to be fully analyzed by the national evaluation team.	• The national evaluation team will rely upon the Volpe Center to monitor and address these risks as they administer the survey.
2. "ICM-corridor specific" traveler information system utilization data may not be available.	• At a minimum, we expect acceptably "ICM corridor specific" usage statistics to be available for the legacy and post-ICM (511) phones systems and the evaluation would focus on those statistics.
3. Adequate diversion count data may not be available and/or too few incidents/events will occur to support a formal statistical analysis.	• Consider focusing on Red Line LRT park & ride lot parking availability and usage instead of U.S. 75 traffic diversion.
4. Attrition among panel members may be high, thus hampering the longitudinal analysis pre and post-ICM.	• Utilize incentives to retain participant participation for the duration of the study.

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Successful evaluation of the traveler response is dependent on the completeness and comprehensiveness of data from the site. It is critical that the surveys be fielded as planned and that the detailed, clean, valid, and tabulated data be provided in a timely fashion after their completion. It is expected that certain difficulties such as low response rates or missing data may be encountered. Some specific risks associated with this evaluation include the following:

- During the pre and post-evaluation phases, there may not be incidents/events sufficiently major in nature to warrant route diversion/switching modes – this would limit the ability to conduct pulse surveys.
- Respondents may not be on the road during the incident/event identified for the pulse survey, and thus response to the pulse survey may be low.
- Attrition among panel members may be high.

The Volpe Center will address these issues in their own planning and administration of the surveys to assure the resulting data optimizes the resources available for its collection.

The traveler information evaluation will be able to be completed in some form. However, the most desirable form of it may not be possible. The analysis calls for usage information that can differentiate Dallas U.S. 75 corridor use from more general use in the existing resources (TxDOT, toll-free) and the new 511 system. If this level of granularity is not available for all of the dissemination outlets (e.g., phone and web), the analysis will focus only on the phone systems where it appears that route-specific usage statistics may be available.

The diversion analysis for incident/event locations depends on the availability of traffic counts for specific time periods, the occurrence of a particular type of incident/event that produces an ICM response, and very specific logistical constraints regarding the diversion scenario location. Should these conditions not occur frequently enough during the pre or post-deployment periods, the evaluation will consider an alternative analysis focusing on DMS messaging pertaining to Red Line LRT park & ride lot availability and park & ride lot utilization.

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