Integrated Corridor Management Initiative: Demonstration Phase Evaluation

Dallas Decision Support System Analysis Test Plan

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16. Abstract

This report presents the test plan for conducting the Decision Support System (DSS) Analysis for the United States Department of Transportation (U.S. DOT) evaluation of the Dallas U.S. 75 Integrated Corridor Management (ICM) Initiative Demonstration. The ICM projects being deployed in Dallas include a suite of strategies aimed at balancing U.S. 75 corridor transportation supply and demand to promote overall corridor efficiency and safety. Operational strategies to be deployed in the Dallas U.S. 75 highway corridor include: simulations to predict travel conditions for improved incident response, interdependent response plans among agencies, traffic diversion to frontage roads and strategic arterials, traveler mode shift to the light rail system during major freeway incidents, and comparative travel time information to the public and operating agencies for freeway, HOV lanes, frontage roads, arterial streets, and light-rail transit lane. Technologies that will be used to carry out these strategies include a Decision Support System, a 511 traveler information system (telephone and website), a regional center-to-center information exchange network, dynamic message signs, parking management systems, transit signal priority and responsive traffic signals. This DSS Analysis Test Plan is based on the ICM Initiative Demonstration National Evaluation Framework. This test plan provides an overview of the DSS Analysis and describes the specific qualitative and quantitative data that will be collected to support the analysis. Data analysis methodologies as well as risks and mitigations associated with this evaluation analysis are also discussed in this test plan.

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LIST OF ABBREVIATIONS

AMS	Analysis, Modeling and Simulation
DART	Dallas Area Rapid Transit
DSS	Decision Support Systems
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HOT	High-Occupancy Tolling
HOV	High-Occupancy Vehicle
ICM	Integrated Corridor Management
I-15	Interstate-15
I-635	Lyndon B. Johnson Freeway
ITS	Intelligent Transportation Systems
KTT	Knowledge and Technology Transfer
LRT	Light Rail Transit
LRV	Light Rail Vehicles
MOE	Measure of Effectiveness
NCTCOG	North Central Texas Council of Governments
NTTA	North Texas Tollway Authority
NWS	National Weather Service
RITA	Research and Innovative Technology Administration
TEARS	Targeted Event Accelerated Response System
TMC	Transportation Management Center
TxDOT	Texas Department of Transportation
TTI	Texas Transportation Institute
U.S. DOT	U.S. Department of Transportation
UMD	University of Maryland
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 Decision Support System (DSS) Analysis, one of seven analyses that comprise the United States Department of Transportation (U.S. DOT) national evaluation of the Dallas Integrated Corridor Management (ICM) Initiative demonstration phase. The ICM demonstration phase includes multimodal deployments in the U.S. 75 corridor in Dallas, Texas and the Interstate 15 (I-15) corridor in San Diego, California. Separate evaluation test plan documents are being prepared for each site. This document, which focuses on Dallas, is referred to as a "test plan" because, in addition to describing the specific data to be collected, it describes how that data will be used to test various evaluation hypotheses and answer various evaluation questions.

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

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

1.1 ICM Program[1]

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

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

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

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

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

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

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

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

1.2 ICM Demonstration Phase Deployments[2]

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

1.2.1 Overview of the Dallas ICM Deployment

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

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

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

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

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

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

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

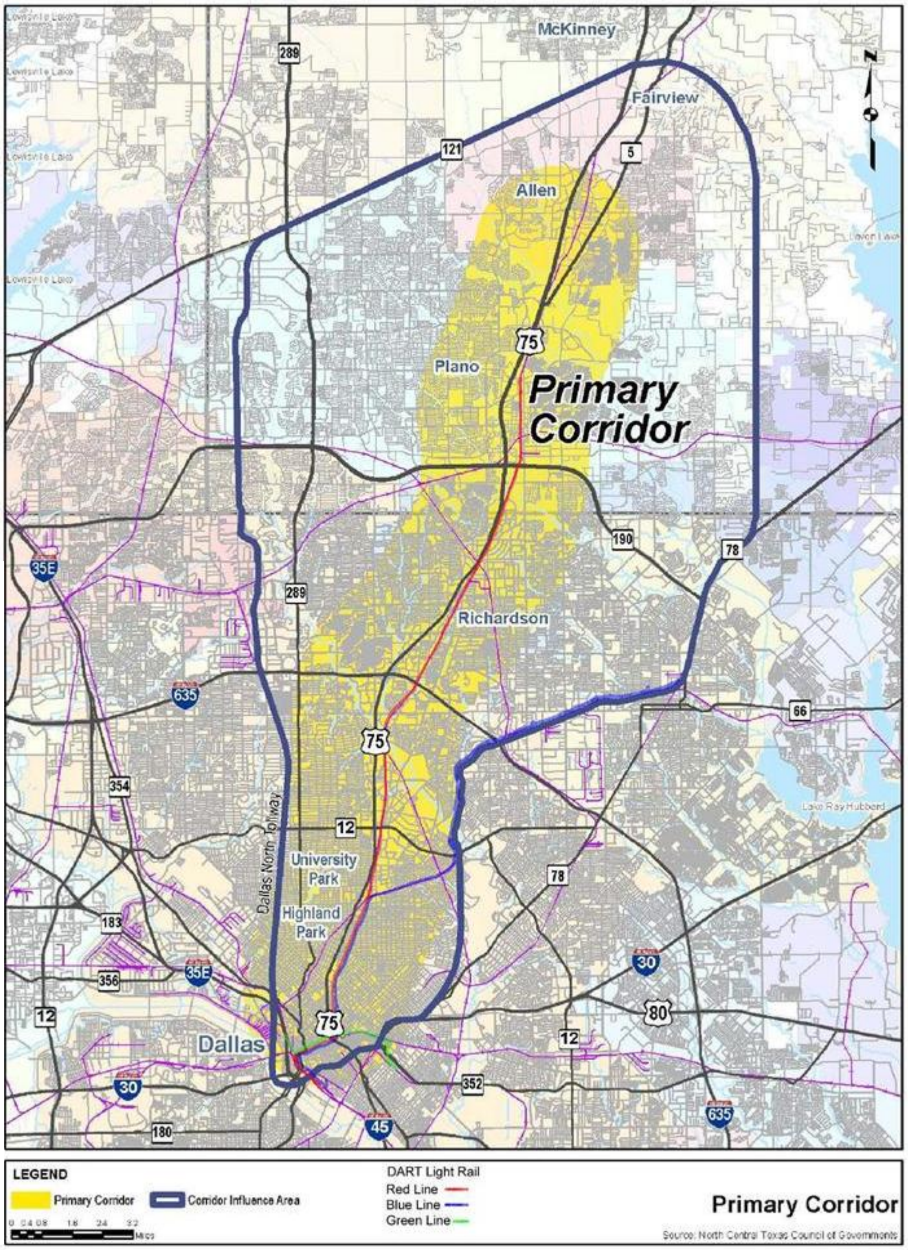

Figure 1-1. U.S. 75 Corridor Boundaries of Dallas ICM Deployment

Table 1-1. Dallas ICM Project Goals

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

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

- A 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. SmartNet provides a conduit for input, fusion and shared, multi-agency access to a variety of transportation condition data.
- A 511 telephone and web-based traveler information system for the region.
- Development of new, event-specific traffic signal timing plans to support traffic diversions onto Greenville Avenue (termed the "Targeted Event Accelerated Response System," or TEARS).
- Arterial street monitoring system, including additional travel time detectors (Bluetooth).
- Using non-ICM funds, various supporting transit improvements including mobile data terminals and automatic vehicle location system replacement.
- Parking management systems for key park & ride lots.

Table 1-2. Summary of Dallas DSS Functionality

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

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It is expected that the various Dallas ICM system capabilities and strategies will be utilized in several different contexts and timeframes. These contexts and timeframes are expected to become more definitive and elaborated as the sites proceed with the design and implementation of their systems. Further, these uses are expected to evolve as the sites work through their six-month "shakedown" periods following the initial system go-live dates, and possibly, continuing to some extent into the 12-month post-deployment data collection period. Currently, it is expected that the ICM system will be applied in at least the following general contexts and timeframes:

1. In "real time" (or near real time), in association with an unplanned event like a traffic incident.
2. In advance, e.g., pre-planned:
    a. Anticipating a specific, atypical event, such as major roadway construction or a large sporting event; and
    b. Periodic or cyclical (e.g., seasonal) adjustments to approaches based on lessons learned and evolution of the ICM strategies and/or in response to lasting changes in transportation conditions. These lasting changes may be either directly related to ICM strategy utilization (e.g., drivers who may have switched to transit during a specific ICM-supported traffic incident choosing to continue to use transit on a daily basis) or to other, non-ICM related changes such as regional travel demand.

1.2.1.1 Current Understanding of DSS Operations

For the purpose of this evaluation test plan, DSS is defined as:

> *The Decision Support Subsystem (DSS) will send response plan requests via the Dallas SmartNET interface to communicate to the various agency operators. For instance, if TxDOT has an incident on the U.S. 75 freeway, when the operator at the DalTrans facility inputs data in their ATMS incident management subsystem, the information from this subsystem would send basic information on the incident (such as location, number of lanes, severity) to the Dallas SmartNET Data subsystem via the regional Center-to-Center communication system. The DSS would receive the information from the Dallas SmartNET subsystem and would then query its database based on specific criteria (location, time of day, network conditions), and select pre-approved response plans. The DSS would send the response plan recommendations to all affected agencies via the Dallas SmartNET subsystem, and the public would be notified via the 511 system of the incident. The agencies in the corridor would accept, reject, or request a modification of the recommended response, based on current conditions within their network. As the conditions of the incident change, and the Dallas SmartNET system is updated, the DSS would also be notified and send out updated response requests, if needed. In addition, the DSS will send out updated responses based on other criteria. For instance, if an incident was occurring during the peak hours, and extended beyond. One potential response during the peak could be to increase the number of Light Rail Vehicles (LRV) in operation. If a certain time of day was reached before any updates were provided, the DSS may send DART an*

update that notifies them that additional LRT are not required. (Source: U.S. 75 ICMS Requirements, dated December 1, 2010)

The Decision Support System for Dallas is only a single component of the overall ICM System as depicted in Figure 1-2. The DSS will execute its role based on multiple inputs originating from the SmartFusion engine (1.2), SmartNET data collection source (1.3) and information leveraged from the databases of the corridors stakeholders.

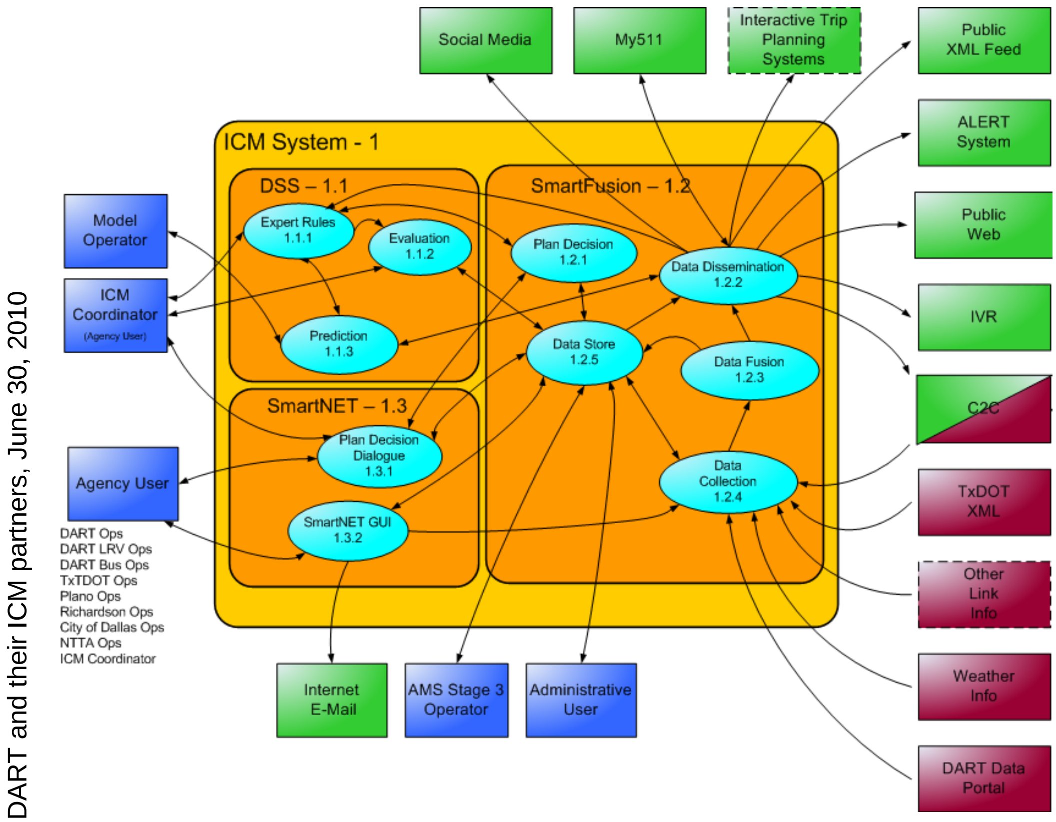

Figure 1-2. Dallas ICMS System Architecture

Information sharing capabilities, including providing actionable information to travelers, and the ability to manipulate transportation capacity such as adjusting traffic signal timing or adding short-term transit capacity are crucial to ICM success.

1.2.2 Dallas ICM Deployment Schedule

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

As indicated in Table 1-3, individual components of the deployment will be completed in a phased manner, with full ICM system operations currently scheduled to commence in early April 2013. The Dallas site team has indicated that they do expect, to at least some degree, to begin using individual components and associated ICM strategies as they become available prior to the overall system go-live. The approach to this analysis attempts to take that phasing into consideration. Since both the completion dates of the individual ICM components and the Dallas site team's utilization of them are expected to evolve as the ICM system design, implementation and shakedown period progress, the approach presented in this test plan may flex somewhat in response.

Table 1-3. Dallas ICM Deployment Schedule

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

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1.2.3 Comparison to the San Diego ICM Deployment

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

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

1.3 National Evaluation Objectives and Process

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

1.3.1 U.S. DOT Hypotheses

The U.S. DOT has established the testing of eight "hypotheses" as the primary objective and analytical thrust of the ICM demonstration phase evaluation, as shown in Table 1-4. There are a number of cause-effect relationships among the U.S. DOT hypotheses; for example, enhanced response and control is dependent on enhanced situational awareness. These relationships will be examined through the evaluation in addition to testing the individual hypotheses. Another important relationship among the hypotheses is that DSS is actually a component of enhanced response and control and, depending on the specific role played by the DSS, may also contribute to improved situational awareness.

Table 1-4. U.S. DOT ICM Evaluation Hypotheses

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

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

1.3.2 Evaluation Analyses

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

Table 1-5. Relationship Between U.S. DOT Hypotheses and Evaluation Analyses

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

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

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

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

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

1.3.3 Evaluation Process and Timeline

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

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

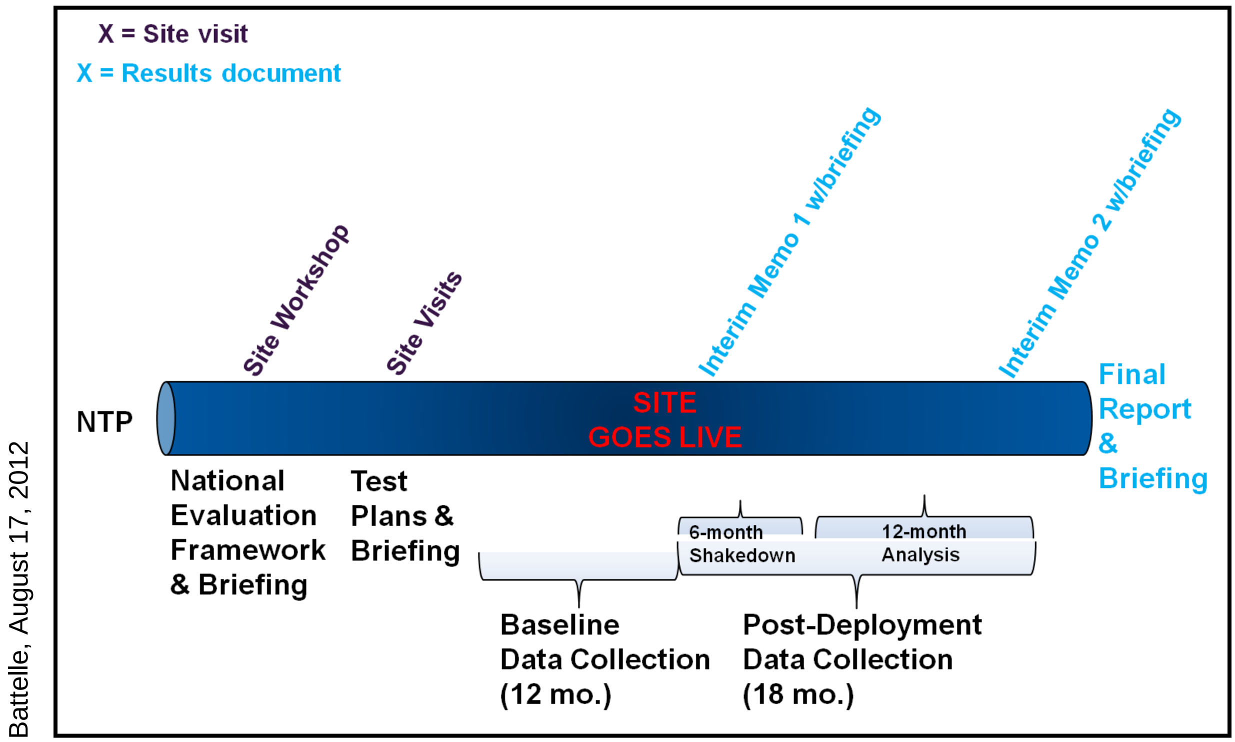

Figure 1-3. Sequence of Evaluation Activities

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

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

1.3.4 Roles and Responsibilities

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

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2.0 ANALYSIS OVERVIEW

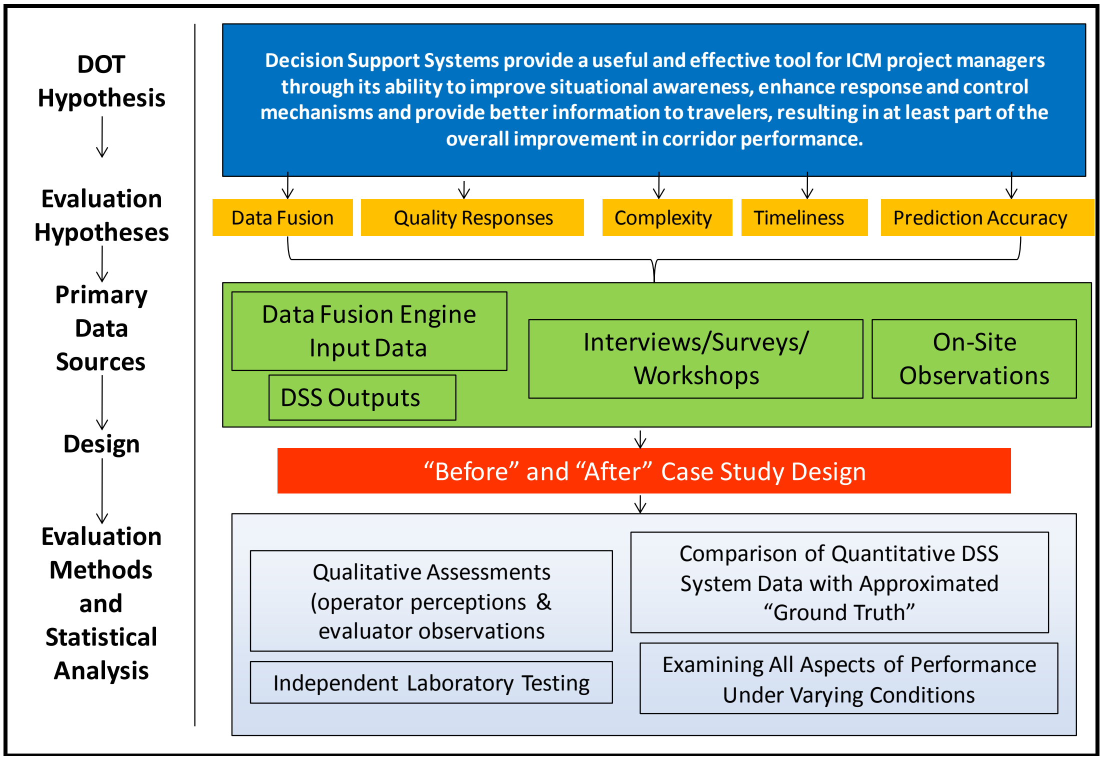
This chapter provides a high-level overview of the approach to the DSS Analysis, including a discussion of evaluation hypotheses to be tested and measures of effectiveness (MOEs). The DSS analysis is one of the two evaluation analyses that focus exclusively on "outputs"—the capabilities acquired by the transportation operating agencies as a result of ICM deployment. The other analysis focusing on outputs is the Technical Capability Analysis. The impact of the DSS on corridor performance outcomes is captured through the Corridor Performance Analysis.

Decision support systems can be considered the "heart" of ICM systems. They provide the critical information and decision making support necessary for transportation operating agencies to understand the significantly increased volume of incoming data and decide between an expanded (by virtue of the ICM deployment) and complex array of alternative actions (response plans)—a determination that can also provide predictions of the results of alternative response plans. This analysis will thoroughly explore specific performance characteristics of the DSS and the overall contributions of the DSS to ICM success. This will include:

- investigation of the ability of data fusion engine to effectively fuse data via the ICMS (where data collection and fusion take place),
- the quality of responses generated by the DSS,
- the accuracy of DSS predictions of transportation system conditions 30 minutes or more into the future,
- the speed of response plan generation, and
- how varying conditions and data loads (e.g., minor incidents, major incidents) impact DSS performance across these various dimensions of performance.

There is no quantitative "before" data since there is no formal DSS technology currently being used. As such, this analysis constitutes a case study and a lab test of capabilities rather than a before-after systems impact assessment.

Figure 2-1 graphically summarizes the approach to this analysis.



Battelle, August 17, 2012

Figure 2-1. Overview of Decision Support Systems Analysis

Table 2-1 provides the analysis' primary data elements, which are further described for evaluating associated MOEs. The national evaluation team will analyze each of the data elements independently, linking the results to the aforementioned evaluation hypotheses which are also listed in the table.

The data elements are categorized by quantitative and qualitative data. A majority of the quantitative data elements will be obtainable through the acquisition of system data from the DSS' fusion engine, while the qualitative data elements will be obtained from manually distributed surveys that will track user impressions.

Discussions of quantitative and qualitative data elements are presented in Chapters 3 and 4, respectively.

Table 2-1. Decision Support System Analysis Hypotheses, MOEs, Data, and Sources[3]

Evaluation Type	Data Element(s)	MOE	Related Hypotheses
Quantitative Data			
1. DSS Outcome Prediction Data	1.1 University of Maryland (UMD) Analysis: generated DSS Simulated Output	• Difference between predicted outcomes and actual operation conditions in terms of corridor performance (volumes, speeds, travel times, throughput), in various scenarios	DSS accurately describes the effect of the various responses
2. DSS Outcomes Data	2.1 UMD Analysis: Outcomes	• Percentage of times operator implements recommended responses • Percentage of times operator alters recommended responses	DSS suggests multiple reasonable strategies and provides the human decision makers with the relevant information to choose between them
3. DSS Timeliness Data	3.1 UMD Analysis: Generated DSS Response Plans	• Average time DSS to deliver an actionable response plan • Average time for DSS to deliver predictions of strategy outcomes	DSS provides recommended strategies with simulated results quickly and any steps that require human intervention can be completed expediently and easily
		• Average number of response plans generated per event-hour[3]	Fewer response plans will be recommended by the DSS during short events during which conditions are relatively stable versus longer events during which conditions vary considerably

[3] The national evaluation team believes that this data will be available in the ICMS system data stream provided by the Dallas site team but was not able to fully verify that based on either the Dallas Draft Detailed Design documentation nor directly with the Dallas site team.

Table 2-1. Decision Support System Analysis Hypotheses, MOEs, Data, and Sources[3] (Continued)

Evaluation Type	Data Element(s)	MOE	Related Hypotheses
Qualitative Data			
4. Dallas Site Team Perceptions	4.1 Dallas Data Fusion Case Study	Case Study: • Case Study for 1.1 on Dallas Data Fusion Engine (see Sections 3.1 and 5.1 for further detail	DSS can take data from disparate sources, standardize/clean it, and turn it into an interpretable and mutually comparable format, successfully recognizing overlaps and gaps in the data streams
5. Operator[4] Perceptions	5.1 TMC Operator Survey	• Responses consistent with operators' experience and perceptions • Perceived quality of responses, including improvement relative to any comparable pre-ICM approaches • Perceived usefulness of information provided to operators for interpretation and decision making, including improvements relative to pre-ICM approaches	DSS suggests multiple reasonable strategies and provides the human decision makers with the relevant information to choose between them
		• Rate the quality of incident responses prior to the deployment of the DSS	DSS provides recommended strategies with simulated results quickly and any steps that require human intervention can be completed expediently and easily

[4] The Term 'operator' in Table 2-1 refers to DalTrans and pertinent municipal transportation management operators

Table 2-1. Decision Support System Analysis Hypotheses, MOEs, Data, and Sources[3] (Continued)

Evaluation Type	Data Element(s)	MOE	Related Hypotheses
Qualitative Data (Continued)			
6. ICM Coordinator Perceptions	6.1 ICM Coordinator Survey	• Perceived quality of responses, including improvement relative to any comparable pre-ICM approaches • Perceived usefulness of information provided to operators for interpretation and decision making, including improvements relative to pre-ICM approaches • Level of operator intervention in altering recommended responses	DSS suggests multiple reasonable strategies and provides the human decision makers with the relevant information to choose between them
		• Perceived accuracy of DSS predictions • Perceived usefulness of the DSS predictions	DSS provides recommended strategies with simulated results quickly and any steps that require human intervention can be completed expediently and easily
7. ICM Operations Committee Perceptions	7.1 ICM Operations Committee Member Survey	• Perceived quality of responses, including improvement relative to any comparable pre-ICM approaches	DSS suggests multiple reasonable strategies and provides the human decision makers with the relevant information to choose between them
		• Perceived accuracy of DSS predictions	DSS provides recommended strategies with simulated results quickly and any steps that require human intervention can be completed expediently and easily

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3.0 QUANTITATIVE DATA

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

3.1 DSS Outcome Prediction Data

Predicted outcome data includes speed, volume, queue length, clearance time, return to normal time, or other "expected future" data about the traffic network. The national evaluation team will examine this prediction data to see if it is accurate in terms of the expected values, trends, or accurate in terms of the amount of time it takes for the road to reach the predicted values. As with all other data elements, it is expected that this data will include timestamps for the time/date at which the prediction was made along with timestamps for when the predictions are expected to become a reality. Prediction data will be compared to the actual field data or outcomes from the mobility portion of the Corridor Performance Analysis (which uses actual field data).

3.2 DSS Outcomes Data

The DSS will suggest multiple potential strategies to the operators and ICM Coordinator, allowing for a decision to be made on the most viable solution based on not only the DSS generated response plan, but the control room observed conditions as well. The test plan will measure the percentage of time the ICM Coordinator approves and operator implements the DSS recommended response plan and how many times it is not implemented. This measure will assist in defining the real-world acceptability of the DSS outputs. Low implementation percentage equals poor DSS response quality and vice versa.

Table 3-1. Quantitative Data Summary

Data Element	Location	Data Source	Data Collection Frequency	Data Collection Period (post-)[5] Start	End	Data Collection Responsible Party	Data Transmittal
DSS Outcome Prediction Data							
1.1 DSS Predicted vs. Actual Corridor Performance	Entire ICM Corridor (see Figure 1-1)	• Public XML Feed • ICM System: 1.2 SmartFusion 1.2.2 Data Dissemination 1.2.3 Data Fusion 1.2.4 Data Collection • Corridor Performance Analysis – Mobility	DSS Operational Periods	April 2013	Oct 2014	ICMS Data Feed	Continuous (UMD Data Feed)
DSS Response Quality							
2.1 DSS recommended responses	Entire ICM Corridor (see Figure 1-1)	• Public XML Feed • ICM System 1.2 SmartFusion 1.2.2 Data Dissemination 1.2.3 Data Fusion 1.2.4 Data Collection	DSS Operational Periods	April 2013	Oct 2014	ICMS Data Feed	Continuous (UMD Data Feed)
DSS Timeliness Data							
3.1 UMD Analysis: DSS timeliness	Entire ICM Corridor (see Figure 1-1)	• Public XML Feed • ICM System 1.2 SmartFusion 1.2.2 Data Dissemination 1.2.3 Data Fusion 1.2.4 Data Collection	DSS Operational Periods	April 2013	Oct 2014	ICMS Data Feed	Continuous (UMD Data Feed)

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[5] Data will be collected from the start of the shakedown period and through the post-deployment period. However, data will only be collected and not analyzed during the shakedown period from April 2013 – October 2013.

3.3 DSS Timeliness Data

The first aspect of the evaluation of DSS "timeliness" will investigate how quickly the DSS is able to identify recommended response plans. To assess this, it is imperative that timestamps from input data are collected along with timestamps for DSS output. For example, it will be important to know that speeds decreased on a roadway at 7:50:02 AM on Dec. 21st, 2011, then an incident was detected and entered into the system at 7:55:03 AM, and then to know that the DSS suggested response plan was generated and "delivered" to the operator at 7:58:05 AM. Understanding the time lags, where they occur, whether they are significant in any way, and how the timeliness may or may not change depending on the complexity of the scenario or current stress on the system will be extremely important. If complex scenarios do not naturally present themselves during the DSS operational phase, then it may be necessary to introduce "pressure testing" in some form. It is, however, quite unlikely that large, complex incidents will not occur throughout the evaluation phase. In this context, "pressure testing[6]" means that if large, complex incidents do not occur naturally during the evaluation period, the University of Maryland (UMD) will develop simulated DSS input data representing such conditions.

Another aspect of the evaluation of DSS timeliness will document and consider the frequency at which the DSS generates response plan recommendations during specific incidents/events and—subjectively—consider whether that frequency appears appropriate given the duration of the incident/event and the variability in conditions over the course of the incident/event. This investigation is based on the premise (supported to some extent through research on ramp metering algorithms in California) that it may be possible to identify/recommend interventions prematurely, that is, to diagnose and recommend a response before traffic and travelers have been able to adjust to the previous intervention. In such a case, the DSS would be recommending responses based on analysis of a traffic/transportation pattern that was unstable—still in flux from the previous response action or intervention. At a minimum, this analysis will document (for a representative sample of incidents/events) the frequency of response plan recommendations by the DSS. This analysis will also endeavor, to the extent possible, to draw observations relative to the appropriateness of the observed frequencies. For example, one response plan implementation over a dynamic, evolving 3-hour incident would appear—on the face of it—possibly too infrequent; that is, not reactive enough to changing conditions over the course of the incident/event. Likewise, generation of a series of 10 DSS-recommended response plans over a fairly static, 28-minute incident may appear too frequent. It is not expected that this analysis will fully address these issues but rather it is intended to take advantage of the available data to advance the currently very limited understanding of these considerations.

[6] In reference to 'pressure testing' it may not be possible to pressure (load) test the DSS without it being taken offline. Therefore, we will evaluate the DSS under observed conditions over the period of testing. However, if possible and deemed necessary; UMD will further investigate the potential to pressure test.

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4.0 QUALITATIVE DATA

This chapter identifies the qualitative data elements to be used in the Decision Support System Analysis. Table 4-1 summarizes key attributes of each data collection activity and the sections that follow provide additional detail for each activity, including survey questionnaires.

Table 4-1. Qualitative Data Summary

Data Collection Activity	Data Collection Periods		Data Collection Schedule		Data Collection Responsible Party	Data Transmittal
	Baseline	Post-Deployment	Baseline	Post Deployment		
4.1 Dallas Data Fusion Case Study		X	X	**Case Studies:** Dec 15, 2013 March 15, 2014 June 15, 2014	National Evaluation Team	Completed case studies sent to National Evaluation Team
5.1 TMC Operator Survey[7]		X	N/A	Nov 15, 2013 Feb 15, 2014 June 15, 2014 Sept 15, 2014 + Immediately following several case study events (pulse surveys)	National Evaluation Team via the Texas Transportation Institute (TTI) Evaluation Liaison / Member of the Dallas Site Team	Completed Surveys sent to National Evaluation Team
6.1 ICM Coordinator Survey		X	N/A	Last Friday of each month during the post deployment period + Immediately following several case study events (pulse surveys)	National Evaluation Team via the TTI Evaluation Liaison / Member of the Dallas Site Team	Completed Surveys sent to National Evaluation Team
7.1 ICM Operations Committee Member Survey		X	N/A	Nov 15, 2013 Feb 15, 2013 June 15, 2014 Sept 15, 2014 + Immediately following several case study events (pulse surveys)	National Evaluation Team via the TTI Evaluation Liaison / Member of the Dallas Site Team	Completed Surveys sent to National Evaluation Team

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[7] 2 Operator survey questions from 5.1 (*Were the DSS recommended responses consistent with your experience and expectations as a TMC operator?* and – *Please rate how your agreement with the following: "The information provided to me by the ICM Coordinator was useful in deciding what response plan I ultimately implemented"*) will be asked during the 'shakedown' period as well (~ late June 2013 and ~ early September 2013), in addition to the post deployment period specified in this table.

4.1 ICM System Data Fusion Engine

The Fusion Engine Analysis will be will be conducted as a "case study," in which the national evaluation team will interview several members of the Dallas site team, shown in Table 4-2, including the ICM Coordinator located at the DalTrans TMC and the Dallas site team lead, Chris Poe to document various design methodologies and decisions including:

Table 4-2. Tentative List of Data Fusion Case Study Participants

Operator Agency	Tentative Participants
DART	Ravi Gundimeda, ICM Coordinator
TTI	Christopher Poe
	Ed Seymour
Telvent	Ahmad Sadegh
	Fariel Bouattoura

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- How the Dallas site team approached data fusion and where they thought it was or wasn't needed;
- Why the site team approached fusion the way that they did including alternatives that were considered and what factors drove their final decision;
- The site team's perceptions of whether their ultimate design worked as planned and if not, why;
- Whether, how, and why they modified their design during shakedown or later; and
- Whether, how, and why any of the national evaluation team's evaluation results related to DSS (e.g., timeliness, accuracy, etc.) may have been influenced by the data fusion approach.

The interviews supporting the case study analysis will be conducted during the Post ICM Deployment timeframe, on December 15, 2013, March 15, 2014, and June 15, 2014.

The Dallas ICM deployment is built off of a commercial 3rd party system called SmartNET. SmartNET, being a subsystem of the ICM System Data, is a proprietary solution that is being modified to meet the needs of the Dallas ICM site. In response to the SmartNET vendor's desires to keep confidential the inner workings of their product, the national evaluation team will, to the extent possible, rely on the systems integrators to provide the data fields with the appropriate time-stamps from the inputs and outputs as shown in Figure 4-1 below.

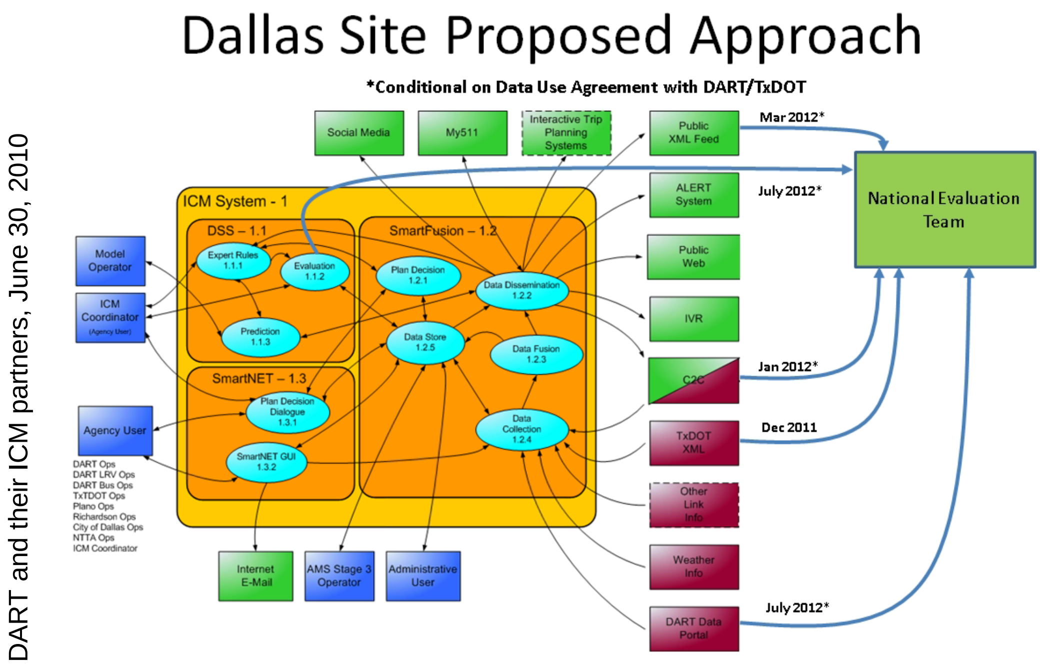

Figure 4-1. Dallas ICM System Architecture

This test plan is based on a high-level understanding of the ICM System Data from reviews of the detailed design documents that have been provided to the national evaluation team from the Dallas site plans. So long as SmartNET developers include appropriate timestamps for all data elements, the evaluation should be able to proceed without issue. Additional information on the evaluation of the fusion engine can be found in Section 5.1.

4.2 TMC Operator Survey

4.2.1 Purpose

The purpose behind surveying the Transportation Management Center (TMC) operators is to garner qualitative impressions of ICMS operating results before and after implementation of the DSS. TMC operators will be working closely with the ICM Coordinator, but are also the front line in any traffic incident management plan, having the final word in executing the recommended automated response based on the information available to them at the time. For this reason, they can provide informed impressions about DSS.

4.2.2 Approach

This survey will be administered to the TXDOT, DART and municipal TMC operators located adjacent to the corridor. The national evaluation team will provide the survey questionnaires to the various TMC Operations Managers who will be responsible for the distribution of the survey and collecting the results that will be provided back to the national evaluation team by TMC operators, as shown in Table 4-3.

Table 4-3. Tentative List of TMC Operator Survey Participants

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

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The survey will be distributed both quarterly and following specific case study events (pulse surveys). The quarterly survey provided to the TMC operators will occur on the following dates[8]:

- November 15, 2013 (only survey that will include the 4th question under 5.1)
- February 15, 2014
- June 15, 2014
- September 15, 2014

The same survey will be distributed as a "pulse survey" within 1 week following events that will serve as case studies. These surveys will summarize the TMC operators' perceptions of a specific event, within a timeframe that allows for the event to be easily recalled. These event-driven surveys will only be administered in conjunction with the "pulse" surveys for the Technical Capability and Traveler Response Analyses (described in separate test plans). Performing traveler (through the Traveler Response Analysis) and ICM agency personnel pulse surveys (in this DSS Analysis and the Technical Capability Analysis) will provide a "360-degree" view of the specific case study (pulsed) events. The determination of which incidents or events will be the subject of the pulse surveys will be made by the Volpe Center, who will administer the traveler pulse surveys. The national evaluation team's understanding is that the Volpe Center will alert the Battelle evaluation team when they are planning to administer a traveler pulse survey so that the Battelle evaluation team can administer their DSS and Technical Capability Analysis pulse surveys.

4.2.3 Questionnaire

Table 4-4 contains the proposed survey questions and their associated response categories.

[8] 2 Operator survey questions from 5.1 (*Were the DSS recommended responses consistent with your experience and expectations as a TMC Operator?* and – *Please rate how your agreement with the following: "The information provided to me by the ICM Coordinator was useful in deciding what response plan I ultimately implemented"*) will be asked during the 'shakedown' period as well (~ late June 2013 and ~ early September 2013), in addition to the post deployment period.

Table 4-4. Questions in the TMC Operator Survey

Question (Numbers reference data elements from Table 2-1)	Response Options
5.1a Were the DSS recommended responses (for example, the development of DMS messages, signal timing changes, or any other ICM-strategy implementing actions with which you are familiar or for which you are responsible) consistent with your experience and expectations as a TMC operator?[9]	(1) Very consistent
	(2) Somewhat consistent
	(3) Neither consistent nor inconsistent
	(4) Somewhat inconsistent
	(5) Very inconsistent
5.1b How would you rate the quality of the incident responses (for example, the development of DMS messages, signal timing changes, or any other recommended actions with which you are familiar or for which you are responsible) compared to your pre-DSS deployment response plans?	(1) Very accurate
	(2) Somewhat accurate
	(3) Neither accurate nor inaccurate
	(4) Somewhat inaccurate
	(5) Very inaccurate
5.1c Please rate how your agreement with the following: “The information provided to me by the ICM Coordinator (generated from the DSS) was useful in deciding what response plan I ultimately implemented.” 9	(1) Strongly agree
	(2) Somewhat agree
	(3) Neither agree nor disagree
	(4) Somewhat disagree
	(5) Strongly disagree
5.1d Prior to DSS, how would you rate the quality of incident responses given the resources and information available to yourself as an operator?[10]	(1) Very good
	(2) Good
	(3) Fair
	(4) Not very good
	(5) Very bad

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[9] 2 Operator survey questions from 5.1 (*Were the DSS recommended responses consistent with your experience and expectations as a TMC operator?* **and –** *Please rate how your agreement with the following: "The information provided to me by the ICM Coordinator was useful in deciding what response plan I ultimately implemented"*) will be asked during the ‘shakedown’ period as well (~ late June 2013 and ~ early September 2013), in addition to the post deployment period.

[10] The Evaluation Team will also consult the AMS Stage 2 results for comparative data.

4.3 ICM Coordinator Survey

4.3.1 Purpose

The ICM Coordinator will be the hub of information when it comes to ICM activities along the U.S. 75 corridor. The ICM Coordinator will be located at the DalTrans TMC and work collectively with the DART and TxDOT TMC operators. This position is responsible for the TMC's utilization of the DSS in the response to incidents. The ICM Coordinator will monitor the DSS and evaluate its generated incident response plans for implementation by the TMC operators. Thus, the person holding the position will be in an ideal situation to provide details related to the DSS' perceived functionality over the course of the post-deployment period.

4.3.2 Approach

The ICM Coordinator, Ravi Gundimeda, will be surveyed every month seeing as this position has the most direct contact with both the DSS outputs and the operators who will be executing the recommended response plans. These short surveys will be completed the last business Friday of every month during the post-DSS deployment period from October 2013 through October 2014. The ICM Coordinator will also receive pulse surveys for the same specific case study events as the ICM Operations Committee and the TMC Operators. The monthly surveys will solicit input on perceptions over the preceding month whereas the case study pulse surveys will solicit input relative to specific events—the same events that will be the subject of the Volpe Center traveler information pulse surveys in the Traveler Response Analysis and the pulse surveys in the Technical Capability Analysis.

4.3.3 Questionnaire

The survey will be presented in a simple document to ICM Coordinator, with the results being tabulated by the national evaluation team. Table 4-5 presents the survey questions and multiple choice answers that will make it easier to record results in an objective manner. Each response is weighted, allowing the final results to be tabulated and reflective of a specific defined value. This survey will be administered only during the DSS deployment phase.

Table 4-5. Questions in the ICM Coordinator Survey

Question (Numbers reference data elements from Table 2-1)	Response Options
6.1a Please rate the quality of the DSS responses, compared to your pre-DSS deployment response plans?	(1) Much better quality
	(2) Somewhat better quality
	(3) Neither better nor worse quality
	(4) Somewhat worse quality
	(5) Much worse quality
6.1b Please rate how your agreement with the following: "The information provided to me by the DSS was useful in deciding what response plan I ultimately recommended for implementation."	(1) Strongly agree
	(2) Somewhat agree
	(3) Neither agree nor disagree
	(4) Somewhat disagree
	(5) Strongly disagree
6.1c How much did you have to intervene with the DSS to alter DSS-recommended response plans?	(1) Always had to intervene
	(2) Sometimes had to intervene
	(3) Seldom had to intervene
	(4) Never had to intervene
6.1d Please rate the accuracy of the DSS predictions of travel conditions.	(1) Very accurate
	(2) Somewhat accurate
	(3) Neither accurate nor inaccurate
	(4) Somewhat inaccurate
	(5) Very inaccurate
6.1e Rate your perceived usefulness of the DSS predictions.	(1) Very useful
	(2) Somewhat useful
	(3) Seldom useful
	(4) Rarely useful
	(5) Never useful

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4.4 ICM Operations Committee Survey

4.4.1 Purpose

The ICM Operations Committee is tasked with overseeing the successful deployment of the ICMS relative to its functional capabilities. The committee meets on a monthly basis to review how traffic congestion has been mitigated through the deployment of ICM resources, most relevant to this analysis, the execution of DSS response plans. The committee, as described to the national evaluation team, is tasked with reviewing a sampling of incidents and determining what level of success the control room experienced in utilizing DSS-recommended response plans.

The purpose of surveying this committee is to gauge the impressions of its members based on its assessment of the DSS functionality. The committee, comprised of several stakeholder agencies, will provide a macro (high level) perspective on the performance of the DSS.

4.4.2 Approach

Each member of the committee, shown in Table 4-6, will be surveyed four times (quarterly) during post-deployment period and following a number of specific case study events (pulse surveys). The quarterly surveys will solicit input on perceptions over the preceding several months. The case study pulse surveys will solicit input relative to specific events—the same events that will be the subject of the Volpe Center traveler information pulse surveys in the Traveler Response Analysis and the pulse surveys in the Technical Capability Analysis. The committee is responsible for assessing the impact and success in ICM deployment.

Table 4-6. Expected ICM Operations Committee Survey Participants

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

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Much of the initial assessment will occur over the first few months into the post-deployment period. As such, it will be appropriate and most beneficial to survey its members after the first couple months of the post-deployment period. Surveys will be conducted on the following dates:

- November 15, 2013
- February 15, 2014
- June 15, 2014
- September 15, 2014

4.4.3 Questionnaire

The survey will be presented in a simple document to each of the ICM Operations Committee participants, with the results being tabulated by the evaluation team. The survey will include the following questions and multiple choice answers that will make it easier to record results in an objective manner. Each response is weighted, allowing the final results to be tabulated and reflective of a specific defined value. This survey will be administered only during the DSS deployment phase.

Table 4-7. Questions in the ICM Operations Committee Survey

Question (Numbers reference data elements from Table 2-1)	Response Options
7.1 Please rate the accuracy of the DSS predictions of travel conditions.	(1) Very accurate
	(2) Somewhat accurate
	(3) Neither accurate nor inaccurate
	(4) Somewhat inaccurate
	(5) Very inaccurate
7.1 Please rate the perceived accuracy and effectiveness of the DSS recommended corridor wide responses being generated and executed.	(1) Very accurate
	(2) Somewhat accurate
	(3) Neither accurate nor inaccurate
	(4) Somewhat inaccurate
	(5) Very inaccurate

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5.0 DATA ANALYSIS

This section presents the approach to evaluating the hypotheses depicted in Figure 2-1. Detailed test plans have been developed for each of the four hypotheses that analyze their associated measures of effectiveness and the reporting of the findings in the technical memos described in Section 1.3.3.

To systematically analyze and interpret the effect of various roadway conditions on the DSS capabilities, special attention will be given to normal daily conditions and periods influenced by special scenarios such as:

- Severe weather
- Major traffic incidents
- Major construction/maintenance
- Holidays (both local and national)
- Incidents involving the Department of Homeland Security
- Major events (e.g., concerts, community festivities)

The national evaluation team will track weather alerts issued by the National Weather Service (NWS). Weather alert information from the NWS will also be stored in the ICM System Data. In addition to proactively observing and tracking weather events, the national evaluation team will review the data that will be obtained from the ICM System Data (via the XML Public Feed, see Figure 4-1) portal on a monthly basis to confirm all severe weather events are recorded. Once a weather event is identified as potentially impacting DSS results, the national evaluation team will gather the following information from the National Weather Service for evaluation: type of event (i.e., snow/ice event, thunderstorms), date and time of the event, duration, event details (e.g., amount of precipitation), and areas of impact.

Planned special events may include but are not limited to sporting events, concerts, and the state fair. Data needed for those events are date, time, duration and location of each event, areas and routes impacted, and traffic management plan implemented. The national evaluation team will obtain planned special event data via the ICM System Data portal (XML public feed) monthly.

This test plan will evaluate DSS responses not only under normal operating conditions, but also under different levels of transportation system complexity.

5.1 Data Fusion Case Study

The purpose of the data fusion case study is to understand how the Dallas site team approached this aspect of ICMS functionality; how well they believe their approach met their objectives; and whether and why any revisions to their approach were necessary over the course of the operational period. As described in Chapter 4, data for the case study will be collected through interviews with a member of the Dallas site team who is in a position to provide comprehensive input on this issue. Notes from the interviews (several interviews will be conducted over the 18-month post-deployment period) will be compiled and reviewed by the national evaluation team and utilized to develop a narrative case study report that will be included as part of the overall Technical Capability Analysis findings. The case study report will include timeline, process and/or other supporting graphical elements as appropriate. In addition to documenting the various "what's, how's, and why's" associated with the Dallas approach to data fusion, the case study will also, as appropriate, include overarching observations and will endeavor to summarize implications for future research and implications for other potential ICM system deployers.

5.2 DSS Accuracy

The analysis of whether the DSS is producing actionable response plans and forecasts of mobility conditions will be crucial in determining whether it is performing as designed or there is missing information in the data fusion process. To measure this, two methods will be instituted. First, a quantifiable analysis of the predicted outcomes produced by the DSS will be compared to the actual conditions. Variances will be tracked and presented in graph-based comparative analysis.

Second, the national evaluation team will survey the ICM Operations Committee for their impressions relative to the predictive accuracy of DSS outputs. The ICM Operations Committee will maintain a broad-based observance of the DSS outputs over the post-deployment period (October 2013 – October 2014) and, therefore, will be well qualified to assess the success of the system. They will be polled via a survey quarterly, starting in the second quarter of the post-deployment period. Each survey will cover their impressions over the previous 90 days.

In order to substantiate the objectives associated with this hypothesis, the MOEs will be analyzed post-DSS deployment. The following MOE's will be evaluated from a quantitative approach:

- The difference between predicted outcomes and the actual operation conditions in terms of corridor performance (volumes, speeds, travel times, throughput) – in various scenarios

The following MOE's will be evaluated from a qualitative approach:

- Perceived accuracy of DSS generated predictions (per the ICM Operations Committee)
- Perceived accuracy of DSS generated predictions (per the ICM Operations Coordinator)

5.3 Timeliness

Obtaining forecasted conditions and incident response plans in a timely manner will be a key issue for the TMC operators, ICM Coordinator, and partner agencies. Therefore, the national evaluation team will track the times it takes to deliver response plans. As noted in Section 3.3, this analysis will also document—for a representative sample of incidents/events of varying durations and complexity—the frequency at which the DSS generates recommended response plans over the duration of an incident/event and, if possible, offer some observations relative to the apparent appropriateness of that frequency.

As data is received by the national evaluation team, abnormal spikes or dips in activity levels (outliers) will be segregated and further analyzed for the contributing factor(s), as listed below. Once the causal factor(s) has been identified, the data will be classified and separated from the now ‘normalized data’ (normal operations data) and compared relative to other events in its same category (e.g., major traffic accident, July 4th holiday, major planned events such as football games), both pre- and post-ICM deployment. This baseline comparison analysis will allow the national evaluation team to compare system performance during various types of operational conditions to see if the system is more or less efficient in certain types of scenarios.

In order to substantiate the objectives associated with hypotheses in this area, the following MOEs will be analyzed post-DSS deployment:

- Average time for the DSS to deliver actionable response plan
- Average time for the DSS to deliver predictions of strategy outcomes
- Average number of response plans generated per event-hour

The analysis of the first two MOEs is expected to be strictly quantitative whereas some qualitative observations on the last MOE (response plan generation frequency) will be developed if possible. Quantitative results will be presented graphically in charts, comparing the time of day performance, complexity performance, etc.

5.4 Quality of the DSS Response

The level of intervention, percentage of interventions, and acceptance rates of the originally recommended DSS response plans, will be measured over the duration of the post-deployment period, reflecting trends during normal operating conditions and unique conditions (i.e., major accidents, heavy volume travel days, special events, etc.).

The goal of the DSS is to intelligently gather agency data and compile potential action plans (responses) that the TMC operator can administer with limited intervention. A high level of intervention would equate to poor output quality.

In order to substantiate the objectives associated with this hypothesis, the MOEs will be analyzed post-DSS deployment. The following MOE’s will be evaluated from a quantitative approach:

- Percentage of times TMC operator implements recommended responses from DSS,
- Percentage of times TMC operator alters recommended responses (without dismissing it completely), and

The following MOE’s will be evaluated from a qualitative approach:

- Responses consistent with the operator’s experience and perceptions (per the TMC operators),
- Perceived quality of responses, including improvements relative to any comparable pre-ICM approaches (per the TMC operators),

- Perceived quality of responses, including improvements relative to any comparable pre-ICM approaches (per the ICM Coordinator),
- Perceived quality of responses, including improvements relative to any comparable pre-ICM approaches (per the ICM Operations Committee),
- Perceived usefulness of information provided to operators for interpretation and decision making, including improvements relative to pre-ICM approaches (per the TMC operators),
- Perceived usefulness of information provided to operators for interpretation and decision making, including improvements relative to pre-ICM approaches (per the ICM Coordinator),
- Level of operator intervention in altering recommended responses (per the ICM Coordinator).

5.5 Exogenous Factors

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

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

  Should these data altering circumstances present themselves, a tailored approach to screening and normalization of affected data will be developed before the data are used in the analysis or such data will need to be excluded from the analysis if data normalization cannot resolve the data quality issue.
- TMC operator tenure relative to their comfort levels when it comes to modifying DSS-generated response plans could have an impact on the MOEs associated with the percentage of times a TMC operator alters a recommended response or the level a TMC operator alters the recommended response. In response to this, the national evaluation team will assess the tenure of the TMC operator staff quarterly and determine whether this factor could potentially affect the resulting statistics and whether there are any grounds for normalizing the data.

6.0 RISKS AND MITIGATIONS

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

Table 6-1. Risks and Mitigations

Risk	Mitigation Strategy
1. Availability of both raw and processed data in a form easily accessible to the national evaluation team.	This is a proverbial "show stopper" for this analysis, therefore, the national evaluation team will work closely with the Dallas site team to determine appropriate connection points for real-time feeds going into the fusion engine (ICM System Data) along with feeds coming out of ICM System Data.
2. Time-stamping of system data	Also a "show stopper," should time stamping of the data not be possible, an alternative means for collecting date/time ranges will need to be incorporated. Potentially reducing the continuous collection of data to pre-planned data "packs" that can be recorded on an as-received basis may be one undesirable alternative.
3. Additional detail on planned DSS functionality and tracking through the design and implementation process.	Without at least minimal access to the DSS interface, full understanding of functionality, usability, and operator interaction will be nearly impossible. Until the actual DSS is operational, there will be questions relative to its actual reporting capability. Should not all of the desired functionality (assumed in this test plan) be realized, the national evaluation team will work with the DSS site team to determine alternative method for data collection in the form of manual strike sheets and data recording processes.

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