Computer-Aided Dispatch – Traffic Management Center Field Operational Test: State of Utah Final Report

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FOREWORD

This *Computer-Aided Dispatch (CAD) –Traffic Management Center (TMC) Field Operational Test (FOT): State of Utah Final Report* provides detail about the integration of the Utah Highway Patrol (UHP), the Utah Department of Transportation (UDOT), the Salt Lake City Fire and Police Departments, the Utah Transit Authority (UTA), and the Valley Emergency Communications Center (VECC) information systems to enable the real-time exchange of incident data. The FOT was designed to demonstrate how the integration of CAD and TMC systems can improve incident response capabilities and how institutional barriers can be overcome. Through the CAD-TMC system, an integrated transportation and public safety incident management information network was developed and implemented for enhanced information-sharing capabilities between multiple incident management response agencies across multiple jurisdictions. This integrated system provides a new information exchange mechanism to complement those that were previously in place. This deployment was implemented specifically for the Incident Management Team Program's Region 2 (Salt Lake Valley), with the intent to expand statewide.

This report will be useful to incident response agencies (e.g., fire and rescue, law enforcement, and transportation) located throughout Utah's four-region Incident Management Team response area. The four-region response area could benefit from having a single, integrated communications system that can be used during traffic incidents, planned or unexpected road closures, construction, or emergency situations. This document provides information for the appropriate incident response agencies to integrate and promote the ability to communicate directly or transmit real-time messages and data via the CAD-TMC integrated system with one another, thereby reducing delays caused by relaying information through operators, dispatchers, or other agencies, and to proactively coordinate their incident management activities. Since the CAD-TMC project has the potential to provide a roadmap for implementing similar networks throughout the United States and in other countries, its progress can be tracked at a national level.

This *Computer-Aided Dispatch –Traffic Management Center Field Operational Test: State of Utah Final Report* provides the conclusions and recommendations to the baseline evaluation criteria used to evaluate the following elements:

- Assess technical and institutional challenges involved in the CAD-TMC deployment.
- Assess the CAD-TMC system performance.
- Determine the CAD-TMC integrated system's impact on efficiency of incident response communications.
- Provide a summary of the lessons learned, recommendations, and benefits associated with the CAD-TMC deployment for use by other agencies contemplating a similar system.

This document supersedes the May 2006 report on the subject.

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16. Abstract

This document provides the final report for the evaluation of the USDOT-sponsored Computer-Aided Dispatch – Traffic Management Center Integration Field Operations Test in the State of Utah. The document discusses evaluation findings in the following study areas:

1) System Functionality: An assessment of the performance of the system and how well the system met technical specifications and functional requirements.

2) System Impact: An assessment of the impact did the integration have on systems operations, in particular impacts on emergency response procedures and response times.

3) Institutional Issues: The identification of institutional issues that were encountered and how these were resolved.

4) Technical Issues: The identification of technical issues that were encountered and how these were resolved.

5) Lessons Learned: The documentation of all lessons learned.

6) Benefits: The identification of both qualitative and quantitative benefits.

7) Conclusions and Recommendations: Utah is one of the very best in the nation in responding to and managing traffic incidents. Utah is fortunate that it had such a positive program in place prior to this field test. A joint process for handling incidents had been developed and refined over several years and included access to 9-1-1/CAD information for all types of incidents. Many of the benefits of an integrated TMC-CAD system were realized well before the field test got underway. The recommendations developed are intended to serve as a general guideline that other states could consider when planning similar CAD-TMC integration projects. The intent was to help states proactively identify issues that may impact deployment cost, schedule, and technical performance, and reflect the lessons learned by Utah during the FOT.

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ABBREVIATIONS

ATMS	Advanced Traffic Management System
CAD-TMC	Computer-Aided Dispatch – Traffic Management Center
CCTV	Closed-Circuit Television
COTM	Contracting Officer's Task Manager
COTR	Contracting Officer's Technical Representative
DOJ	Department of Justice
DPS	Department of Public Safety
DSS	Data Specification Sets
EMS	Emergency Medical Services
ETS	Event Tracking System
FOT	Field Operational Test
GIS	Geographical Information System
IAM	Interagency ATMS Message
IEEE	Institute of Electrical and Electronics Engineers
IMT	Incident Management Team
IP	Internet Protocol
IPR	Interim Project Review
ISDM	Inter-agency Shared Data Messages
ISR	Inter-agency Service Requests
ITS	Intelligent Transportation Systems
ITS JPO	Intelligent Transportation Systems Joint Program Office
I/X	Import/Export
LSI	Legacy System Interface
MOE	Measure of Effectiveness
MOU	Memorandum of Understanding
NTCIP	National Transportation Communications for ITS Protocol
RFP	Request for Proposal
SLC	Salt Lake City
SLCFD	Salt Lake City Fire Department
SLCPD	Salt Lake City Police Department
TMC	Traffic Management Center
TOC	Traffic Operations Center
UDOT	Utah Department of Transportation
UHP	Utah Highway Patrol
USDOT	United States Department of Transportation
UTA	Utah Transit Authority
VECC	Valley Emergency Communications Center
XML	Extensible Markup Language

EXECUTIVE SUMMARY

Background

Reducing traffic-related fatalities and improving emergency response capabilities are two primary goals of the U.S. Department of Transportation's (USDOT) Intelligent Transportation Systems Joint Program Office (ITS JPO), ITS Public Safety Program. To help achieve these goals, the ITS Public Safety Program is committed to:

- Improving incident detection and notification.
- Reducing emergency response times.
- Improving information flows between emergency response agencies (real-time wireless communications links, integration of systems).

To demonstrate how the integration of Computer-Aided Dispatch (CAD) and Traffic Management Center (TMC) systems can improve incident response capabilities and how institutional barriers can be overcome, the USDOT ITS JPO sponsored two field operational tests (FOT) through the ITS Public Safety Program that integrated CAD-TMC systems in Utah and Washington State, respectively.[1] As stated in the Request for Proposals (RFP) for the CAD-TMC Integration FOT evaluation:

> Transportation, law enforcement, fire, and emergency medical personnel are discovering significant improvements in public safety operations can be made when information is shared across organizations and jurisdictions. Equipment and personnel can be more efficiently deployed, incidents can be cleared faster, and incident scenes can be made safer for the responders and the traveling public.

> To date there has been little effort to integrate highway traffic management with public safety systems. Nor have systems supporting public safety operations been developed in the context of a regional ITS architecture or ITS standards. Most existing CAD systems are proprietary and not equipped to easily share information with systems with dissimilar interfaces. Further complicating integration are various data, message formats, and standards used by public safety agencies and transportation agencies. Nevertheless, CAD and ATMS systems can be integrated and data can be shared, provided that a number of related institutional and technical challenges are addressed. New procedures and methods of response that capitalize on the availability of the shared information must also be developed.[2]

It is important to understand the baseline conditions in Utah before discussing the FOT or the evaluation results. The Utah Department of Transportation (UDOT) and Utah Highway Patrol (UHP) had a long-established relationship for sharing details of incidents occurring on the freeway system. UHP has provided a CAD listing of incidents since the opening of its joint center with UDOT in 1999. The Incident Response program that began in 1994 was moved to

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[1] The ITS JPO served as the Contract Technical Representative. The Federal Highway Administration (under ITS JPO jurisdiction) served as the Contract Technical Manager.

[2] USDOT, ITS JPO-sponsored RFP, "National Evaluation of the Computer-Aided Dispatch – Traffic Management Center Integration Field Operational Test Request for Proposals," March 7, 2003, page 1.

this joint center and the operators are dispatched by the UHP. The TMC monitors both the UHP CAD log and the radio frequencies used by UHP troopers and the Incident Management Team (IMT) specialists. The IMT program was expanded in 2000 to Regions 1 and 3 (the regions immediately north and south of the Salt Lake City region) in anticipation of the Winter Olympics. These specialists have direct mobile to mobile communications with the maintenance personnel in their regions.

Due to the existing procedures among the project participants, it is a recognized challenge for the CAD-TMC integration FOT to show substantial improvement in accuracy and timeliness of incident reporting and response.

The CAD-TMC Integrated System

Utah's integrated CAD-TMC system was intended to include the following elements and perform the associated functions:

- **Create a common message set**, structured in a uniform and open format, to enable the exchange of information between multiple agencies with unique requirements, policies, and operating environments. Two interagency-shared data messages (ISDM) are planned: the inter-agency service requests (ISR) and the interagency Advanced Traffic Management System (ATMS) message (IAM). The ISR specifically requests services rendered by public safety agencies and secondary responder services. ISRs may be between CAD systems and/or between CAD systems and ATMS to specifically request public safety and secondary responder services. The IAM relates to traffic condition advisories and traffic control requests between CAD systems and the ATMS.
- **Support the ISRs via data specification sets (DSS)** that incorporate the standard data elements found in all CAD Systems. The DSS will specify an Extendable Markup Language (XML) application to Import and Export (I/X) the data sets. The DSS will also specify the data standards for each element, as per the Institute of Electrical and Electronics Engineering (IEEE) standards, including IEEE 1512-2000, 1512.1, and 1512.2, as available and applicable. The ISR-DSS specifications will be in the public domain.
- **Select a commonly used operating system and language** (e.g., Windows 2000 and Visual Basic) to develop legacy system interfaces (LSI) between existing UHP and UDOT systems to enable information exchange. The LSI will be a stand-alone server program in the public domain designed for nationwide application at Traffic Management Centers (TMC) for the ISR and IAM messages between different vendor CAD systems and between CAD systems and ATMS.
- **Develop LSIs between the State systems and county and municipal government systems** (Valley Emergency Communications Center [VECC], Salt Lake City [SLC]).
- **Integrate the new Utah Transit Authority (UTA) CAD system** currently under development.
- **Continue UDOT ITS Division-developed unique browser-based Event Tracking System (ETS) to manage and update planned events (**i.e., roadway construction), and in real-time for subsequent dissemination to the traveling public. The ETS is being deployed statewide, and will be used by local city, county, and State agencies. Information from the ETS will be updated and integrated into the CommuterLink traffic management system, including 511, using XML.

System Performance Test Results

The system performance study was designed to:

- Describe the environment in which the FOT will operate that could affect the applicability of the CAD-TMC concept to other sites and the interpretation of the system impacts data. This will help other potential deployment users to better understand the applicability of the CAD-TMC concept to their sites.
- Identify key performance measures that should be met by similar deployments to achieve the system impacts observed by the FOT deployment. This will help other deployment users identify and focus on the performance goals needed to achieve similar results. Also, document the design basis for these performance measures to help other deployment users adjust these measures to better suit their local conditions.
- Calculate and document the key performance measures for the system as it was deployed. This will help identify limitations in the deployed system that might affect the observed system impacts. Also, identify and document other performance measures that are gathered by the deployment team (e.g., during component and integration testing). While this data is not as critical to the evaluation as the key measures, the data should be available from the deployment team to reduce the cost associated with reporting the data.
- Identify other factors that affect the deployed system's performance. After the system is deployed, users may identify other factors that could make the system more useful and knowledge that could benefit others in developing similar systems.

In addition to these activities related to evaluating the performance of the deployed system, the system performance study was intended to:

- Evaluate the degree to which ITS standards such as IEEE 1512 and National Transportation Communications for ITS Protocol (NTCIP) were incorporated into the deployed system.
- Address the approach used to share data between map databases from different vendors and GIS standards that were applied.

The system performance study was evaluated through:

- Interviews with project management and technical staff.
- Observations of technical staff using the integrated system at TMCs.
- Review of data obtained from the integrated system.

The system performance test results are summarized in table 1.

Table 1. System Performance Test Results Summary

Evaluation Objective	Hypothesis	Test Results
Objective #1: Document the system component performance.	The system meets functional specifications.	Achieved.
	The CAD and TMC systems will be able to link data on an incident.	Achieved.
	Using the system improved incident response procedures.	To a significant extent, achieved through prior projects. Project specific impact not measurable.
Objective #2: Automate the seamless transfer of information between traffic management workstations and police, fire, and EMS CAD systems from different vendors.	The system meets functional specifications.	Achieved.
	The FOTs will decrease the reliance on manual methods for exchanging information.	Preliminary result – achieved.
	The FOTs will increase the extent and reliability of information exchanges.	Preliminary result – achieved.
Objective #3: Extend the level of integration to include secondary responders such as utilities, towing and recovery, public works, and highway maintenance personnel.	Improved integration of secondary responders will reduce incident recovery time by getting required recovery personnel to the incident site as quickly as possible to begin recovery operations.	Secondary responders (ambulance, utilities, etc.) were not included in the project.

Objective #1: Document the System Component Performance

The Evaluation Team relied on a combination of observations and interviews to determine whether or not the system component performance meets functional specifications. Seeing the system work and finding out if the system meets operator expectations are the best indications of successfully meeting system performance needs.

After the integrated system was implemented, a demonstration of the capability was held at the TMC with positive results. A mock incident was sent from the UHP to the TMC, with the TMC having the ability to review each detail of the incident. The TMC staff was able to input updates to the incident information without needing to telephone the information to the UHP. The demonstration clearly illustrated that the technology works properly and has expanded the potential for improved sharing of future incident details.

Objective #2: Automate the Seamless Transfer of Information between Traffic Management Workstations and Police, Fire, and EMS CAD Systems from Different Vendors

From observations and interviews, it was demonstrated that the integrated system reduces the reliance on manual methods for exchanging information. Incidents reported by partner agencies are transmitted to the integrated system and easily imported into the UDOT incident management system. Sharing information on incidents reported by other agencies, particularly

from the Valley Emergency Communications Center (VECC), has significantly reduced UDOT operator reliance on listening to scanners to "discover" incidents of interest.

Objective #3: Extend the Level of Integration to Include Secondary Responders such as Utilities, Towing and Recovery, Public Works, and Highway Maintenance Personnel

Secondary responders have not yet been included in the FOT, and this component of the evaluation was not conducted.

System Impact Test Results Summary

The system impact study was designed to:

- Determine if the CAD-TMC integration improves the efficiency and productivity of incident response.
- Determine if the CAD-TMC integration improves mobility and reduces delays during incidents.
- Determine if CAD-TMC integration enhances incident-specific traffic management plans.
- Determine if the CAD-TMC integration will reduce exposure of response personnel and secondary crashes during incident response activities
- Determine if CAD-TMC integration will improve incident management information available to travelers.

The system impact study was evaluated through:

- Interviews with project management and technical staff.
- Observations of technical staff using the integrated system at TMCs.
- Review of data obtained from the integrated system.

Evaluation findings related to the seamless transfer of information between the traffic management workstations and police, fire, and EMS CAD systems from different vendors were qualitative, as follows:

- From observations, communication among response agencies was enhanced by CAD-TMC integration. Project meetings enhanced face-to-face communication. Phone calls are focused on clarifying specific information rather than trying to receive all of the information on an incident.
- From observations, efficiency in documenting incident management improved.
- From interviews, scene clearance time improved. Better traveler information allows the public the opportunity to bypass the incident which leads to less congestion and better response sooner (response units getting to the scene via a clear route). This conclusion by responding agencies could not be verified.
- There were some apparent inconsistencies between the codes included in the "before" data collected (April – June 2004) and the "after" data collected (April – June 2005). The reasons for the inconsistencies are not known, but could range from a problem in translation to broader data issues. The questions that followed from these inconsistencies, however, led to the team rejecting most of the quantitative analysis that was done on the before and after data sets.

- An additional issue encountered with the before data was that the "end time" field was recorded on the hour or half hour or was not completed, making the use of this data for quantitative analysis problematic.
- It should be noted, however, that a significant benefit of the FOT was a significant improvement in the quantity and quality of data collected. The system is generating standardized identification codes that all agencies understand and is also generating accurate incident "start time" and "end time" data.

The system impact test results are summarized in table 2.

Table 2. System Impact Test Results Summary

Evaluation Objective	Hypothesis	Test Results
Objective #1: Productivity –To determine if the CAD-TMC integration improves the efficiency and productivity of incident response.	CAD-TMC integration enhances communications among responders.	Achieved – Key issue to be addressed is that of refining information exchange to meet agency specific requirements.
	CAD-TMC integration improves efficiency of on-scene operations.	Not measured during the evaluation.
	CAD-TMC integration enhances efficiency in documenting incident management.	Achieved.
	CAD-TMC integration reduces incident clearance times.	Not measured during the evaluation.
Objective #2: Mobility – To determine if the CAD-TMC integration improves mobility and reduces delays during incidents.	CAD-TMC integration enhances mobility during incident management (IM) activities.	No impact measured during the evaluation.
Objective #3: Capacity/ Throughput –To determine if CAD-TMC integration enhanced incident-specific traffic management plans.	CAD-TMC integration enhances incident-specific traffic management plans.	Not measured during the evaluation.
Objective #4: Safety – CAD-TMC integration will reduce exposure of response personnel and secondary crashes during incident response activities.	CAD-TMC increases safety for response personnel.	Not measured during the evaluation.
	CAD-TMC increases safety to the traveling public.	Not measured during the evaluation.
Objective #5: Traveler Information – To determine if CAD-TMC integration will improve incident management information available to travelers.	CAD-TMC integration enhances customer satisfaction and mobility during incident management activities by improving traveler information.	Qualitative assessment: Improved ability to post incident information for public access via 511, Web site.
UTA Objective: To determine if the integration of the UTA CAD system improves UTA's ability to respond to incidents.	The CAD-TMC integration will enable UTA to more effectively implement reroute decisions in response to an incident.	CAD-TMC integration provided real-time information on unplanned incidents and complemented existing UTA incident management procedures. Additional benefit from system is information provided on planned incidents, such as road closures and/or construction activities.

Benefits Summary

Enhanced field operations were associated with locating and responding to incidents. To a significant extent, this benefit was previously realized by Utah. UDOT and UHP had previously co-located staff at TMCs, and CAD terminals were placed in TMCs to enable data sharing. The most significant benefit realized by the project was the ability to engage in direct data exchange between legacy systems rather than having an operator observe two or more terminals. This real-time exchange of data adds to the benefits previously obtained through inter-agency cooperation and represents an additional enhancement of field operations and fills what had been a gap in the existing incident management and response program already in place in Utah.

Geo-location for placing incidents and marginal improvement in scene clearance. Observed benefits included the use of Geo-location in providing a mechanism to place incidents without operator intervention, and from interviews, a qualitative assessment that scene clearance time seemed to improve marginally. Better traveler information allows the public the opportunity to bypass the incident which leads to less congestion and better response sooner (response units getting to the scene via a clear route). This logic seems sound; however, data was not available to support these conclusions.

Enhanced communications among responders; enhanced on-scene activities. The evaluation was not able to completely assess this benefit. The system is newly deployed and while operational is still undergoing refinement. This benefit would be more accurately assessed when the system has matured and has been in use for a period of several years instead of several months.

Enhanced efficiency in documenting the incidents. In the first 2 months of operation, the number of incidents documented by the integrated system increased by about 800 percent, as noted in section 4.2.1. The number of incidents for which the TMC maintained data increased significantly after the CAD-TMC integration. The main difference observed between the before and after data discussed above was that UDOT seemed to maintain much more complete incident records after the deployment, both in terms of the number of incidents recorded and the details recorded about each incident. It is believed that this increase is due in large part to the fact that CAD data was more readily available to TMC operators after the CAD-TMC deployment. This is supported, in part, by the large number of incidents in the after data for which Dispatch Services/9-1-1 were listed as the reporting agency.

Improved data quality. The electronic data collection, particularly in recording the incident start and stop times, has significantly improved overall data quality. An additional example of this is reflected in a decrease in the error rate for the coding of incidents by type.

Improved interagency working relationships. Utah had already achieved substantial progress in this area, and the project represented a continuation of this benefit. Utah's success in this area is represented by the inter-agency discussions on the amount and type of data that should be exchanged between the systems—the inter-agency cooperation that enabled this data exchange established the venue for addressing this type of system refinement based on initial deployment experience.

Enhanced communication with the traveling public and media. This benefit would be more properly addressed at system maturity. While anecdotal evidence obtained during after project interviews indicates that enhanced communication is occurring, assessing this metric based on several years of implementation experience will provide a more accurate measure the benefit of enhanced communication to the traveling public and the media. From observations, efficiency in documenting incident management improved. This was

presented in section 4.1, and was also an objective of the system impact study. Input for some fields was automated so UDOT operators did not have to enter this data.

Conclusions

Utah is fortunate that it had a well-established Incident Management program in place prior to this field test. A joint process for handling incidents had been developed and refined over several years and included access to 9-1-1/ CAD information for all types of incidents. Many of the benefits of an integrated TMC-CAD system were realized well before the field test got underway.

The FOT has proven worthwhile for the agencies to continue their quest to develop a true real-time data exchange system. As improvements are completed, operators from both agencies will recognize the benefits. To date, the agencies have already benefited from improved data collection, both in quantity and quality.

The real value of this FOT can be applied in Region 4 within Utah, and in other states that do not have the interoperability and strong institutional relationships that are already in place in the Salt Lake Valley region. This is especially true for areas where multiple agencies from state and local government agencies may respond to incidents on freeways, such as home rule states,[3] where interoperable CAD would be a huge benefit in trying to provide real-time traffic information. This would apply both to other regions within Utah and to other states. Delays in obtaining information in these outlying areas far exceed the delays that occur in the Salt Lake City area and sometimes significant events are not reported to UDOT at all. The strong institutional relationships already established in Utah, both between state agencies and state and local government agencies, can serve as a model to other regions on how to achieve interoperability.

Recommendations

A number of recommendations were developed as a result of the FOT. These recommendations are offered to other states or jurisdictions considering similar deployments, and are intended as a guide to help identify issues that could impact system deployment, in particular, cost, schedule, and system performance. Also included are transit-specific lessons learned, with recommendations derived from UTA's participation in the project.

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[3] The term "home rule states" refers to a certain type of governmental organization within states. The following definition of home rule is incorporated from the National League of Cities Web site: <http://www.nlc.org/about_cities/cities_101/153.cfm>: "Home rule is a delegation of power from the state to its sub-units of governments (including counties, municipalities, towns or townships, or villages). That power is limited to specific fields, and subject to constant judicial interpretation. Home rule creates local autonomy and limits the degree of state interference in local affairs."

General Recommendations

#1: Involve IT staff early-on in the project planning process. Interviewees mentioned the importance of involving agency information technology staff early in the development of the integrated system. This is important so the IT organization provides technical input to the system to assure that the computing and communication environment fit within each agency and can be effectively maintained.

#2: Understand the importance of close working relations from the start. All of those interviewed by the Evaluation Team mentioned the importance of the close working relationship among the agencies involved in this FOT. The close working relationship was strengthened by the work these agencies did in preparation for and during the 2002 Winter Olympic Games. Although not every region can strengthen relationships among agencies by hosting the Olympic Games, agencies should consider how to build these relationships in advance implementing an integrated system.

#3: Provide dedicated staff working on integration, or staff with emphasis on integration. Interviewees mentioned that it was often difficult to spend enough time on the integrated system. Decisions and work items sometimes took longer than those involved would have preferred. Even though every agency supported the integrated system, staff had normal responsibilities with integration duties added on. It would be ideal if staff involved had a priority on the integrated system tasks.

#4: Build in short development cycles to reduce staff turnover issues. Interviewees mentioned that some agencies had critical staff turnover during the implementation of the integrated system. Staff turnover can be disruptive to implementation schedules and budgets as new people have to come up to speed on the system. If the system is planned to have incremental implementations (see section 5.4, Technical Challenges), then the development cycles for each incremental implementation can be short to minimize the likelihood that staff will turnover during a given development cycle. Staff turnover between cycles is not as disruptive as turnover during a development cycle.

#5: Understand the importance of considering role of business practices in the integrated system. As discussed earlier in this document, it is important that the integrated system not require a change in the operator's or dispatcher's work process. However, if other aspects of an agency's business practice would improve the integrated system, it should be considered. For example, VECC agencies were concerned about providing certain information to the integrated system. UDOT is planning to develop an MOU with the VECC agencies that will specify how the information will be used. This may allow a change in those agencies' business practices that will lead to more information shared in the integrated system.

#6: Understand the importance of coordination meetings. Interviewees mentioned the importance of ongoing, periodic coordination meetings with the partner agencies. These meetings kept communication open and emphasis on the integrated project.

#7: Coordinate deployment schedule with vendor schedule for system modifications and upgrades. As mentioned in section 5, CAD systems are generally off-the-shelf products. Vendors have a fixed release schedule. It is important to coordinate project schedules with the vendors' release schedules.

#8: Define what data is exchanged and when. In the Utah system, the IEEE 1512 standard was selected for incident management messages and codes. However, not all vendors supported those codes. It is important for agencies to prepare for differences in codes and determine how to handle these differences.

#9: Decide what incidents will be shared among agencies and what information will be exchanged when an incident is shared. The experience in Utah is leading the participating agencies to automatically send incidents of interest and allow the receiving

systems to filter those incidents to display the ones that are likely to be of most interest to the operators.

#10: Understand the importance of incremental implementation. In the Utah system, agencies learned a lot in the initial implementation of the integrated system. The agencies are using that knowledge to plan improvements to the integrated system. For agencies planning an integrated system, it is recommended that they plan an initial implementation and at least one subsequent, incremental improvement. Any group of agencies is almost certain to learn how they would prefer to have the system operate. The project and related contracts should be arranged to allow the agencies to implement what they learn in the initial implementation.

#11: Understand the importance of redundant communication path. As discussed in section 5, a back-up communication pathway is important. Agencies should plan to include redundant communications in an integrated system.

#12: Minimize or avoid duplicate entry. Because not all needed information is transferred from VECC to the integrated system, UDOT operators have to enter data in their system that was already entered by VECC dispatchers in their system. Ideally, any given piece of information would only be input once by any operator in the integrated system. This is an important concept to plan for in any integrated system.

Transit-Specific Recommendations

Transit #1: Expect a great deal of complexity in interfacing with the various network protocols and security infrastructures for multiple public sector agencies, in particular, given the sensitive nature of much of the subject matter for the messages. Not everything UTA thought it understood at the outset turned out to be correct, both technically and institutionally. There is no effective way to learn these things other than by working through them with the other agencies, and it is useful to understand that extra time and effort will be needed.

Transit #2: A technical example was the need to make various unexpected changes in UTA's messaging interface to accommodate the specific configurations of the messaging system interfaces developed later by other agencies. UTA did not anticipate the amount of time that would be needed for such adjustments to the configuration of its software.

Transit #3: An institutional example was the unexpected difficulty for dispatchers in being able to quickly interpret public safety agency incident messages, due to the various codes and jargon used.

Transit #4: For agencies that need to work with a vendor for the necessary enhancements to their respective CAD systems, it will be useful to establish strong working relationships and effective contractual mechanisms for ongoing technical support. It would be difficult to anticipate the specifics of all required vendor support for incorporation into system specifications. This leads to vendor support being needed for requirements that were not necessarily incorporated into UTA's original specifications. Since UTA developed and enhanced its software using in-house resources, it did not need to work with a vendor and did not experience this directly. However, several of the other agencies did need to work with their respective CAD software vendors to implement the changes, and this was UTA's observation on the effect.

Transit #5: Incident information generated by public safety agencies needed to be filtered and processed before being presented, for effective use by transit dispatchers. In their raw form, it was found that only some of these incident messages would affect traffic. In addition, the message description contained a range of information not needed by transit operations and in a format that was difficult to decipher. The filtering and processing could be performed either by a designated staff person, or by another agency such as UDOT. The

purpose of this filtering and pre-processing for UTA would ideally be to (1) limit messages to those that could affect traffic in main corridors of the UTA service area; (2) provide a plain language description of the potential traffic impact location; and (3) distinguish between messages about new incidents and updates on existing incidents.

1. INTRODUCTION

1.1   BACKGROUND

Reducing traffic-related fatalities and improving emergency response capabilities are two primary goals of the U.S. Department of Transportation's (USDOT) Joint Program Office (JPO) Intelligent Transportation Systems (ITS) Public Safety Program. To help achieve these goals, the ITS Public Safety Program has implemented a number of initiatives with specific objectives toward:

- Improving incident detection and notification.
- Reducing emergency response times.
- Improving information flows between emergency response agencies (real-time wireless communications links, integration of systems).[4]

Currently, most major metropolitan areas in the United States rely on some type of Advanced Traffic Management System (ATMS) to help manage mobility, congestion, and incident response. Many states have installed an extensive infrastructure of remote cameras, loop detectors, and other ITS applications that provide traffic management services. These systems are operated from centralized Traffic Management Centers (TMC), where traffic-related information is received and processed, and appropriate remedial actions are deployed and coordinated. However, to date, many of these systems are not integrated with the CAD systems used by law enforcement agencies.[5]

1.2   PROBLEM STATEMENT

The USDOT-funded Computer-Aided Dispatch Traffic Management Center (CAD-TMC) integration and data exchange Field Operational Test (FOT) is one of many initiatives implemented to meet the ITS Public Safety Program goals. The objective of this FOT was to improve information flows between emergency response agencies and improve incident response capabilities. The intent was to develop the technical capability to exchange information as well as to identify and resolve the institutional barriers that can arise when multiple agencies are involved in this type of project.

To achieve these objectives, the USDOT sponsored two FOTs that integrated CAD-TMC systems in Washington State, and Utah, respectively. Both states have well-established incident response programs and have developed the institutional relationships needed to support multiple agency information exchange.

The rationale for this effort was stated in the Request for Proposals (RFP) for the CAD-TMC Integration FOT evaluation:

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[4] Excerpted in part from the UDOT ITS Program Safety Web site: <http://www.its.dot.gov/pubsafety/index.htm> (February 7, 2006).
[5] USDOT, ITS JPO, ITS Public Safety Program article, "Utah, Washington State Projects Will Demonstrate Integration of Intelligent Systems and Computer-Aided Dispatch," accessed from: <http://www.itspublicsafety.net/law_fldtest.htm> (February 7, 2006).

> *To date there has been little effort to integrate highway traffic management with public safety systems. Nor have systems supporting public safety operations been developed in the context of a regional ITS architecture or ITS standards. Most existing CAD systems are proprietary and not equipped to easily share information with systems with dissimilar interfaces. Further complicating integration are various data, message formats, and standards used by public safety agencies and transportation agencies. Nevertheless, CAD and ATMS systems can be integrated and data can be shared, provided that a number of related institutional and technical challenges are addressed. New procedures and methods of response that capitalize on the availability of the shared information must also be developed.[6]*

It is important to understand the baseline conditions in Utah before discussing the FOT or the evaluation. The Utah Department of Transportation (UDOT) and Utah Highway Patrol (UHP) have cultivated a long-standing relationship for sharing details of incidents that occur on the freeway system. UHP has provided UDOT with a CAD listing of incidents since the opening of its joint center with UDOT in 1999. The Incident Management Program that began in 1994 was moved to this joint center where the DOT field responders are dispatched by the UHP. The TMC monitors both the UHP CAD log and the radio frequencies used by UHP troopers and the Incident Management Team (IMT) specialists.

The IMT program was expanded in 2000 to Regions 1 and 3 (the regions immediately north and south of the Salt Lake City region) in anticipation of the Winter Olympics. These IMT specialists have direct mobile to mobile communications with the maintenance personnel in their regions. The IMT specialists respond to incidents to provide a full range of incident management services to prevent secondary crashes, reduce congestion, and restore normal traffic as soon as possible. Figure 1 presents a map of Utah delineating the three regional areas (Regions 1 – 3) served by the IMT program.

Given the nature of this well-established program, many of the benefits that might be expected from this type of FOT have already been realized, in particular, the resolution of institutional barriers. Due to the existing procedures as defined, it is a recognized challenge for the CAD-TMC integration FOT to show substantial improvement in accuracy and timeliness of incident reporting and response. To further improve the overall performance of incident response in the field is also a major challenge because of the stringent performance standards put in place for the 2002 Winter Olympic Games. UHP and UDOT emphasized quick clearance of incidents. They tracked each aspect of incident management to ensure they are keeping closures to an absolute minimum. Follow up training and after action review meetings were used for improved performance prior to and after the Games to ensure better response and clearance of all types of incidents. However, the FOT did address a key gap in the program – the ability of the agencies to exchange incident data electronically on a real-time basis using common formats and standards.

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[6] USDOT, ITS JPO-sponsored RFP, "National Evaluation of the Computer-Aided Dispatch – Traffic Management Center Integration Field Operational Test Request for Proposals," March 7, 2003, page 1.
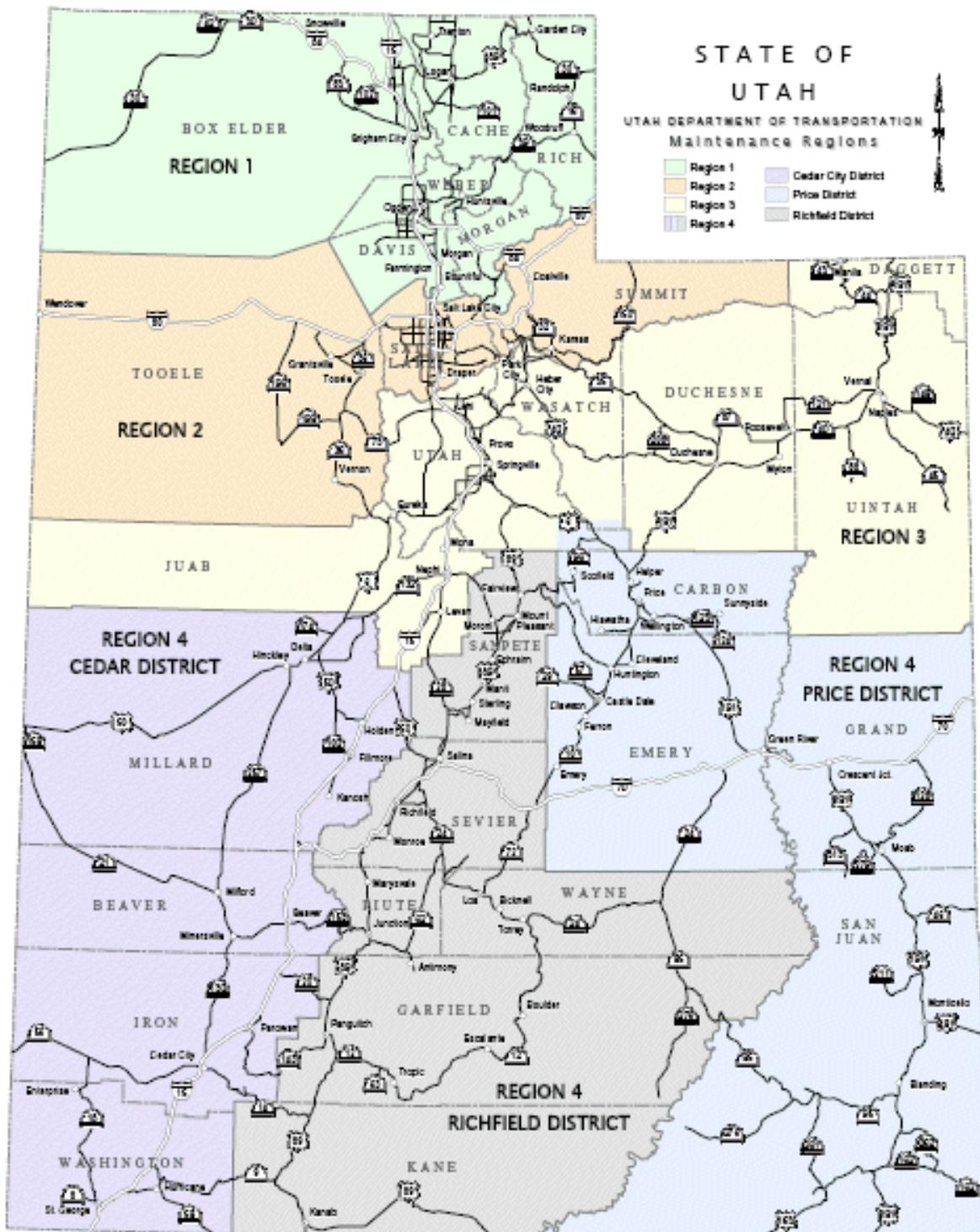
**Figure 1. Utah Area Map Showing Regions 1-3 Served by the
Incident Management Program.[7]**

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[7] Source: Utah Department of Transportation.

UDOT served as the lead agency of the FOT. In addition to UDOT, the other Government agencies that participated in the CAD-TMC integration FOT included:

- SLC Police Department (SLCPD).
- SLC Fire Department (SLCFD).
- Utah Department of Public Safety (DPS).
- Valley Emergency Communications Center (VECC).
- Utah Transit Authority (UTA).
- USDOT's ITS JPO.

1.3   REPORT ORGANIZATION

The USDOT determined that the Utah CAD-TMC integration FOT should be evaluated under the Joint Program Office's National ITS Assessment Program. This final report presents the evaluation findings of the FOT.

The remainder of this report is structured as follows:

- **Section 2 – Implementation Results:** This section summarizes the results of the FOT implementation. The summary includes information on project components that were successfully implemented and project components that were not implemented or not completed at the time the evaluation was completed.
- **Section 3 – Evaluation Strategy:** This section summarizes the strategy developed for the evaluation and how this strategy was implemented. This includes a discussion of data collection, both quantitative and qualitative, and the mid-term modification to the evaluation scope and schedule.
- **Section 4 – Test Results:** This section presents the detailed results for two of the tests conducted as part of the evaluation:
  - System Performance Study – An assessment of how well the system met technical specifications, including as assessment of the standards used for system deployment.
  - System Impact Study – An assessment of what impact the integration had on incident response procedures, operations, and system mobility.
- **Section 5 – Evaluation Findings:** This section discusses the findings of the evaluation. Findings are presented in support of each test component discussed in section 4 plus the results of the following study:
  - Institutional and Technical Issues – How these issues are identified, what the specific issues are, and how the issues have been resolved.
- **Section 6 – Conclusions and Recommendations:** This section discusses overall conclusions and recommendations, and presents the following results:
  - General and transit-specific recommendations for technical and institutional lessons learned: What are the lessons learned, and how are they useful to ITS JPO and other states considering similar deployments.
  - Benefits Summary: A summary of the quantitative and qualitative benefits identified during the evaluation.

2. IMPLEMENTATION RESULTS

2.1   INTENDED SYSTEM ELEMENTS AND FUNCTIONS

Utah's integrated CAD-TMC system was intended to include the following elements and perform the associated functions:

- Create a common message set, structured in a uniform and open format, to enable the exchange of information between multiple agencies with unique requirements, policies, and operating environments. Two interagency-shared data messages (ISDM) are planned: the inter-agency service requests (ISRs) and the interagency ATMS message (IAM). The ISR specifically requests services rendered by public safety agencies and secondary responder services. ISRs may be between CAD systems and/or between CAD systems and ATMS to specifically request public safety and secondary responder services. The IAM relates to traffic condition advisories and traffic control requests between CAD systems and the ATMS.
- Support the ISRs via data specification sets (DSS) that incorporate the standard data elements found in all CAD Systems. The DSS will specify an Extendable Markup Language (XML) application to Import and Export (I/X) the data sets. The DSS will also specify the data standards for each element, as per the Institute of Electrical and Electronics Engineering (IEEE) standards, including IEEE 1512-2000, 1512.1, and 1512.2, as available and applicable. The ISR-DSS specifications will be in the public domain.
- Select a commonly used operating system and language (e.g., Windows 2000 and Visual Basic) to develop legacy system interfaces (LSI) between existing UHP and UDOT systems to enable information exchange. The LSI will be a stand-alone server program in the public domain designed for nationwide application at TMCs for the ISR and IAM messages between different vendor CAD systems and between CAD systems and ATMS.
- Develop LSIs between the State systems and county and municipal government systems (Valley Emergency Communications Center [VECC], Salt Lake City [SLC]).
- Integrate the new UTA CAD system currently under development.
- Continue UDOT ITS Division-developed unique browser-based Event Tracking System (ETS) to manage planned events (i.e., roadway construction), and to update these events in real-time for subsequent dissemination to the traveling public. The ETS is being deployed statewide, and will be used by local city, county, and State agencies. Information from both the ETS and the existing 511 system will be updated and integrated into the CommuterLink traffic management system using XML.

The system architecture developed for the Utah CAD-TMC integration FOT is shown in figure 2.[8]

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[8] Incorporated from: State of Utah, "A Proposal for the Integration of Computer-Aided Dispatch – Traffic Management Integration Field Operational Test," p. 16, (July 11, 2002).
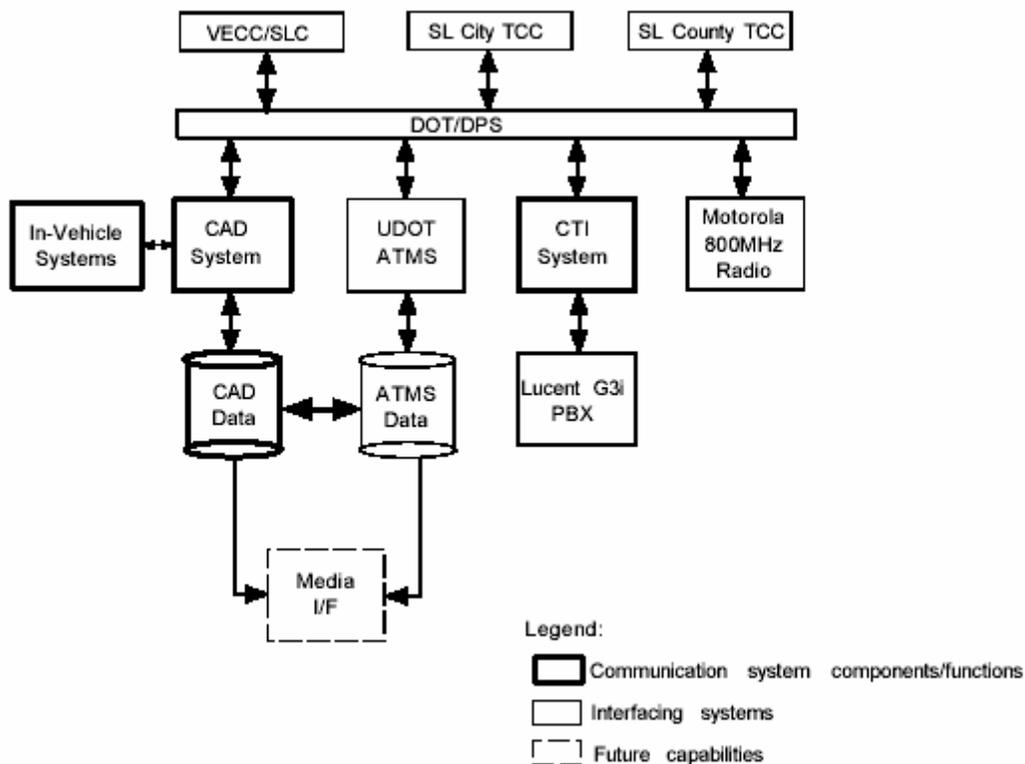
Figure 2. Utah CAD-TMC System Architecture.[9]

2.2   IMPLEMENTED SYSTEM

For the FOT, the participating agencies used their existing CAD and related technologies. The Traffic Operations Center's (TOC) CommuterLink continued to provide the current ITS technologies, including closed-circuit television (CCTV) roadway coverage. UDOT distributes CommuterLink's CCTV video images and image selection controls to SLCPD, SLCFD, VECC, and UTA. Traffic information also is available via CommuterLink's Web pages (http://commuterlink.utah.gov/ie.htm). The CAD-TMC integration FOT tested the specific effects of introducing the shared data from the participating agencies, as facilitated by CAD-to-CAD ISRs and CAD-to-ATMS IAMs, regarding the performance of responders and related benefits.

The primary system changes that were required were involved only in the software applications. Since modifications to each participating agency's CAD system are maintained by the vendors, system reliability is not viewed as a future issue, and is a good means to support those systems. UTA modified its own software, and maintains its CAD system in-house. The integration software will be maintained by UDOT on an ongoing basis, along with its other systems.

Overall, the project participants indicated that the technical implementation was successful. Agencies were able to either modify their systems themselves, as was the case for UTA; have their systems integrator modify their system, as was the case for UDOT; or have their vendor modify their system, as was the case for VECC and SLCPD. (At the time during which this

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[9] Source: State of Utah, "A Proposal for the Integration of Computer-Aided Dispatch – Traffic Management Integration Field Operational Test," p. 16, (July 11, 2002).

report was written, SLCFD was still working with its vendor to complete modifications to its system to allow participation in the integrated system.)

2.2.1. Data Exchange

From the time the project was first implemented, participants expressed concern about the following issues:

- **The amount of data exchanged among the agencies.** There was sensitivity about overwhelming partner agencies with information about situations in which they weren't interested.
- **Operator and dispatcher workload.** There was concern that requiring dispatchers and/or operators to take additional actions in addition to their normal work processes had the potential to overload individuals during busy times. There also was a concern that the additional actions might be difficult to work into the normal daily routine, even during less busy times.
- **The appropriate types of data to be exchanged in the system.** There was sensitivity to the types of information that might be exchanged and how the receiving agency might use that information. In addition, there was some concern, primarily from SLCPD, about when information would be released to the public and when it could be released without compromising law enforcement actions.

Amount of Data Exchanged

Early discussions among the project participants led to slightly different approaches taken to address these concerns, depending on the agency involved. The concerns surrounding the amount of data exchanged led to discussion about filtering the records that would be exchanged. Ideally, only certain types of entries would be exchanged. However, because this information had never been exchanged before, it wasn't clear how to filter the entries by type.

The decision was made by most agencies involved to give the individual dispatcher or operator the responsibility to determine what entries should be transferred to the integrated system. Operator interfaces were generally modified to add a feature to share the entry by selecting to share the information and to which agencies the information would be sent. Drop-down menus were generally used as a means to simplify and speed the operator's action and to minimize the impact on operator or dispatcher workload. Operators at each agency were able to screen the entries in the integrated system and could decide whether to view a specific entry and whether or not to bring the entry into their systems.

The result, however, was to add a step to the operator work process. In general, this led to additional work to already busy operators. In the case of the two agencies that probably have the greatest need to exchange information, UDOT and DPS, it was determined that the existing level of integration is sufficient, since each agency already has access to the other's system. Both the UDOT and DPS felt that the added actions are unnecessary. Since UDOT and DPS already access each other's data, the benefit of taking additional steps to ensure the information goes into the integrated system is not obvious. As a result, neither agency chose to add their entries to the integrated system very often.

For SLCPD, adding the step of deciding when the appropriate time is to allow the system to exchange information about a particular event means that the dispatcher must go back and

select an entry for it to be shared. This step was also out of the normal work process. The dispatcher, after entering the event, would move on to other activities, usually with other events and emergencies. Without any cue from the system, the dispatcher had to recall that there was an event in which other agencies might be interested, determine whether or not the situation might compromise actions being taken by police officers, and then go back to the event and send the event information to the integrated system. The result was that very few SLCPD events go into the integrated system.

Operator Workload

The preceding discussion about the added steps necessary for operators/dispatchers to make decisions regarding information exchange relates directly to the second concern, operator workload. Agencies also were concerned about any increase in the operator or dispatcher workload. One agency, in particular, was so concerned that this element regarding operator workload became the driving force behind its decisions regarding the system implementation. Instead of requiring their operators to decide which entries may be appropriate to send to other agencies and determine the agencies with which to share the information, VECC decided to send all information directly to the integrated system.

Because some of VECC's client agencies were concerned about how the data might be used, VECC decided to take a conservative approach to the data that would be sent to the integrated system. Event type and location were selected as the fields that were of most interest to other agencies. The free text field was not included. As a result, the direction of travel is not included in the data that is sent from VECC to the integrated system. The result was that the UDOT operators would review the incidents in the integrated system that come from VECC. If one of the entries looked like it would be of interest to them, the UDOT operators needed to verify the direction that is affected by the incident. If a camera provided a view of the location, it was determined that the operator would use that device to confirm the direction affected by the incident and verify the incident itself. If no camera was located in the area, the operator would listen to the scanner and try to find other ways (such as telephoning VECC) to verify the incident and determine direction.

Appropriate Data to Be Exchanged

The concerns surrounding the sensitivity of some data being exchanged required that certain data fields would be transferred and others would not. There was no distinction between data that would be sent to one agency versus another agency. The agencies chose a relatively conservative approach to which data fields were sent out, in part, because they were not certain how the information might be used or distributed once it was transferred. As mentioned above, VECC chose to send all of its records to all agencies, but was one of the most conservative in what fields are actually sent for each event—just event type and location.

In some cases, the limited data that exchanged did add to the operator workload. As mentioned previously, the UDOT operators have to find alternative sources of information to add needed information and to verify the events that come in from VECC.

None of these results were particularly surprising when one considers that this system allowed data exchange that could never be exchanged in the past. The agencies took a prudent approach to provide the information that seemed the most useful in the manner that was viewed to work best with each agency's existing business practices. As will be stated in later sections

on lessons learned, the agencies discovered what works well, what needs to be improved, and are committed to make improvements as they have resources to do so.

2.2.2. System Modifications

To integrate the various CAD systems and the TMC, each system had to be modified. The partner agencies modified their own systems, generally through contracting with the original system providers. In the case of UTA, the modifications were made by internal staff. For the agencies that used the original system providers, separate contracts were issued.

Some issues surfaced surrounding the codes used in each system. These codes represented a variety of information from incident type to geographic location. The base systems included slightly different codes for similar information, and there were not always direct correlations between the codes used among the different systems. The UDOT system integrator provided an XML template that included the current version of 1512 codes, but the translation from the vendor codes to the standard codes was a bigger issue than envisioned. The translation wasn't always straightforward because there wasn't a one-to-one correlation. Mapping from one agency's terminology to another's created some difficulties.

2.2.3. Use of Standards

Department of Justice Standards

The CAD vendors tended to use Department of Justice (DOJ) standards. Currently, the DOJ has an effort underway to get all CAD systems to use one standard to ensure that the various CAD systems can communicate with one another. However, UDOT uses ITS standards in its TMC and wanted to continue with those standards to remain consistent with the rest of its system. UDOT uses the IEEE 1512 family of standards for incident management as its primary standards. Therefore, both DOJ and ITS standards had to be used. Although there are current efforts underway to make these two families of standards consistent, they are not yet completely harmonized.

Geo-location Standards

It was determined that different geo-location referencing schemes also are used by the different systems. While most systems use latitude-longitude geo-location, the DPS CAD system used State plane coordinates, which were translated into latitude-longitude coordinates in the integrated system.

Since the location information from VECC included an event's latitude and longitude coordinates, the integrated system could automatically place the event once the UDOT operator accepted the event in the UDOT system. This automated action was found to reduce an important but previously manual step in the UDOT operator's process, which resulted in saved time in the operator workload.

2.2.4. UTA

Each participating agency added software capability to send and receive IEEE 1512 standard messages to indicate a new incident or to post/update the status of an existing incident. UTA

had developed its CAD system in-house, and had the flexibility to incorporate its desired level of functionality as appropriate.

Given the limited initial knowledge about which types of messages would prove useful to send and receive, UTA opted to be able to view and generate every message type. UTA expressed concern about the potential to miss out on important information by not viewing any particular pre-designated types of messages, given that even relatively minor incidents have the potential to significantly affect transit operations.

Therefore, the protocol for determining whether or not a message is useful to UTA was modified as follows:

> The UTA dispatcher was notified of all incoming messages on the system's primary CAD screen. This primary screen notification provided a listing with a summary title for all recently received messages, in reverse chronological order. The UTA dispatcher is able to select an item from the list to view more specific details about an incident and its status/history. In addition to using this information to assist with whatever operational actions are considered appropriate, the dispatchers use the existing documentation arm of the UTA CAD system to log any incidents considered relevant to UTA operations.

UTA expressed that the current system using the full message set was consistent with its original intentions, and originally thought that all participating agencies also were also going to send and receive the full message set. However, some other participating agencies limited the types of messages they would send or receive, and it was UTA's understanding is that in some cases, those choices are affected by constraints associated with the need to work with the CAD system vendor to implement the changes.

3. EVALUATION STRATEGY

3.1   EVALUATION STRATEGY OVERVIEW

The evaluation strategy developed for the CAD-TMC integration FOT was designed to address both ITS JPO and UDOT goals and objectives for the project. The goals and objectives for this evaluation were developed using an iterative approach involving extensive review by ITS JPO and the two affected States: Utah and Washington.

The Evaluation Team reviewed all available project documentation, including the application submitted to ITS JPO by each State in response to ITS JPO's Request for Applications distributed on May 16, 2002. Based on this review, the Evaluation Team presented high-level goals and objectives in its proposal submitted in response to ITS JPO's RFP of March 7, 2003. These proposed goals and objectives were reviewed with the ITS JPO Contracting Officer's Technical Representative (COTR), the ITS JPO Public Safety Coordinator, and the Mitretek Analyst on May 6, 2003, and then again during a joint June 2, 2003 kick-off meeting with Utah State DOT representatives.

The proposed goals and objectives were revised based on these meetings, and presented to the ITS JPO COTR, the ITS JPO's Public Safety Coordinator, and the Mitretek Analyst on June 16, 2003, and to Utah and Washington State during evaluation strategy briefings conducted on June 25 and June 26, 2003, respectively. The final evaluation and objectives presented in this plan reflect the input obtained from ITS JPO and the two States throughout this process.

3.2   GOALS AND OBJECTIVES

The Evaluation Team used the following high-level, ITS JPO-established FOT goals and objectives as the starting point for developing goals and objectives for the evaluation:

- The FOT will demonstrate the feasibility of automating the seamless transfer of information between traffic management workstations and police, fire and Emergency Medical Services (EMS) CAD systems from different vendors.
- The FOT will incorporate ITS standards such as IEEE 1512 and National Transportation Communications for ITS Protocol (NTCIP) into the integration of public safety and transportation information systems. Other standards areas that will have to be addressed are those pertaining to Geographic Information Systems (GIS).
- The FOT will extend the level of integration to include secondary responders such as utilities; towing and recovery; public works; and highway maintenance personnel.

The ITS JPO further identified a number of specific quantitative goals and objectives to be assessed during the evaluation, in particular, to:

- Determine how the FOT enhances communications among responders.
- Assess the extent to which the FOT enhances efficiency in documenting incidents.
- Determine how the FOT enhances on-scene operations.
- Measure the extent to which the FOT reduces incident clearance times.

The ITS JPO also specified that the final evaluation report include an assessment of institutional and technical challenges, and a summary of lessons learned and benefits, both qualitative and quantitative.

The high-level goals established for the CAD-TMC integration FOT by UDOT included:

- To demonstrate that open communication between the law enforcement and transportation agencies can improve emergency response and traveler information distribution. This open communication involves State agencies and county, municipal, and local government agencies.
- To demonstrate how this information exchange can be done without placing additional burdens on the already busy emergency response and radio dispatch staffs.[10]

The State also adopted the high-level goals and objectives for the FOT established by the ITS JPO described previously: automating the seamless exchange of data; using the appropriate ITS standards; and integrating local-, municipal-, and county-level emergency responders.

In developing goals for the evaluation, the ITS JPO- and UDOT-determined objectives were used to identify final evaluation goals that incorporated elements of both. The proposed goals were reviewed with both the ITS JPO and the State to ensure consistency and to ensure that data was available to conduct tests to support the evaluation.

As shown in table 3, the final evaluation goals and objectives were designed to enable the assessment of project performance as compared to both the ITS JPO and UDOT goals.

Table 3. Final Evaluation Goals and Objectives

Evaluation Goal	Evaluation Objectives
Assess System Performance	Automate the seamless transfer of information between traffic management workstations and police, fire, and EMS CAD systems from different vendors.
	Incorporate ITS standards such as IEEE 1512 and NTCIP into the integration of public safety and transportation information systems. Also, address standards related to GIS and sharing data between map databases from different vendors.
	Extend the level of integration to include secondary responders such as utilities; towing and recovery; public works; and highway maintenance personnel.
Assess System Impact	CAD-TMC integration will improve productivity and efficiency.
	CAD-TMC integration will improve mobility.
	CAD-TMC integration will improve safety.
	Assess CAD-TMC integration with 511/Internet interface.
	Assess the integration of the UTA CAD and the impact on transit operations.

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[10] ITS JPO, ITS Public Safety Program brochure, titled "DOT Projects in Utah, Washington State Will Demonstrate Public Safety, Transportation Integration System."

Evaluation Goal	Evaluation Objectives
Assess Institutional Challenges and Technical Issues	Identify institutional and technical challenges and document how they were resolved.
Identify Lessons Learned	Develop a Lessons Learned Summary.
	Identify institutional and technical challenges and document how they were resolved.
Summarize Benefits	Develop a Benefits Summary.

The Evaluation Plan articulated how to assess the degree to which the goals and objectives presented in table 3 would be met. The following studies and assessments were developed to assess these goals and objectives, as discussed in sections 3.2.1 through 3.2.6.

3.2.1. System Performance Study

The system performance test was designed to:

- Describe the environment in which the FOT will operate that could affect the applicability of the CAD-TMC concept to other sites and the interpretation of the system impacts data. This will help other potential deployment users to better understand the applicability of the CAD-TMC concept to their sites.
- Identify key performance measures that should be met by similar deployments to achieve the system impacts observed by the FOT deployment. This will help other deployment users identify and focus on the performance goals needed to achieve similar results. Also, document the design basis for these performance measures to help other deployment users adjust these measures to better suit their local conditions.
- Calculate and document the key performance measures for the system as it was deployed. This will help identify limitations in the deployed system that might affect the observed system impacts. Also, identify and document other performance measures that were gathered by the deployment team (e.g., during component and integration testing). While this data was not as critical to the evaluation as the key measures, the data should be available from the deployment team to reduce the cost associated with reporting the data.
- Identify other factors that affect the deployed system's performance. After the system is deployed, users may identify other factors that could make the system more useful and knowledge that could benefit others in developing similar systems.

In addition to these activities related to evaluating the performance of the deployed system, the system performance study was intended to:

- Evaluate the degree to which ITS standards such as IEEE 1512 and NTCIP were incorporated into the deployed system.
- Address the approach used to share data between map databases from different vendors and GIS standards that were applied.

3.2.2. System Impact Study

System impacts were evaluated using elements of the framework provided by the ITS JPO's National ITS Program Goal Areas: Mobility; Capacity/Throughput; Productivity; Safety; and

Customer Satisfaction.[11] The evaluation sought to quantify and document the benefits across these measurable areas for two very broadly defined beneficiary groups: incident responders and travelers. The system impact study was designed to:

- Determine if the CAD-TMC integration improves the efficiency and productivity of incident response.
- Determine if the CAD-TMC integration improves mobility and reduces delays during incidents.
- Determine if CAD-TMC integration enhances incident-specific traffic management plans.
- Determine if the CAD-TMC integration will reduce exposure of response personnel and secondary crashes during incident response activities
- Determine if CAD-TMC integration will improve incident management information available to travelers.

3.2.3. Institutional Challenges Assessment

The institutional challenges were identified and documented primarily through stakeholder interviews. Interviews with project stakeholders provided the primary information source for identifying challenges and the processes by which they were resolved. These interviews were conducted on a before and after deployment basis.

The institutional challenges study was intended to:

- Document inter-agency cooperation at the State level, in particular, the processes used for identifying and solving problems.
- Assess how county and municipal agencies are integrated into the program (VECC, SLC).
- Identify what information is shared, and how the agencies determined that this was the right information to share.
- Document how UHP and UDOT determined what the information availability would be for exchanges between the CAD-TMC systems.
- Document how frequently the information provided through the project is used by:
  - Responders.
  - Travelers.
  - Media.
- Document how these end-users used the information provided, and identify how the information was used.
- Determine if end-users found the information useful, and why or why not.
- Assess how the various CAD vendors were able to establish working relationships and share data.

3.2.4. Technical Challenges Assessment

The technical challenges assessment documented how the FOT teams addressed technical challenges such as overcoming the barriers associated with incompatible and/or proprietary systems. In conducting the assessment, the Evaluation Team primarily relied on interviews with technical staff at each participating agency to identify the specific challenges addressed and

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[11] Additional information regarding the ITS Evaluation Guidelines – ITS Evaluation Resource Guide can be accessed from the ITS Joint Program Office Web site at: <http://www.its.dot.gov/EVAL/eguide_resguide.htm>.

evaluate how those challenges were resolved. Results from this assessment are presented in section 6.

3.2.5. Lessons Learned Assessment

The lessons learned assessment summarized lessons learned during the other portions of this evaluation. The Evaluation Team also explicitly requested information on lessons learned during interviews and meetings associated with the evaluation. Results from this assessment are presented in section 6.

3.2.6. Benefits Summary Assessment

The Benefits Summary documents benefits derived from the all of the individual studies in this evaluation. Results from this assessment are presented in section 6.

3.3   DATA COLLECTION

Both qualitative and quantitative data were collected for the before (baseline) and after the FOT deployment. The collection of before data focused on establishing a baseline that was used to measure the impact of the FOT deployment. Collection of after data provided data that was compared to the baseline data to determine the impact of the FOT deployment.

Qualitative data collection was conducted for both the before and after data collection phases using the following methods:

- **Stakeholder/Vendor Interviews.** The Evaluation Team interviewed stakeholders/ vendors in person or via phone as the primary means to collect the qualitative information/data needed to successfully perform the CAD-TMC integration FOT evaluation. Stakeholder interviews also were used as a means of identifying issues relevant to the CAD-TMC evaluation. Stakeholder agencies interviewed included UDOT, UHP, VECC, UTA, SLCPD, and SLCFD.
- **Site Visits.** The Evaluation Team conducted periodic site visits with appropriate stakeholders/vendors to collect needed data not easily transmitted via phone, e-mail, or other convenient means.
- **Observations.** Visual observations were used as a means of collecting data that is not otherwise documented or easily conveyed. An example of this included documenting the activities of CAD and TMC operators before and after the new system was deployed to identify any changes in day-to-day procedures or work requirements.

Quantitative data were obtained for the periods of April through June 2004 (before) and for April through June 2005 (after). The qualitative data collected were used to gain user impressions of system performance and impacts, and to identify institutional/technical challenges and lessons learned. Quantitative data were used to assess system performance and system impact.

Sources for quantitative data collected through this FOT are presented by agency, as listed below. Under each data source are the specific field headings from which data were pulled.

- **UDOT:**
    - Incident Management System records:
        1. DIRECTION
        2. INCIDENT ID
        3. COUNTY CODE ID
        4. ESTIMATED END
        5. SCHEDULED START
        6. SCHEDULED END
        7. ACTUAL START
        8. ACTUAL END
        9. CONFIRM TIME
        10. LAST UPDATE TIME
        11. X POSITION
        12. Y POSTION
        13. INCIDENT TYPE ID
        14. LOCATION TYPE ID
        15. PRIMARY ROUTE
        16. SECONDARY ROUTE
        17. LOCATION TEXT
- **UTA:**
    - Dispatch System message logs (Fixed Route Operations):
        1. LOG NUMBER
        2. LOG DATE
        3. LOG TIME
        4. CLEAR TIME
        5. DIRECTION
        6. MINUTES LATE
        7. PROBLEM
        8. COMMENTS
    - Dispatch System message logs (Paratransit Operations):
        1. LOG NUMBER
        2. LOG DATE
        3. LOG TIME
        4. ACCIDENT/INCIDENT/NOTE
        5. CLEAR TIME
        6. LOCATION
        7. PROBLEM
        8. COMMENTS
- **VECC:**
    - CAD system message logs (Call records):
        1. RECORD NUMBER
        2. CALL TYPE (LAW/FIRE/EMS)
        3. CALL NATURE
        4. PRIORITY OF CALL
        5. WHEN OCCURRED EARLIEST
        6. WHEN OCCURRED LATEST
        7. WHEN REPORTED
        8. WHEN MODIFIED
        9. HOW RECEIVED
        10. RESPOND TO ADDRESS

11. CITY CODE
12. GEOBASE ADDRESS ID
- CAD system message logs (Radio logs):
  1. LOG DATE
  2. X POSITION
  3. Y POSITION
  4. UNIT
  5. CALL ID
  6. AGENCY
  7. DESCRIPTION
  8. SHIFT
  9. CALL TYPE
- **SLCPD:**
  - CAD system message logs:
    1. DATE
    2. TIME
    3. CASE TYPE
    4. LOCATION
    5. X POINT
    6. Y POINT
    7. SEVERITY
    8. NUMBER VEHICLES
    9. NUMBER INJURED
    10. NUMBER KILLED
- **SLCFD:**
  - CAD system message logs:
    1. INCIDENT TYPE DESCRIPTION
    2. INCIDENT BEGIN TIME
    3. INCIDENT END TIME

Qualitative data were collected through interviews with and observations of the following agencies:

- **UDOT.** Before and after interviews were conducted with UDOT TOC personnel in July 2004 and September 2005. Before and after interviews were conducted with system development personnel in July 2004 and September 2005. Evaluation Team members also observed the operation at the TOC in July 2004 and September 2005. Various field observations and interviews with field personnel occurred at different times during the evaluation periods. UDOT personnel also were involved with several meetings to discuss the integration project, the most notable of which was the agency partner meeting held September 7, 2005.
- **UHP/DPS.** Input was received from key field and dispatch personnel through interviews and meetings during the evaluation period.
- **UTA.** Before and after interviews were conducted with UTA in August 2003 and October 2005. UTA also provided feedback during the agency partner meeting in September 2005.
- **VECC.** Primary input from VECC occurred during the agency partner meeting in September 2005.
- **SLCPD.** Primary input from SLCPD occurred after it came online, during the agency partner meeting in September 2005.

3.4   MODIFICATION TO EVALUATION SCOPE

An Interim Project Review (IPR) of the ITS JPO Public Safety Program-funded Utah CAD-TMC integration FOT was held on January 28, 2005. Participants included the Joint Program Office ITS Public Safety Coordinator, the COTR, the Mitretek Analyst, the Utah Project Manager, representatives from other stakeholder agencies, the system integrator, and the Evaluation Team. The purpose of the IPR was to:

- Provide the project team with a status report on evaluation activities, in particular, on the status of baseline data collection.
- Obtain an update on the status of project implementation.
- Discuss next steps:
  – When to collect after project data.
  – When to complete evaluation activities.
  – Assess potential benefits of expanding the scope of the evaluation.

No significant developments beyond the original scope of the evaluation were identified during the IPR. A decision was reached by the meeting participants that the evaluation would be completed within the existing scope and schedule. It was determined that the SLCFD system would not be online and tested until April 2005; therefore, SLCFD would not be included in the final data collection activities, which were scheduled for and conducted between May and June of 2005. Further discussion determined that additional activities would include the after interviews and operation observations.

4. TEST RESULTS

The data discussed in section 3.1 was collected and analyzed according to the modified evaluation strategy described in section 3.4. This section presents the analysis results and a results summary regarding the system performance and system impact FOTs. Institutional and technical challenges were also assessed; however, because these are completely qualitative in nature, they are presented in section 5, Evaluation Findings. The lessons learned, which also provided important findings for this evaluation, are presented in section 6, Conclusions and Recommendations.

4.1   SYSTEM PERFORMANCE TEST RESULTS

Table 4 summarizes the system performance test results based on the discussion in section 3. Following the table is a discussion for each evaluation objective, along with the corresponding results in sections 4.1.1 through 4.1.3.

Table 4. System Performance Study Test Results Summary

Evaluation Objective	Hypothesis	Test Results
Objective #1: Document the system component performance.	The system meets functional specifications.	Achieved.
	The CAD and TMC systems will be able to link data on an incident.	Achieved.
	Using the system improved incident response procedures.	To a significant extent, achieved through prior projects. Project specific impact not measurable.
Objective #2: Automate the seamless transfer of information between traffic management workstations and police, fire, and EMS CAD systems from different vendors.	The system meets functional specifications.	Achieved.
	The FOTs will decrease the reliance on manual methods for exchanging information.	Preliminary result – achieved.
	The FOTs will increase the extent and reliability of information exchanges.	Preliminary result – achieved.
Objective #3: Extend the level of integration to include secondary responders such as utilities, towing and recovery, public works, and highway maintenance personnel.	Improved integration of secondary responders will reduce incident recovery time by getting required recovery personnel to the incident site as quickly as possible to begin recovery operations.	Secondary responders (ambulance, utilities, etc.) were not included in the project.

4.1.1. Objective #1: Document System Performance

Following are the three hypotheses associated with the objective to document the system's performance:

- The system meets functional specifications.
- The CAD and TMC systems will be able to link data on an incident.
- Using the system improved incident response procedures.

The Evaluation Team relied on a combination of observations and interviews to determine whether or not the system met the functional specifications. Actually seeing the system work and finding out if the system met operator expectations were the best indicators to determine that the system successfully met system performance needs.

After the integrated system was implemented, a demonstration of the capability was held at the TMC with excellent results, as reported by the participants. A mock incident was sent from the UHP to the TMC, with the TMC having the ability to review each detail of the incident. The TMC staff was able to input updates to the incident information without needing to telephone UHP. The demonstration clearly illustrated that the technology worked properly and has excellent potential for improved sharing of incident details.

In interviews with UDOT deployment staff and operators from UDOT and their partner agencies, all described the system as meeting functional specifications. The consensus was that the system is "doing the job it was intended to do."

While observing the system in operation, information from partner agencies was displayed on the integrated system window within seconds from the time of input. For example, since UDOT operators have access to the VECC CAD Web site, incidents entered into the CAD system could be observed to display in the integrated system. The system also responded well when operators brought an outside incident (one from a partner agency) into the UDOT traffic management system through the integrated system. The time interval range varied from nearly instantaneous to taking a few seconds to populate the fields that could be populated by the partner agency data.

Through this demonstration and the observations of the working system, incidents that were brought into the UDOT traffic management system could be updated and sent out to other agencies. Data could be linked from one system to the other through incident number and geo-location. The system was designed to allow the operator to make the final determination of where incidents reported from more than one agency are the same and should be linked or not. As the test successfully showed, the system did provide this capability.

It was more difficult to determine to what extent incident response procedures were improved. Because of the close working relationship among the FOT partner agencies, improvements in field response activities could not be readily observed. In fact, all those interviewed acknowledged that little, if any, improvement occurred in field procedures. However, this outcome was expected going into the test.

There were some improvements in incident response procedures and resulting efficiencies in documenting incident management in the operations and dispatch centers in the region. In addition to improved efficiency, there are three other improvements that should be mentioned:

- Time to enter an incident first reported by a partner agency.
- Accuracy of the information in the incident record.
- Number of incidents included in the incident reporting system.

The time required to enter incidents into the UDOT incident management system that were first reported by a partner agency was reduced as a result of automated data exchange. Previously, incident data was entered manually. Minimizing the time to enter an incident is important because all of the incident information that goes to the public either by the CommuterLink Web site or 511 comes from the UDOT incident management system. The quicker an incident can be reported, the sooner the public will know about it and take appropriate action. The incidents are reported essentially instantaneously to the CommuterLink Web site and 511 once the incident is "declared", or entered, by the operator.

In interviews with UDOT operators, estimates of up to 1 or 2 minutes in time saved to get the incident entered and located were reported. This improvement was recognized as a two-fold time savings factor. First, some of the incident fields were populated from information from the partner agency. Operators estimated a10- to 50-second improvement because of fields automatically being populated. The second factor is that the system can carry geo-location information so the incident can be located automatically rather than being placed at the proper location by the operator. The operators had estimated that between 1 to 2 minutes in time savings were realized because of the automatic placement of incidents.

Limited observations showed about a 5- to 10-second savings in time to enter incident data on incidents reported by VECC. VECC data had limited data brought into the system, however; only incident type and location are transmitted by the VECC system. (See later discussions of institutional challenges in section 5 and conclusions in section 6 for more discussion.) From observations made before the integrated system was implemented, normal incidents took from 50 to 120 seconds to populate and place. In the after observations, it took about 15 seconds to fill in the empty fields from VECC incidents. With automatic placement of incidents, the process is considered complete as soon as the empty fields are populated and the operator "declares" or enters the incident. The observations showed a time savings of roughly 35 to 105 seconds, relatively close to the operator estimates. (It should be noted that the observations, both before and after, were on relatively quiet days with few incidents and no major incidents. It is easy to see where greater time savings could occur on busier days.)

It should be noted that additional improvements would result for incidents reported by any of the partners with some modifications to the system. Those modifications include more automation in sending incidents to the integrated systems for all agencies other than VECC, which sends out all of its incidents; filtering incidents at the receiving agency so only incidents of interest are displayed to operators; and populating more fields in the integrated system, especially from VECC.

Accuracy of the information included in the incident record was improved because information from the partner CAD systems was imported directly into the UDOT incident management system. This process reduced the likelihood of introducing a manual operator error when the operator would re-enter the data. In addition, the geo-location information attached with the entries from some agencies reduced the likelihood that the incident would be positioned in the wrong location.

Although the interviews with operators downplayed any possibility of improved accuracy, the manual steps that were necessary in the old system provided some probability of errors, especially in placing the incident. Even though the improved accuracy may not have been perceived as a major improvement, it is worth mentioning.

The number of incidents included in the integrated system was considerably larger than in the nonintegrated system. All VECC incident entries are transmitted to the integrated system. Prior to the integration, UDOT operators relied on scanners or the VECC CAD Web site to find out about incidents outside UHP's jurisdiction. During the FOT, the operators needed to decide on which incidents from VECC in the integrated system should be brought into the incident management system and reported to the public. Interviewees thought that they may be handling between 75 and 100 percent more incidents. The incident logs showed that there were nearly 5 times as many incidents reported per month after the integrated system as before. (See section 4.2 regarding the test results for system impact.)

In discussions with UDOT managers, the opinion was expressed that some of the increase in number of incidents was because the test overall placed more emphasis on reporting incidents due to the heightened awareness of the importance of reporting incidents. Regardless of the overriding reason, there was a large increase in the number of incidents reported.

4.1.2. Automate Information Transfer between TMC and Emergency Responders

The second objective under system performance was to automate the seamless transfer of information between traffic management workstations and police, fire, and EMS CAD systems from different vendors. The following three hypotheses are associated with this objective:

- The system meets functional specifications.
- The FOTs will decrease the reliance on manual methods for exchanging information.
- The FOTs will increase the extent and reliability of information exchanges.

From the discussion in section 4.1.1, it was effectively demonstrated that the system met the functional specifications.

From observations and interviews, it was demonstrated that the integrated system reduced the reliance on manual methods for exchanging information. Incidents reported by partner agencies were transmitted to the integrated system and easily imported into the UDOT incident management system. Sharing information on incidents reported by other agencies, particularly from VECC, significantly reduced UDOT operator reliance on listening to scanners to "discover" incidents of interest.

Before the integrated system was deployed, the scanners were the primary way of UDOT's finding out about incidents from agencies other than UHP. Operators kept part of their attention on the scanners at most times. When busy with other tasks, the operators indicated that it would be very easy for an operator or dispatcher to miss an incident. If the operator missed part of the message from the scanner, it would be very difficult to get the information unless the operator/dispatcher called the agency that reported the incident. Additionally, if the location or agency was part of the message that was missed, there was no method available for the operator to gather or retrieve additional information. With the integrated system, operators were still able listen to scanners, but generally only after they saw an incident come in on the integrated system and they needed to get additional information.

The number of times the operator needed to phone other agencies to get additional information also was reduced. During the before observations, operators called other agencies routinely. During the after observation, operators only rarely called other agencies.

From observations and interviews, it was proved that integration increased the extent and reliability of information exchanges. Information passed to other agencies directly from CAD so conversations only were needed to clarify information, which translated to there being a reduced likelihood of operators misunderstanding the basic aspects of the incident.

4.1.3. Integration of Secondary Responders

Secondary responders (ambulance, utilities, etc.) were not included in the FOT. Initially, UDOT wanted to incorporate ambulance services and tow trucks. This approach was not pursued because the ambulance services were transitioning from private operators to municipal services. It was too early in the transition process to incorporate ambulance dispatch in the integrated system. Since the tow industry does not use CAD, it was not practical to incorporate this entity into the integrated system.

4.2   SYSTEM IMPACT TEST RESULTS

To assess the system impacts of the CAD-TMC deployment, data was collected from the following sources:

- UDOT incident logs.
- SLCFD incident logs.
- SLCPD incident logs.
- UTA call logs for paratransit and fixed routes services.
- VECC call and radio logs.

Data from before the CAD-TMC deployment was collected for the period from April through June 2004. Data from after the deployment was collected for the same period during 2005.

Table 5 summarizes the system performance study test results based on the discussion in section 3. Following the table is a discussion for each evaluation objective, along with the corresponding results in sections 4.2.1 through 4.2.5.

Table 5. System Impact Study Test Results Summary

Evaluation Objective	Hypothesis	Test Results
Objective #1: Productivity – To determine if the CAD-TMC integration improves the efficiency and productivity of incident response.	CAD-TMC integration enhances communications among responders.	Achieved – Key issue to be addressed is that of refining information exchange to meet agency specific requirements.
	CAD-TMC integration improves efficiency of on-scene operations.	Not measured during the evaluation.
	CAD-TMC integration enhances efficiency in documenting incident management.	Achieved.
	CAD-TMC integration reduces incident clearance times.	Not measured during the evaluation.
Objective #2: Mobility – To determine if the CAD-TMC integration improves mobility and reduces delays during incidents.	CAD-TMC integration enhances mobility during incident management (IM) activities.	No impact measured during the evaluation.
Objective #3: Capacity/ Throughput – To determine if CAD-TMC integration enhanced incident-specific traffic management plans.	CAD-TMC integration enhances incident-specific traffic management plans.	Not measured during the evaluation.
Objective #4: Safety – CAD-TMC integration will reduce exposure of response personnel and secondary crashes during incident response activities.	CAD-TMC increases safety for response personnel.	Not measured during the evaluation.
	CAD-TMC increases safety to the traveling public.	Not measured during the evaluation.
Objective #5: Traveler Information – To determine if CAD-TMC integration will improve incident management information available to travelers.	CAD-TMC integration enhances customer satisfaction and mobility during incident management activities by improving traveler information.	Qualitative assessment: Improved ability to post incident information for public access via 511, Web site.
UTA Objective: To determine if the integration of the UTA CAD system improves UTA's ability to respond to incidents.	The CAD-TMC integration will enable UTA to more effectively implement reroute decisions in response to an incident.	CAD-TMC integration provided real-time information on unplanned incidents and complemented existing UTA incident management procedures. Additional benefit from system is information provided on planned incidents, such as road closures and/or construction activities.

4.2.1. UDOT Incident Logs

Before the CAD-TMC deployment, the UDOT incident logs contained information about 336 incidents that occurred during the period from April until June 2004 as shown in table 6.

Table 6. Incidents Logged from April 1 through June 30, 2004

Month	Count
April	50
May	114
June	172

However, these incident logs did not include any information about accidents; they only included information about construction and other activities that could result in road closures. The incident type information was inferred from a numeric Incident Type field, which assumed that the same codes were used for the 2004 data as for the 2005 data. The duration recorded for these incidents was not very detailed, with incidents beginning and ending on the half hour.

There were some apparent inconsistencies between the codes included in the before and after data collected. The reasons for the inconsistencies were not known, and could range from a problem in translation with regard to the definition of incidents to broader data issues. Based on questions that arose from these inconsistencies, most of the quantitative analysis that was done on the before and after data sets was rejected by the Evaluation Team.

After the CAD-TMC deployment, the UDOT incident logs contained much more detail about a much larger set of incidents, with nearly 5 times as many incidents reported per month than in the before data. An interesting aspect of this increase in incidents is that the project partner agencies were reported to be discussing issues related to the type and quantity of data that needs to be collected, such as the need for data filters to ensure that the system is not overloaded with redundant information about an incident. Table 7 presents the increased amount of incidents logged during May and June 2005[12] over the corresponding months in 2004.

Table 7. Increases in After-Deployment Incident Data Reports for May and June 2005

Month	Count
May	678
June	950

The after-deployment data was also more complete than before the deployment. For example, the "City" code (a code used to identify the city in which the incident occurred) was specified for only 69 incidents in the before data, and was specified for 833 incidents in the after data with the time stamps for the incidents were usually recorded to the nearest minute. Both of these

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[12] After data was not available for the month of April 2005 due to delays in system start-up operations.

observations indicated that the information obtained from the integrated system contained more real-time traffic information and that the overall accuracy of the data was highly improved.

The fact that the after data was more complete also meant that this data would support more detailed incident analyses than the before data. Table 8 shows how incident duration varied with the type of incident and recorded the type and quality of the data being generated by the integrated system. This level of detail and accuracy was significantly improved when compared with the before project data quality.

Table 8. Incident Duration Variables Recorded Based on Number of Incidents by Incident Type

Incident Duration	Number of Incidents by Incident Type				
	Accident	**Stall**	**Debris**	**Congestion**	**Construction**
<=5 min	37	39	7	--	1
5 to 15 min	82	22	7	2	--
15 to 30 min	189	21	5	1	--
30 to 60 min	515	34	9	3	2
60 to 120 min	394	22	3	3	--
120 to 720 min	78	15	1	2	36
720+ min	2	1	--	--	7

4.2.2. UTA Call Logs

UTA provided two types of call logs: one each for the paratransit vehicles and for the fixed route vehicles. It should be noted that UTA paratransit dispatch uses its CAD system differently than UDOT. UTA defines their accident, incident, and note fields as follows:[13]

- Accident: This field can be either an accident with a vehicle or a passenger. Most accidents are with passengers.
- Incident: This field is used mainly for passenger behavioral issues (some dispatchers put these in the notes field).
- Note: This field is primarily used for passenger behavioral issues, broken down vehicles, passengers that don't show, and passengers that pay for round trip fares.

The paratransit logs included 328 records covering the period from April to June 2004. Each call was classified as an accident, incident, or note, as listed in table 9. Most of the records classified as an accident were actually misclassified, and an informal review of the accidents did not identify any that were related to incidents of concern to UDOT.

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[13] UTA definitions for accident, incident, and note provided by email communiqué May 18, 2006, via Mr. Richard Manser (UDOT) and Mr. Nolan Hess, TransCore (system integrator).

**Table 9. UTA Call Log Incidents Reported by Incident Type and Number
Before and After Deployment**

Incident Type	Number of Records	
	Before	After
Accident	23	415
Incident	54	63
Note	251	377

4.2.3. VECC Call and Radio Logs

The VEC call and radio logs are detailed logs of calls received by VECC and radio messages exchanged with field units. For example, the before VECC call logs included 180,814 records about VECC calls. The radio logs included more than 500,000 records of radio calls. As with the SLCPD and SLCFD data, there appeared to be little overlap between these incidents and the incident monitored by UDOT. For example, of the 500,000 radio log records in the before data, only 9 had a 10-code field related to traffic.

4.2.4. UTA CAD Integration

Table 10 summarizes the planned quantitative aspect of the UTA CAD integration assessment to complement the qualitative assessment based on the before and after interviews. This table includes the objective, hypothesis, measures of effectiveness (MOE), data sources, and analysis performed. It did not prove feasible to measure the changes in time to implement and rerouting of routes based on the available data sources, so the quantitative aspect of this assessment was not completed. However, the qualitative assessment based on the before and after interviews provided considerable insight into these and other impacts of the CAD integration on UTA operations. The remainder of this section reports on these insights gained from the qualitative assessment.

Table 10. UTA CAD Integration Assessment

Objective	Hypothesis	MOEs	Data Sources	Analysis
To determine if the integration of the UTA CAD system improves UTA's ability to respond to incidents.	The CAD-TMC integration will enable UTA to more effectively implement reroute decisions in response to an incident.	Changes in time needed to implement rerouting following an incident. Changes in time needed to end rerouting once an incident has been cleared.	Sources include UTA CAD system and UTA logs; TMC incident logs.	Descriptive statistical analysis of key measures and comparison of *baseline* and *after* cases.

UTA did not feel that the availability of this new information tool had a significant impact on the incident management practices and capabilities of UTA dispatchers. Due to the dynamic and autonomous nature of their roles, UTA dispatchers were already empowered to make operational decisions including those needed in response to incidents. To support this role, UTA already had protocols in place for the general operational response to various scenarios. This new information did not change these practices and capabilities, but did provide a new information exchange mechanism to complement those that were previously in place.

In practice, the new messaging interface did not usually address advance notice disruptions such as road closures or delays. Instead, the new messaging interface focused on the real-time status of unexpected disruptions. UTA already had established mechanisms for receiving advance notice disruption information through other channels, including CommuterLink in particular, and relied on ongoing information sharing with each of the 72 municipalities in which the agency operated to receive information on planned road disruptions.

Although the messages did not usually address advance notice disruptions, UTA dispatchers were asked to log these as well using the documentation arm of the CAD software. Overall, the extended information in the CAD system documentation arm served as a new source of information for customer service agents, who could ask the dispatcher to query the documentation arm information to help research a customer issue.

In the past, UTA would typically become aware of an on-street incident when it was first encountered in revenue service. The primary effect of the messaging interface was that in some cases, UTA would be made aware more quickly of an incident that might affect its operations, before it was encountered in revenue service. This established a new opportunity to mitigate the impact of an incident on operations. Although a supervisor still needed to assess the incident to determine if a detour could/should be implemented, the quicker notification allowed a supervisor to be dispatched more quickly, thus reducing the time until an operational response could be implemented and mitigating the impact. However, depending upon an incident's location and duration, it was not always feasible to implement an operational response. When this occurred, the quicker incident notice did not necessarily translate into a reduced operational impact.

For unplanned incidents, UTA's procedure would be to respond to on-site supervisor feedback. With the messaging interface, sometimes the supervisor could be dispatched before the incident was first encountered by an operator. However, if a UTA operator encountered an incident first, the UTA procedure would be to contact 9-1-1. UTA did not typically take responsibility for initiating an incident report to other agencies via the messaging interface without first having a supervisor onsite to assess it (by which time the incident report has usually already been initiated by a public safety agency).

UTA has had the capability for dispatchers to notify other parts of the UTA organization about a service disruption, using one of several internal email distribution lists. UTA opted not to establish any automated linkage between incoming incident messages and this email distribution capability. UTA relied on its dispatchers to assess incoming incident messages in the context of all other available information to decide which of these will result in a UTA service disruption.

UTA felt that although it was slower than some other agencies to initiate its participation in the FOT, the agency was able to implement its solution fairly quickly as a result of having developed its CAD system in-house and not needing to negotiate the system modification with a vendor.

5. EVALUATION FINDINGS

5.1   SYSTEM PERFORMANCE

The primary system performance assessment findings are as follows:

- From interviews and observation, the system meets functional specifications.
- From observations, the CAD and TMC can link incidents. Observed incidents from the CAD terminal displayed properly in the integrated system.
- From observations and interviews, some TMC incident response procedures were improved. The time to enter an incident discovered by a participating agency into the UDOT incident management system was reduced by as little as 30 seconds to as much as nearly 2 minutes. The accuracy of the information in the incident record was improved because information from the partner CAD systems is imported directly into the UDOT incident management system reducing the chance of making an error if the operator was to enter the data manually.
- Geo-location data passed with the incident reduces the chance that the incident will be placed in the wrong location.
- The number of incidents included in the incident reporting system increased dramatically—nearly 5 times the number of incidents were included per month after the integrated system was implemented.
- From observations and interviews, the integrated system reduces the reliance on manual methods for exchanging information. Partner agency incidents are automatically brought into UDOT system. The integration system reduced operator reliance on listening to scanners.
- From observations and interviews, integration increased the extent and reliability of information exchanges. Information is passed from other agencies directly from the CAD systems so conversations are only needed to clarify information.

5.2   SYSTEM IMPACT

The time period for which after project data was collected coincided with the initial months of system operation. Some quantitative data was obtained and analyzed, but the State has not had adequate time to use the system and develop a database that might be used to develop a comprehensive empirical estimate of system impact.

Although the amount of quantitative data available for analysis was limited, the Evaluation Team noted that one result of the FOT was a significant improvement in the quality of the data. For example, the before project data collected frequently had incident start and stop times indicated on the hour or half hour, and also contained a large number of incidents for which one or both times were not entered. In the after project data, the system was able to accurately capture both start and stop times to the minute.

An additional example of improved data quality involved the coding of incidents. Prior to the FOT, coding errors were common, in particular when agencies attempted to map their incident codes to UDOT codes. With the integration, this translation is done electronically and agencies are now able to match incidents using the integrated system.

The evaluation findings related to system impact are qualitative, as follows:

- From observations, communication among response agencies was enhanced by CAD-TMC integration. Project meetings enhanced face-to-face communication. Phone calls were focused on clarifying specific information rather than trying to receive all of the information on an incident.
- From observations, efficiency in documenting incident management improved. (See the similar finding under System Performance above.)
- From interviews, scene clearance time improved. Better traveler information allowed the public the opportunity to bypass the incident, which resulted in less congestion and better response sooner (response units getting to the scene faster via a clear route). This conclusion by responding agencies could not be verified because before data on clearance time was not available.

5.3   INSTITUTIONAL CHALLENGES

In general, Utah faced fewer institutional challenges than would be expected in most states in implementing an integrated CAD-TMC system. Agencies in Utah had very close working relationships, particularly DPS/UHP and UDOT. DPS dispatchers were located in the UDOT TOC and working relationships were particularly strong. In addition, the momentum from the 2002 Winter Olympics and the strengthened institutional relationships significantly supported the evaluation efforts. Even in this setting, however, there were some institutional challenges that the agencies involved had to overcome, which are described in sections 5.3.1 through 5.3.5.

5.3.1. Data Sharing

The first of the institutional challenges was partially due to the unique position held by the VECC in the region. VECC dispatches for essentially all emergency response agencies in Salt Lake County with the exception of DPS/UHP, Salt Lake City, and the Sheriff's Office. This single agency allowed UDOT and UHP to coordinate with fewer agencies. However, VECC had to reflect its client agencies' policies. As a result, VECC doesn't have the authority to provide certain types of information to the integrated system. Because the VECC system incorporated many agencies, the automation has to reflect a consensus or agreement position among all of the agencies involved. The agency with the most conservative policy in data sharing would drive what the system provides. Some of VECC's client agencies were concerned over how the information would be used and controlled after it was shared in the integrated system. The agencies were especially concerned about the privacy of individuals involved in the incident. As a result, only incident type and location were transmitted to the integrated system.

With the initial system operation, the shortcomings of sharing only the limited incident type and location data became evident, as stated in section 4 of this document. Currently, an effort is underway to develop a Memorandum of Understanding (MOU) that will cover how shared information will be used and protected. The UDOT incident management system used the following operator-entered fields:

- Incident Type.
- Detection Type.
- Location (City/County and Description)
- Primary Characteristics.
- Lanes Closed.

- Location Type.
- Direction.
- Personnel/Vehicles Involved.
- Estimated Duration.
- Severity.
- Impact.

UDOT would like additional information shared to reduce the entry required by its operators. Especially desired is the direction of travel, the start time of the incident (which is automatically generated when the UDOT operator initiates an incident), and the time the incident is closed (also automatically generated for incidents that were opened by a UDOT operator).

For other agencies that may consider implementing an integrated CAD-TMC system, it would be wise to work out an agreement on how the data will be used and protected prior to system implementation. This action would ensure that all system partner agencies would receive as much data as is needed by the incident management and reporting system.

5.3.2. Operator and Dispatch Procedures

With the exception of the VECC staff, the integrated system design relied on CAD operators to decide which incidents should be sent to which partner agencies. This decision point added a step in the operator/dispatcher normal work process. As a result, incidents were not shared consistently from dispatcher to dispatcher. When they are particularly busy, it was less likely that a dispatcher would have the time to add any steps into their normal work process. It may also be most critical that the incidents that occurred during these busy times be shared. Therefore, it is important for integrated systems to accommodate existing work processes for operators or dispatchers.

UDOT has planned future system improvements that will automate sharing incidents with rules for the data that can be shared and to determine what incidents should be sent to which agencies. This planned improvement is discussed more fully in section 5.4 of this document.

5.3.3. Primary Agency Responsibilities

Another institutional challenge faced in Utah was that each agency had its own primary responsibility. Integrating the CAD and TMC functions is not a primary responsibility of any of the partner agencies, but is important to all agencies. As a result, sometimes individual agency priorities required that less attention be paid to the integrated system than would have been optimal. It is unreasonable to think that priorities would change during the development and implementation of the integrated system.

In Utah, the partner agencies were responsive to project requirements. Project participant meetings helped keep the project momentum and open communications ongoing, and provided a venue to promote emphasis on the project from each partner agency's perspective. Agencies interested in pursuing an integrated CAD-TMC system should keep in mind the importance of these meetings. In addition, the approach and schedule for developing and implementing an integrated system should reflect the challenges inherent in working with multiple agencies on a project that is not top priority for any one of the participating agencies. Schedules should be longer than initially anticipated and more effort should be budgeted for meetings and coordination.

5.3.4. CAD System Modifications Contractual Arrangements

The integration required that all of the CAD systems had to be modified. Each agency contracted directly with its respective CAD vendor to upgrade the individual agency's CAD system. Coordination among and between the vendors and UDOT's system integrator was often challenging. UDOT's system integrator was responsible for making the whole system fit together and work according to specifications, but had no control and limited influence over the work being done by the individual CAD vendors.

An alternative approach could have been the agencies forming a consortium to contract for the entire integrated system. A single integrator could be contracted, who then subcontract to each CAD vendor. The agencies involved would have control over the work in their systems through the consortium, and the single integrator would have more control or influence over the work contracted to the vendors.

5.3.5. UTA

An overall institutional challenge for UTA was that many agencies, in particular, the public safety agencies, felt that there were security and/or privacy issues with releasing much detail on incidents via the messaging interface. As a consequence, this led to messages from these agencies indicating that the message related to a certain incident type, but with little additional insight – not even about the incident status (i.e., new, ongoing, ended), which was the primary type of additional information of interest to UTA. In some cases, there were some additional details included in the message description field, but UTA dispatchers found it difficult to quickly decipher the meaning of the various encoded information or to extract the traffic impact implications.

The combination of this challenge, along with UTA's choice to receive all messages, led to a general feeling for UTA dispatchers of being flooded with messages, with those from particular agencies containing information of limited value to UTA. The practical consequence was that dispatchers came to pay only limited attention to messages generated by those agencies.

In hindsight, UTA indicated that it might be more effective in the future for the system to evolve towards UDOT generating "traffic impact-oriented" messages based on monitoring the messages from all agencies, which UTA could monitor.

5.4   TECHNICAL CHALLENGES

Even though the Utah CAD-TMC integration project was determined to be a technical success, there were some rising technical challenges. The way in which the Utah agencies overcame these challenges may be instructive to other agencies considering a similar project.

5.4.1. CAD System Upgrade Schedules

The approach taken in Utah required an upgrade to every CAD system included in the integrated system. Since CAD systems are primarily off-the-shelf products, the main reason for the upgrade was to provide standards-compliant messages for system communication. The CAD systems developers provided upgrades on a fixed release schedule to ensure that the

systems would continue to be supported as part of the core CAD product. However, the overall project schedule was dependent on the CAD vendors' release schedules.

For agencies taking a similar approach to an integrated system, it is crucial to include consideration of the vendor release schedules in the overall project schedule.

5.4.2. Degree of Automation

As discussed in section 4, the original approach for most of the agencies was to allow the dispatchers to decide which incidents should be sent to which partner agencies. However, as discussed under institutional challenges, this approach led to changes in the dispatchers' work processes.

The technical challenge was to determine the level of automation that would be appropriate and to provide a system that allowed some flexibility in the level of automation. This determination would enable agencies to start at one level of automation, and then change as they learned what worked best for their dispatchers and their partner agencies.

Since the Utah agencies intend to modify their systems to allow more automation, they will need to upgrade their systems to do so.

5.4.3. Information Filtering

For VECC, all incidents were sent to the integrated system. However, not all incidents were of interest to all agencies. Operators at UDOT, for example, had to decide which VECC incidents should be brought into their incident management system. VECC had been transmitting all incident data, and at times it was difficult to determine the degree of importance of each transmittal to the CommuterLink system. In busy times, it was likely that some incidents that could be of interest were missed by UDOT operators. Automatic filtering of incidents would help by presenting only those incidents of most interest to the operators.

The partner agencies and the UDOT system integrator discussed filtering incidents early in the project. However, because the agencies involved had no experience in receiving incidents from partner agencies, they weren't sure what filters would be most useful. Following the end of the FOT, they determined that it would be beneficial to add a mechanism to filter messages. Both the sending and receiving agencies would provide filters to the messages.

For other agencies considering an integrated system, it would be valuable to consider a similar option and plan to include filtering if funding allows.

5.4.4. Communication and Architecture

Communication among agencies in any integrated system is critical. Messages and information have to reliably pass among the systems. In Utah, a fiber optics system was used to provide the primary communication medium. In case the fiber-optics system ever malfunctioned or was damaged, Utah's contingency plan included using the Internet as a back-up communication mechanism to link agencies via the State's wide area network.

5.4.5. Architecture and Standards

The Utah system utilizes a peer-to-peer architecture. Each vendor wrote their communication routines to conform to the protocol that UDOT and its system integrator specified. The protocol relied on ITS standards, and was based heavily on the IEEE 1512 incident management standard.

One of the challenges was that not all CAD systems used a code set that would be compatible with IEEE 1512 codes. The options from which dispatchers in the dispatch centers can select did not necessarily have a one-to-one correspondence to the IEEE 1512 codes. This led to an imprecise translation among the CAD systems and the UDOT incident management system.

5.4.6. GIS Standards

Geo-referencing standards are also important in an integrated system so that the location of an incident transmitted from one system is interpreted as the same location by another. Not all of the systems use the same geo-referencing scheme, so a translation from one system to another would be required. The DPS/UHP system uses State Plane Coordinates, as do many State police agencies nationwide. The system translates State Plane Coordinates to latitude-longitude. This translation is relatively straightforward in a confined space, such as the Salt Lake City region. However, over a larger geographic area, such as the entire State, there would be distortions as the plane coordinate system is translated to the spherical coordinates of latitude-longitude.

Agencies considering an integrated system should be aware of the various geo-referencing schemes used by the systems involved so accurate translation can be included in the schedule and budget.

5.4.7. UTA

An ongoing technical challenge for UTA was that the IEEE 1512 incident messaging standard underwent some evolution, and the agency needed to adjust its implementation to incorporate those changes.

In addition, since UTA was one the first agencies to implement its messaging interface, the agency found that it also needed to make ongoing adjustments to reflect changes in firewall and Internet Protocol (IP) address settings as other agency interfaces came on-stream.

Yet another ongoing evolutionary challenge was the switch, after the system became operational, from Internet-based communications to use of the ATMS fiber optic communications system. While UTA already had security and access rights infrastructure in place for communications with other agencies via the Internet, the switch to fiber optic communications required that additional infrastructure be established.

Also, it was necessary to ensure that other agencies (1) provided UTA the required security and access rights to their infrastructure; (2) provided documentation on these rights to UTA; and (3) informed UTA of changes in its security and access rights configuration.

While UTA understands that fiber optic communications holds an intrinsic advantage over Internet-based communications regarding message security, UTA did not feel that fiber optic communications provided any noticeable increase in the performance of the message delivery system from the agency's perspective.

6. CONCLUSIONS AND RECOMMENDATIONS

This section provides the overall conclusions and specific recommendations as they relate to lessons learned regarding institutional and technical challenges. A benefits summary also is included to aid other States and agencies in determining the value of integrating a CAD-TMC system.

6.1   CONCLUSIONS

Utah is fortunate that it had a well developed and established program in place prior to this field test. A joint process for handling incidents had been developed and refined over several years and included access to 9-1-1/CAD information for all types of incidents. Many of the benefits of an integrated TMC-CAD system were realized well before the field test got underway.

The FOT has proven worthwhile for the agencies to continue their quest to develop a true real-time data exchange system. As improvements are completed, operators from both agencies will recognize the benefits.

The real value of this FOT can be applied in Region 4 within Utah, and in other states that do not have the interoperability and strong institutional relationships that are already in place in the Salt Lake Valley region. This is especially true for areas where multiple agencies from state and local government agencies may respond to incidents on freeways, such as home rule states,[14] where interoperable CAD would be a huge benefit in trying to provide real-time traffic information. This would apply both to other regions within Utah and to other states. Delays in obtaining information in these outlying areas far exceed the delays that occur in the Salt Lake City region and sometimes significant events are not reported to UDOT at all.

6.2   RECOMMENDATIONS

The recommendations developed by the Evaluation Team are intended to serve as a general guideline that other states could consider when planning similar CAD-TMC integration projects. The intent was to help states proactively identify issues that may impact deployment cost, schedule, and technical performance, and reflect the lessons learned by Utah during the FOT.

The recommendations are presented in two sections. Section 6.2.1 presents general recommendations for consideration by all stakeholder groups involved in this type of project. Section 6.2.2 captures recommendations specific to the involvement of transit agencies in this type of integration, which were derived from UTA's experience.

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[14] The term "home rule states" refers to a certain type of governmental organization within states. The following definition of home rule is incorporated from the National League of Cities Web site: <http://www.nlc.org/about_cities/cities_101/153.cfm>: "Home rule is a delegation of power from the state to its sub-units of governments (including counties, municipalities, towns or townships, or villages). That power is limited to specific fields, and subject to constant judicial interpretation. Home rule creates local autonomy and limits the degree of state interference in local affairs."

6.2.1. General Recommendations

#1: Involve IT staff early-on in the project planning process. Interviewees mentioned the importance of involving agency information technology staff early in the development of the integrated system. This is important so the IT organization provides technical input to the system to assure that the computing and communication environment fit within each agency and can be effectively maintained.

#2: Understand the importance of close working relations from the start. All of those interviewed by the Evaluation Team mentioned the importance of the close working relationship among the agencies involved in this FOT. The close working relationship was strengthened by the work these agencies did in preparation for and during the 2002 Winter Olympic Games. Although not every region can strengthen relationships among agencies by hosting the Olympic Games, agencies should consider how to build these relationships in advance implementing an integrated system.

#3: Provide dedicated staff working on integration, or staff with emphasis on integration. Interviewees mentioned that it was often difficult to spend enough time on the integrated system. Decisions and work items sometimes took longer than those involved would have preferred. Even though every agency supported the integrated system, staff had normal responsibilities with integration duties added on. It would be ideal if staff involved had a priority on the integrated system tasks.

#4: Build in short development cycles to reduce staff turnover issues. Interviewees mentioned that some agencies had critical staff turnover during the implementation of the integrated system. Staff turnover can be disruptive to implementation schedules and budgets as new people have to come up to speed on the system. If the system is planned to have incremental implementations (see section 5.4, Technical Challenges), then the development cycles for each incremental implementation can be short to minimize the likelihood that staff will turnover during a given development cycle. Staff turnover between cycles is not as disruptive as turnover during a development cycle.

#5: Understand the importance of considering role of business practices in the integrated system. As discussed earlier in this document, it is important that the integrated system not require a change in the operator's or dispatcher's work process. However, if other aspects of an agency's business practice would improve the integrated system, it should be considered. For example, VECC agencies were concerned about providing certain information to the integrated system. UDOT is planning to develop an MOU with the VECC agencies that will specify how the information will be used. This may allow a change in those agencies' business practices that will lead to more information shared in the integrated system.

#6: Understand the importance of coordination meetings. Interviewees mentioned the importance of ongoing, periodic coordination meetings with the partner agencies. These meetings kept communication open and emphasis on the integrated project.

#7: Coordinate deployment schedule with vendor schedule for system modifications and upgrades. As mentioned in section 5, CAD systems are generally off-the-shelf products. Vendors have a fixed release schedule. It is important to coordinate project schedules with the vendors' release schedules.

#8: Define what data is exchanged and when. In the Utah system, the IEEE 1512 standard was selected for incident management messages and codes. However, not all vendors supported those codes. It is important for agencies to prepare for differences in codes and determine how to handle these differences.

#9: Decide what incidents will be shared among agencies and what information will be exchanged when an incident is shared. The experience in Utah is leading the participating agencies to automatically send incidents of interest and allow the receiving

systems to filter those incidents to display the ones that are likely to be of most interest to the operators.

#10: Understand the importance of incremental implementation. In the Utah system, agencies learned a lot in the initial implementation of the integrated system. The agencies are using that knowledge to plan improvements to the integrated system. For agencies planning an integrated system, it is recommended that they plan an initial implementation and at least one subsequent, incremental improvement. Any group of agencies is almost certain to learn how they would prefer to have the system operate. The project and related contracts should be arranged to allow the agencies to implement what they learn in the initial implementation.

#11: Understand the importance of redundant communication path. As discussed in section 5, a back-up communication pathway is important. Agencies should plan to include redundant communications in an integrated system.

#12: Minimize or avoid duplicate entry. Because not all needed information is transferred from VECC to the integrated system, UDOT operators have to enter data in their system that was already entered by VECC dispatchers in their system. Ideally, any given piece of information would only be input once by any operator in the integrated system. This is an important concept to plan for in any integrated system.

6.2.2. Transit-Specific Recommendations

UTA cited the following general technical and institutional lessons learned, with recommendations provided as appropriate:

Transit #1: Expect a great deal of complexity in interfacing with the various network protocols and security infrastructures for multiple public sector agencies, in particular, given the sensitive nature of much of the subject matter for the messages. Not everything UTA thought it understood at the outset turned out to be correct, both technically and institutionally. There is no effective way to learn these things other than by working through them with the other agencies, and it is useful to understand that extra time and effort will be needed.

Transit #2: A technical example was the need to make various unexpected changes in UTA's messaging interface to accommodate the specific configurations of the messaging system interfaces developed later by other agencies. UTA did not anticipate the amount of time that would be needed for such adjustments to the configuration of its software.

Transit #3: An institutional example was the unexpected difficulty for dispatchers in being able to quickly interpret public safety agency incident messages, due to the various codes and jargon used.

Transit #4: For agencies that need to work with a vendor for the necessary enhancements to their respective CAD systems, it will be useful to establish strong working relationships and effective contractual mechanisms for ongoing technical support. It would be difficult to anticipate the specifics of all required vendor support for incorporation into system specifications. This leads to vendor support being needed for requirements that were not necessarily incorporated into UTA's original specifications. Since UTA developed and enhanced its software using in-house resources, it did not need to work with a vendor and did not experience this directly. However, several of the other agencies did need to work with their respective CAD software vendors to implement the changes, and this was UTA's observation on the effect.

Transit #5: Incident information generated by public safety agencies needed to be filtered and processed before being presented, for effective use by transit dispatchers. In their raw form, it was found that only some of these incident messages would affect traffic. In addition,

the message description contained a range of information not needed by transit operations and in a format that was difficult to decipher. The filtering and processing could be performed either by a designated staff person, or by another agency such as UDOT. The purpose of this filtering and pre-processing for UTA would ideally be to (1) limit messages to those that could affect traffic in main corridors of the UTA service area; (2) provide a plain language description of the potential traffic impact location; and (3) distinguish between messages about new incidents and updates on existing incidents.

6.3   BENEFITS SUMMARY

The Benefits Summary presented in the Evaluation Plan identified the key metrics to be assessed during the course of the evaluation. The following benefits were identified:

#1. Enhanced field operations was associated with locating and responding to incidents. To a significant extent, this benefit was previously realized by Utah. UDOT and UHP had previously co-located staff at TMCs, and CAD terminals were placed in TMCs to enable data sharing. The most significant benefit realized by the project was the ability to engage in direct data exchange between legacy systems rather than having an operator observe two or more terminals. This real-time exchange of data adds to the benefits previously obtained through inter-agency cooperation and represents an additional enhancement of field operations and fills what had been a gap in the existing incident management and response program already in place in Utah.

#2. Geo-location for placing incidents and marginal improvement in scene clearance. Observed benefits included the use of Geo-location in providing a mechanism to place incidents without operator intervention, and from interviews, a qualitative assessment that scene clearance time seemed to improve marginally. Better traveler information allows the public the opportunity to bypass the incident which leads to less congestion and better response sooner (response units getting to the scene via a clear route). This logic seems sound; however, data was not available to support these conclusions.

#3. Enhanced communications among responders; enhanced on-scene activities. The evaluation was not able to completely assess this benefit. The system is newly deployed and while operational is still undergoing refinement. This benefit would be more accurately assessed when the system has matured and has been in use for a period of several years instead of several months.

#4. Enhanced efficiency in documenting the incidents. In the first 2 months of operation, UDOT increased documented incidents of 800 percent, as noted in section 4.2.1. The number of incidents for which the TMC maintained data increased significantly after the CAD-TMC integration. The main difference observed between the before and after data discussed above was that UDOT seemed to maintain much more complete incident records after the deployment, both in terms of the number of incidents recorded and the details recorded about each incident. It is believed that this increase is due in large part to the fact that CAD data was more readily available to TMC operators after the CAD-TMC deployment. This is supported, in part, by the large number of incidents in the after data for which Dispatch Services/9-1-1 were listed as the reporting agency.

#5. Improved data quality. The electronic data collection, particularly, recording the incident start and stop times, has significantly improved overall data quality. An additional example of this is reflected in a decrease in the error rate for the coding of incidents by type.

#6. Improved interagency working relationships. Utah had already achieved substantial progress in this area, and the project represented a continuation of this benefit. Utah's success

in this area is represented by the inter-agency discussions on the amount and type of data that should be exchanged between the systems—the inter-agency cooperation that enabled this data exchange established the venue for addressing this type of system refinement based on initial deployment experience.

#7. Enhanced communication with the traveling public and media. This benefit would be more properly addressed at system maturity. While anecdotal evidence obtained during after project interviews indicates that enhanced communication is occurring, assessing this metric based on several years of implementation experience will provide a more accurate measure the benefit of enhanced communication to the traveling public and the media. From observations, efficiency in documenting incident management improved. This was presented in section 4.1, and was also an objective of the system impact study. Input for some fields was automated so UDOT operators did not have to enter this data.

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