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

Contract #: DTFH61-02-C-00061
ITS Program Assessment Support Contract
Task SA61004

Submitted to:

United States Department of Transportation
Mr. David Helman
Dr. Joseph Peters

Submitted by:

Science Applications International Corporation
1710 SAIC Drive
M/S T1-12-3
McLean, VA 22102

July 2006

U.S. Department
of Transportation

FOREWORD

This *Computer-Aided Dispatch (CAD) –Traffic Management Center (TMC) Field Operational Test: Washington State Final Report* provides detail about the integration of the Washington State Patrol (WSP) and the Washington Department of Transportation (WSDOT) information systems to enable the real-time exchange of incident data. The field operational test (FOT) was also 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 *Computer-Aided Dispatch (CAD) –Traffic Management Center (TMC) Field Operational Test (FOT): State of Washington Final Report* will be useful to incident response agencies (e.g., fire and rescue, law enforcement, transportation) located throughout Washington State, which 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 these 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 document 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, and recommendations associated with the CAD-TMC deployment for use by other agencies contemplating a similar system.

This document supersedes an earlier report on the subject.

<table>
<tr><td>1. Report No.</td><td>2. Government Accession No.</td><td colspan="2">3. Recipient's Catalog No.</td></tr>
<tr><td colspan="2" rowspan="2">4. Title and Subtitle
Computer-Aided Dispatch – Traffic Management Center Field Operational Test Final Report: State of Washington</td><td colspan="2">5. Report Date
May 2006</td></tr>
<tr><td colspan="2">6. Performing Organization Code</td></tr>
<tr><td colspan="2">7. Authors
Nick Owens (SAIC), Mark Carter (SAIC), Chuck Louisell (SAIC), Robert Haas (SAIC), Carol Mitchell (SAIC) , Leslie Jacobson (PB Farradyne), Joel Ticatch (PB Farradyne) , John O'Laughlin (PB Farradyne), Jason Stribiak, (PB Farradyne), Matthew Seal (PB Farradyne), and Douglas Parker (Transystems).</td><td colspan="2">8. Performing Organization Report</td></tr>
<tr><td colspan="2" rowspan="2">9. Performing Organization Name and Address
Science Applications International Corporation (SAIC)
1710 SAIC Drive, M/S T1-12-3
McLean, VA 22102</td><td colspan="2">10. Work Unit No. (TRAIS)</td></tr>
<tr><td colspan="2">11. Contract or Grant No.
DTFH61-02-C-00061;Task SA61004</td></tr>
<tr><td colspan="2" rowspan="2">12. Sponsoring Agency Name and Address
United States Department of Transportation
ITS Joint Program Office, Room 2416
400 7th Street, SW
Washington, DC 20590</td><td colspan="2">13. Type of Report and Period Covered</td></tr>
<tr><td colspan="2">14. Sponsoring Agency Code
HOIT-1</td></tr>
<tr><td colspan="4">15. Supplementary Notes
Mr. David Helman (COTM)
Dr. Joseph I. Peters (COTR)</td></tr>
<tr><td colspan="4">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 Washington. 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.</td></tr>
<tr><td colspan="2">Key Words
Intelligent Transportation Systems, ITS Deployments, Transportation, Computer-Aided Dispatch, Traffic Management Centers</td><td colspan="2">18. Distribution Statement
No restrictions. This document is available to the public from: The National Technical Information Service, Springfield, VA 22161.</td></tr>
<tr><td>19. Security Classif. (of this report)
Unclassified</td><td>20. Security Classif. (of this page)
Unclassified</td><td>21.No of Pages
55</td><td>22. Price
N/A</td></tr>
</table>

Form DOT F 1700.7 Reproduction of completed page authorized.

TABLE OF CONTENTS

ABBREVIATIONS v
EXECUTIVE SUMMARY 1
1. Introduction 12
1.1 Background 12
1.2 Problem Statement 12
1.3 Report Organization 13
2. Implementation Results 15
2.1 Pre-FOT Incident Response 15
2.2 The Washington CAD-TMC FOT 16
2.3 System Implementation 18
2.3.1. Secondary Response Agency 18
2.3.2. System Modification 19
2.3.3. Use of Standards and Data Translations 20
3. Evaluation Strategy 21
3.1 Evaluation Strategy Overview 21
3.2 Goals and Objectives 21
3.2.1. System Performance Study 25
3.2.2. System Impact Study 25
3.2.3. Institutional Challenges Assessment 26
3.2.4. Technical Challenges Assessment 26
3.2.5. Lessons Learned Assessment 26
3.3 Data Collection 27
3.4 Interim Project Review 28
4. Test Results 30
4.1 System Performance Test Results 30
4.1.1. Objective #1: Document the System Component Performance 31
4.1.2. Automate Information Transfer between TMC and Emergency Responders 33
4.1.3. Integration of Secondary Responders 34
4.2 System Impact Test Results 34
4.2.1. Impact on Productivity 36
4.2.2. The Impact on Mobility, Safety, Capacity, and Throughput 39
5. Evaluation Findings 40
5.1 System Performance 40
5.2 System Impact 40
5.3 Institutional Challenges 41
5.3.1. Inclusion of Secondary Responders 41
5.3.2. WSP Use of WSDOT Data 41
5.3.3. Geographic Boundary Differences 41
5.3.4. Rural versus Urban Needs 42
5.4 Technical Challenges 42
5.4.1 Latency 42
5.4.2 CAD System Upgrade Schedules 43
5.4.3 Geo-location 43
5.4.4 Use of Standards 43
6. Conclusions and Recommendations 44
6.1 Conclusions 44

6.2 Recommendations 44
6.2.1 General Recommendations 44
6.2.2 Technical Recommendations 45
6.2.3 Institutional Recommendations 46
References 47

LIST OF TABLES

Table 1. Combined ITS JPO and WSDOT Evaluation Goals 3
Table 2. System Performance Test Results Summary 5
Table 3. System Impact Test Results Summary 8
Table 4. Combined ITS JPO and WSDOT Evaluation Goals 23
Table 5. System Performance Test Results Summary 31
Table 6. System Impact Test Results Summary 35

LIST OF FIGURES

Figure 1. Washington CAD-TMC System Architecture. 18
Figure 2. CAD Incidents Before and After the CAD-TMC Deployment. 36
Figure 3. Arrival Time for CAD Incidents. 37
Figure 4. Number of CARS Incidents Before and After Deployment. 38
Figure 5A. Number of CARS Incidents, Northwest Region. 38
Figure 5B. Number of CARS Incidents, Northwest Region. 38
Figure 6. Number of CARS Incidents Relative to CAD Incidents. 39

ABBREVIATIONS

ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
CAD-TMC	Computer-Aided Dispatch-Traffic Management Center
CARS	Condition Acquisition and Reporting System
COTM	Contracting Officer's Task Manager
COTR	Contracting Officer's Technical Representative
DMS	Dynamic Message Signs
DSS	Data Specification Sets
EMS	Emergency Medical Services
FOT	Field Operational Test
FTP	File Transfer Protocol
GIS	Geographical Information System
IAM	Interagency ATMS Message
IEEE	Institute of Electrical and Electronics Engineers
IPR	Interim Project Review
IT	Information Technology
ITS	Intelligent Transportation Systems
ITS JPO	Intelligent Transportation Systems Joint Program Office
JOPS	Joint Operation Policy Statement
MSETMC2C	Message Sets for External Traffic Management Center to Center
MOU	Memorandum of Understanding
NTCIP	National Transportation Communications for ITS Protocol
RFP	Request for Proposal
TMDD	Traffic Management Data Dictionary
SAE	Society of Automotive Engineers
TMC	Traffic Management Center
USDOT	United States Department of Transportation
WSDOT	Washington State Department of Transportation
WSP	Washington State Patrol
XML	Extendable Markup Language

EXECUTIVE SUMMARY

Background

Most major metropolitan areas in the United States rely on some type of advanced traffic management system(s) (ATMS) to help manage mobility, congestion, and incident response. Many States have installed an extensive infrastructure of remotely operated cameras, loop detectors, and other ITS applications that provide traffic management services. These systems are typically operated from centralized Traffic Management Centers (TMC), where traffic-related information is received and processed and appropriate remedial actions are deployed and coordinated. These TMCs are typically the hub of traffic management operations.

The hub of public safety and law enforcement operations is the dispatch center, where calls for assistance are received and officers are dispatched to respond to those calls. Dispatch operations are managed by Computer-Aided Dispatch (CAD) systems that track information about incidents that require a public safety answering point or law enforcement response and help manage that response.

These two separate systems overlap when responding to traffic incidents, which often have a need for both public safety/law enforcement and traffic management responses. However, to date, there have been few cases where the TMC systems used to manage traffic have been integrated with the CAD systems used to manage public safety and law enforcement. To investigate the benefits of integrating CAD and TMC systems, the U.S. Department of Transportation (USDOT) Intelligent Transportation Systems Joint Program Office (ITS JPO) funded the CAD-TMC Field Operational Test (FOT) in Washington State and Utah, as well as an independent evaluation of that FOT. This report presents the findings of the evaluation of the Washington State CAD-TMC FOT.

Reducing traffic-related fatalities and improving emergency response capabilities are two primary goals of the USDOT's 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).[1]

To demonstrate how the integration of CAD and TMC systems can improve incident response capabilities and how institutional barriers can be overcome, the USDOT ITS JPO, sponsored two FOTs through the ITS Public Safety Program that integrated CAD-TMC systems in Utah and Washington State, respectively. 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,

[1]Excerpted in part from the USDOT ITS Program Safety Web site: < http://www.its.dot.gov/pubsafety/> (February 7, 2006).

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]

The WSDOT CAD-TMC Integrated System

The system integration and data exchanges within this project are summarized as three main components, defined as “PRIMARY ALERT,” “RESPONSE SUPPORT,” and “SECONDARY ALERT,” and are described as follows.

Component #1 – PRIMARYALERT

PRIMARY ALERT serves as the main connection between the WSP CAD system and the WSDOT TMC. This component filters the CAD data and transfer those portions suited for receipt and use by the TMC. The key aspects of PRIMARY ALERT are as follows:

- Only specified fields are transferred from the WSP CAD system into the TMC system. Although there is a tremendous amount of data generated by the CAD system, only a small portion of that data is of interest to WSDOT, and similarly, only a portion could be shared with other public agencies.
- Information exchange between agencies is intended to be seamless and automatic, e.g., not requiring the operators to re-enter data in a different format or perform any intermediate tasks to exchange data. Any data translations are accomplished using automated software code that performs required translations without user intervention.

Component #2 – RESPONSE SUPPORT

The intent of the RESPONSE SUPPORT component is to transfer any available information from WSDOT to the WSP that would support WSP response efforts. Unlike PRIMARY ALERT, this information transfer will consist of information about other external events near the incident. For example, in the event that a crash is reported to WSP on I-5 just north of Tacoma, the PRIMARY ALERT component is intended to transfer information from WSP to WSDOT. RESPONSE SUPPORT displays information to WSP about nearby events, such as slow traffic, construction, accidents, or other extreme events (i.e., pass closures, flooding, National Weather Service warnings, etc.) that might impede the patrol officer’s response.

[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.

Component #3 – SECONDARY ALERT

The third component is SECONDARY ALERT, which is intended to reach those responders beyond the WSP and WSDOT jurisdictions, including local Emergency Medical Services (EMS) providers, tow truck dispatchers, and local utility companies. The general philosophy of SECONDARY ALERT is as follows:

> To provide as comprehensive and complete information in the most useful fashion to secondary responders across the entire State of Washington, recognizing that the dispatch systems of these secondary responders vary widely in complexity.[3]

At least one EMS provider (Skagit County EMS) was going to serve as a demonstration for the transfer of information to the CAD system of a non-WSP responder. However, for a variety of reasons discussed in section 2.3, Skagit County EMS did not participate in the FOT. The Secondary Alert component was not included in the FOT.

Evaluation Goals and Objectives

The combined ITS JPO and WSDOT evaluation goals and objectives developed for the CAD-TMC integration FOT are summarized in table 1.

Table 1. Combined ITS JPO and WSDOT Evaluation Goals

ITS JPO	WSDOT	Evaluation Goal	Evaluation Objective
System Performance			
The FOT will automate the seamless transfer of information between traffic management workstations and police, fire and EMS CAD systems from different vendors.	Enable the automated electronic exchange of data between agencies on a real-time basis. This electronic data exchange will address the one outstanding need that still exists between WSDOT and WSP.	Document system component performance.	Determine the feasibility of automating the seamless transfer of information between traffic management workstations and police, fire, and EMS CAD systems from different vendors.
The FOT will incorporate ITS standards such as IEEE 1512 and NTCIP into the integration of public safety and transportation information systems. Other standards areas that will have to be addressed are those pertaining to	The State has committed to using ITS standards and to develop a system that conforms to the National ITS Architecture.	Document system component performance.	Investigate the benefits of incorporating 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.

[3] Adapted from: Legg, Bill, WSDOT, "Application for RFA Number DTFH61-02-X-00062, Computer-Aided Dispatch (CAD) – Traffic Management Center Integration Field Operational Test (FOT)."

ITS JPO	WSDOT	Evaluation Goal	Evaluation Objective
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.	Integrate local, county, and municipal government emergency management and response agencies (fire and rescue, law enforcement).	Document system component performance.	Determine the benefits of extending the level of integration to include secondary responders such as utilities, towing and recovery, public works, and highway maintenance personnel.
System Impact			
FOT enhances communications among responders. FOT enhances efficiency in documenting incidents. FOT enhances on-scene operations. FOT reduces incident clearance times. FOT improves information available to traveling public and media.	Expected project impacts include: Reduce the time needed to deploy assets to respond to an incident. Reduce exposure of response personnel. Reduce secondary collisions resulting from the initial incident. Reduce the time needed to post incident-related information on the State's traveler information systems (Internet, 511), as well as provide information to the media. Improve the quality of information provided to the media and traveling public.	Conduct a system impact study.	Determine whether CAD-TMC integration improves: Productivity and efficiency. Mobility. Safety. Integration with 511/Internet interface.
Institutional and Technical Challenges			
Assess institutional and technical challenges.	Improved inter-agency relationships, in particular understanding of each agency's role and duties, to dissolve institutional barriers between the two agencies.	Identify institutional and technical challenges.	Document process by which institutional and technical issues were resolved.
Lessons Learned			
Document lessons learned.	Not specifically established, but fully supported.	Identify lessons learned.	Document lessons learned that would be of benefit for other jurisdictions considering similar deployments.

ITS JPO	WSDOT	Evaluation Goal	Evaluation Objective
Benefits			
Summarize benefits.	Not specifically established, but fully supported.	Identify benefits from integrating the CAD-TMC system.	Identify qualitative and qualitative benefits achieved by the deployment that can be used by other jurisdictions to obtain support (programmatic, technical, funding) for similar deployment.

System Performance Test Results

The assessment of system performance was conducted 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 results of the system performance test are summarized in table 2.

Table 2. 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, 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.	Achieved previously through placement of CAD terminals at TMCs. Enhanced through project.
	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	Improved integration of secondary responders will reduce incident recovery time by getting required recovery personnel to the incident site as quickly as possible to	Not achieved during the evaluation period.

Evaluation Objective	Hypothesis	Test Results
recovery, public works, and highway maintenance personnel.	begin recovery operations.	

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 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.

Through interviews with the WSDOT system developers and the WSDOT project manager, the system performed according to expectations and the functional specifications established. In observations of the integrated system, Evaluation Team members saw that there is latency in the system from when an entry is entered into and displayed on the WSP CAD and when it is displayed in Condition Acquisition and Reporting System ([CARS][4], the integration platform). This latency was known during the development of system requirements and design. As mentioned in section 2, the latency is a product of the way in which the WSP CAD system is designed. There is also additional latency in presenting information in the 511 system or on the WSDOT traffic information Web site. This was also foreseen during the project conceptualization phase.

The latency does not affect whether the system meets its functional specifications. However, it is important to note that the significance of the latency differs depending on the area and the view of the WSDOT operators involved. Operators in more rural regions were reported to be satisfied with the system and its performance. In urban areas, there were more mixed feelings about the system and its inherent latency issues. Only one operator interviewed in the Seattle TMC said he used the integrated system. The other operators entered incident information directly into CARS as soon as they saw an incident of interest displayed on the WSP CAD terminal. They did not feel they could wait for the incident to display in the integrated system to complete the entry and send it to the travel information systems.

It is important to realize that the operators in the urban areas (Seattle and Tacoma) had access to WSP CAD terminals before the integrated system was implemented. The operators were used to seeing incidents on the CAD terminal, deciding which ones were of interest, and entering the appropriate information into CARS. Because of this experience, any latency from the display on the CAD terminal to the integrated system would be noticeable. Operators in rural regions did not have access to WSP CAD terminals prior to the integrated system and getting the information, even with some latency, greatly improved the information and timeliness of incidents that they report to the travel information systems.

There have been some improvements in incident response procedures in the WSDOT operations centers. Improving the efficiency of documenting incident management will be covered in the next section. In addition to improved efficiency, there are two other improvements that should be mentioned:

[4] CARS is a non-proprietary, standards based condition reporting system that allows authorized users to enter, view and disseminate critical road, travel, weather and traffic information. Additional information is available at www.carsprogram.org/public/documents/CARSprogram.pdf

Time to enter an incident first reported by a partner agency.
Accuracy of the information in the incident record.

Objective #2: Automate the Seamless Transfer of Information between Traffic Management Workstations and Police, 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 when the operators choose to use it. Incidents reported by WSP CAD are transmitted to the integrated system and easily imported into CARS. For regions that did not have WSP CAD terminals, this information sharing is the only reliable way to receive incident information. Where CAD terminals were not available, WSDOT operators relied on scanners, calls from WSP, and radio calls from WSDOT field personnel to find out about incidents. It was very easy to miss incidents because the operators didn't hear scanner reports or because WSP dispatchers or WSDOT field personnel were too busy to call in the incident.

From observations and interviews, integration increased the extent and reliability of information exchanges. Information passed from WSP directly through CAD to CARS so conversations were only needed to clarify information. There was a lower likelihood of misunderstanding basic aspects of the incident. In locations where WSP CAD terminals existed, this benefit was already realized. However, where the terminals weren't available, the ability to focus voice communication only on details that need clarification is a tremendous benefit.

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. As the project and discussions between WSDOT and Skagit County EMS progressed, this concept did not appear to really be a benefit. Skagit County EMS was too small, with too focused a mission to really be a good candidate as a secondary responder incorporated in the integrated system.

System Impact Test Results Summary

The assessment of system impact was conducted 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 high degree of operational integration between WSP and WSDOT that existed before the CAD-TMC FOT meant that the impact of the FOT on operational productivity would be limited. Many of the operational benefits that could be achieved through a CAD-TMC integration had already been accomplished through other means, such as providing a CAD terminal in the individual TMCs. Other potential benefits of the integration were negated by technical limitations of the integration. For example, most TMC operators reported that the long lag time before the automated system made CAD incidents available to CARS induced them to continue to use the manual, pre-FOT approach for populating CARS with incident data. For those operators that did not use the system, no benefits related to its use were possible. The Evaluation Team observed lower usage rates in the Olympic and Northwest areas.

Thus, these impacts may under-represent the impacts that might be found in a similar integration at other locations.

Evaluation findings related to system impact are qualitative, as follows:

- From observations and interviews, due to the existing operational integration between WSP and WSDOT that existed before the CAD-TMC FOT, there was little change in the nature of the CAD incidents, other than an increase in the total number of incidents that occurred.
- From observations and interviews, there was also little change in the response times before and after the deployment.
- Because the CAD-TMC deployment had little impact on TMC and CAD operations, an impact on mobility, safety, capacity, and throughput was not possible.

The results of the system impact test are summarized in table 3.

Table 3. 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 with WSDOT and WSP.
	CAD-TMC integration improves efficiency of on-scene operations.	Not measured during the evaluation.
	CAD-TMC integration enhances efficiency in documenting incident management.	Partially achieved; further reductions will enhance results.
	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 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	CAD-TMC integration enhances customer satisfaction and mobility during incident management	Not directly measured. Increased number of incidents posted to traveler information systems

Evaluation Objective	Hypothesis	Test Results
improve incident management information available to travelers.	activities by improving traveler information.	indicates improved flow of information to public.

Conclusions and Recommendations

It is important to note that WSDOT and WSP have a long-standing relationship for sharing details of incidents that occur on the roadway system in the northwest and Olympic regions of the State (this includes the Seattle metropolitan area). WSP has provided a CAD listing of incidents for several years to the WSDOT TMCs to monitor to which incidents the field patrols were receiving and responding. With cameras or detectors available to WSDOT operators, they could verify the incidents and provide information to the media. The WSDOT operators could also use Dynamic Message Signs (DMS) to advise motorists of the incidents. That system was manual, however, and required the WSDOT operator to create an entry based on the input from the WSP CAD system.

An important and frequent participant in all roadway incidents is the WSDOT Incident Response Team. Expanded in recent years to all regions in the State, these operators are dispatched by the WSP, have direct mobile to mobile communications with troopers, and with the maintenance personnel in their regions. They respond to incidents to provide a full range of incident management services to prevent secondary crashes, reduce congestion, and restore normal traffic flow as quickly as possible.

For the CAD-TMC FOT to show substantial improvement in accuracy and timeliness was recognized as a challenge because of the existing procedures and relationships in place. The FOT has proven worthwhile for the agencies to continue their quest to develop a true real-time data exchange system.

Recommendations

General Recommendations

1. **Involve IT staff early-on in the project planning process.** Interviewees emphasized 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 ensure 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 interviewees commented on the importance of a close working relationship among the agencies involved in this FOT. As is noted in section 2 of the report, WSP and WSDOT have established a Joint Operations Policy Statement governing incident response procedures, and conduct regular meetings to discuss operational issues. The two agencies had long-standing, well-established working relationships prior to the FOT that provided a forum for resolving issues encountered during the deployment.
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. **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. For example, as discussed in section 5, WSDOT originally intended to be able to populate event information in the WSP CAD system through a "hazard flag." The WSP CAD application did not lend itself to ingesting the WSDOT data as proposed and dispatchers would have to access WSDOT event information through a Web interface, and congestion information through either a Web interface or TMC workstation software. This approach would have required dispatchers to change their normal work processes to access and view this information.
5. **Coordinate deployment schedule with vendor schedule for system modifications and upgrades.** As stated in section 5, CAD systems are generally off-the-shelf products. Vendors have a fixed release schedule, so it is important to coordinate project schedules with the vendors' release schedules.
6. **Define what data is exchanged and when**. In Washington State, WSP had concerns about releasing all incident-related information recorded in the CAD system. The WSP did not want to provide WSDOT with information that might compromise the investigation of incidents or other proprietary information related to law enforcement activities. The two agencies eventually established a protocol on what information would be provided to WSDOT, and a filter was developed that selected only the agreed to information from the CAD system when incident information was pushed to the CARS system.

Technical Recommendations

1. **Coordinate deployment schedule with CAD vendor schedule for system modifications and upgrades.** There were times that the project schedule was not met because the vendor release schedule was unknown when the CAD-TMC project schedule was developed.
2. **Establish common incident location identifiers.** There was confusion and a potential problem identified with ability to correctly locate incidents because the WSP and WSDOT typically used somewhat different location identifiers. These location identifiers may be different names for the same landmark or may be different ways to describe the same location. It would be helpful to come to agreement on a method of describing locations among the parties involved. In addition, it would be beneficial to agree on as many common incident locations as practical.
3. **Consider system latency.** It is critical to consider what is acceptable for latency in the system. This may differ from region to region, agency to agency, even operator to operator. Latency should be considered early during the system approach development phase and needs to be considered a system requirement once the appropriate levels of latency are identified.
4. **Consider automation.** In general, the more automation, the better. Things to consider are whether operators sometimes or always need to verify incidents before the information is sent out. This may vary by situation, so the system needs to be designed with the needs of various operators and stakeholders in mind. There may need to be different approaches in rural and urban areas.

Institutional Recommendations

1. **Select response partners carefully.** There must be a clear benefit to the partner in the integration. As mentioned is section 2.3, Skagit County EMS was too small with too focused a mission to really be a qualified candidate as a secondary responder incorporated in the integrated system. WSDOT initially selected Skagit County EMS because it was small and WSDOT thought it would be a better initial step to incorporate a smaller, less complex response agency. In hindsight, WSDOT representatives indicated that they should have selected a response agency where there were more traffic problems. For example, on an urban freeway where roving incident response vehicles have just started operation, it might be beneficial to know when and to what location local police and fire are dispatching response units. It would be interesting to determine if knowledge about the actions and location of the WSDOT incident response vehicles would be a benefit for dispatchers at these local agencies.
2. **Focus on primary objectives.** In Washington State, the primary objective is providing improved traveler information. The primary view of success was whether or not information about incidents to the public is improved and provided on a more timely basis. By focusing on the primary objectives, trade-off decisions can be made more easily. Also, the focus on primary objectives helps determine the best design alternatives.
3. **Work process.** WSDOT initially thought that providing information about traffic conditions and WSDOT incident management activities directly to WSP dispatchers would be beneficial to the dispatchers. However, the information was not integrated into the dispatcher's applications well, so the dispatcher's work process would need to change to make use of this information. As a result, WSDOT is now considering sending a map layer to the WSP dispatch terminals that will show events and perhaps traffic congestion. Also, WSP will be equipping vehicles with AVL. WSP has suggested that the WSDOT incident response vehicles and service patrols be equipped with AVL to display their locations in the WSP system. Together, these approaches will provide the functionality originally envisioned by WSDOT, and would fit much better into the WSP dispatchers' work process as well.
4. **System training.** From interviews with development staff and operators, additional training would have been beneficial in the WSDOT system. There are some subtleties in how to configure the system to provide operators with the most benefits. Although it initially seems straightforward with little need for additional training, it is important to train operators on how to use the system features and to allow them to ask the developers how to use the system in specific situations to gain the desired results.

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).[5]

Most major metropolitan areas in the United States rely on some type of advanced traffic management system(s) (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 Center (TMCs), where traffic-related information is received and processed and appropriate remedial actions are deployed and coordinated. These TMCs are typically the hub of traffic management operations.

The hub of public safety and law enforcement operations is the dispatch center, where calls for assistance are received and officers are dispatched to respond to those calls. Dispatch operations are managed by Computer-Aided Dispatch (CAD) systems that track information about incidents that require a public safety, law enforcement, traffic management, or emergency medical services (EMS) response and help in managing that response.

These two separate systems overlap when responding to traffic incidents, which often have a need for law enforcement, EMS, and traffic management responses. However, to date, there have been few cases where the TMC systems used to manage traffic have been integrated with the CAD systems used to manage public safety and law enforcement. To investigate the benefits of integrating CAD and TMC systems, the USDOT ITS JPO-funded the CAD-TMC Field Operational Test (FOT) in Washington State and Utah, as well as an independent evaluation of that FOT. This report presents the findings of the evaluation of the Washington State CAD-TMC FOT.

1.2 PROBLEM STATEMENT

The current USDOT ITS JPO-funded Computer-Aided Dispatch Traffic Management Center (CAD-TMC) integration and data exchange FOT, is one of many initiatives implemented to meet the ITS Public Safety Program goals. The objective of the FOT was to demonstrate how the integration of CAD and TMC systems can improve information flows between emergency response agencies, and in turn, improve incident response capabilities. The intent was to develop the technical capability to exchange information as well as identify and resolve the

[5] Excerpted in part from the USDOT ITS Program Safety Web site: < http://www.its.dot.gov/pubsafety/> (February 7, 2006).

institutional barriers that can arise when multiple agencies are involved in this type of project. To achieve these objectives, the USDOT ITS JPO 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 the FOT is well stated in the Request for Proposals (RFP) for the CAD-TMC Integration FOT evaluation:

> 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]

By 2003, the USDOT ITS JPO had signed cooperative agreements with the States of Washington and Utah to conduct CAD-TMC FOTs that would integrate State Highway Patrol CAD systems with the TMCs operated by the State DOTs. Later that year, the UDOT ITS JPO contracted with Science Applications International Corporation (SAIC) to conduct an independent evaluation of the FOTs.

1.3 REPORT ORGANIZATION

This report presents the findings of the evaluation of the Washington CAD-TMC integration FOT. The remainder of the report is structured as follows:

- **Section 2 – Implementation Results:** This section of the report 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.

[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.

Section 5 – Evaluation Findings: This section discusses the evaluation findings. 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:

- Recommendations for technical and institutional lessons learned: What are the lessons learned, and how are they useful to USDOT 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 PRE-FOT INCIDENT RESPONSE

Prior to the FOT, the primary emergency response agency for Washington State roadways was the Washington State Patrol (WSP). Emergency cellular 911 calls were received at the WSP dispatch center and in-field troopers regularly report progress to the dispatch center as they respond to crashes and events in the field. As a result, the WSP dispatch center was the primary source of information about incidents impacting the Washington State roadway system.

Also prior to the FOT, WSDOT TMC operations have been shown to be a valuable resource in responding to events because of the traffic surveillance capabilities used to monitor incident sites and identify travel routes to those sites. WSDOT has also provided personnel and equipment to help manage traffic at event locations and clear incidents to restore normal traffic flow.

Because of these complementary capabilities in responding to incidents, WSP and WSDOT have cultivated a long-standing history of working together to improve incident response. At an organizational level, the two agencies have held annual senior management retreats and monthly regional coordination meetings. One result of this coordination was the establishment of a Joint Operations Policy Statement (JOPS) that states the two agencies would share data to improve incident response. This policy was implemented by encouraging WSP CAD dispatchers and WSDOT TMC operators to exchange information about events and by providing access to each organizations incident response data.

Prior to the implementation of the FOT, the following process was used to exchange incident information between the two agencies. WSP dispatchers, usually the first notified about an event, would initiate the exchange of event information. While the WSP dispatchers' primary responsibility is to manage the WSP's response to an incident, the dispatchers also notified WSDOT TMC operators about significant incidents verbally by radio or telephone. Alternately, TMC operators might note information about an incident by monitoring information on the WSP CAD remote data terminals located in WSDOT TMCs. These terminals provided read-only access to current activities being logged into the WSP CAD.

In addition to the incident information data exchange process described in the preceding paragraph, it should be mentioned that the WSP Dispatch and PSAP Supervisor in the Bellevue region of the State (northwest) also had access to and secondary control of CCTV cameras in the metro area. This access is also used to identify and provide information about incidents.

WSDOT TMC operators used this incident information to help manage their response to each incident. Responses might have included dispatching road crews to manage traffic at the incident and entering information into WSDOT's CARS platform. WSDOT dispatchers used CARS to assist in roadway response, and CARS supplied a portion of the traveler information content to WSDOT's 511 system and Internet pages. CARS is used to provide communication and coordination support.

Throughout an incident, WSP dispatchers and TMC operators continued to use these communication systems—radio, telephone, and data terminals—to share information and coordinate responses. Although this system has proven effective in facilitating the exchange of information, it also was determined to be a time- and resource-intensive approach to communication. One result of using this system was that it sometimes limited the amount of information communicated between the agencies about a particular event.

In an attempt to address this situation and ensure that event information exchange captured all reported events, WSP and WSDOT agreed to participate in the FOT to facilitate the development of an integrated CAD-TMC system. The timing of the FOT also coincided with the implementation of a new, state-of-the-art WSP CAD system. The new WSP CAD system established a common platform used by all WSP dispatchers and also improved WSP's ability to record incident data.

2.2 THE WASHINGTON CAD-TMC FOT

The Washington State deployment of an integrated CAD-TMC system included the following primary elements:

- The PRIMARY ALERT CAD Interface, which filtered data from the WSP CAD system and pushes it to WSDOT CARS.
- The RESPONSE SUPPORT Web Interface, which provided WSDOT traffic information to the WSP CAD dispatchers.
- The SECONDARY ALERT CAD Interface, which was proposed to push WSP CAD information to the Skagit County Emergency Medical Services (EMS) CAD system. A Secondary Alert Web Interface was also proposed to make incident information from CARS available to other secondary responders.[7]

Component #1 – PRIMARYALERT

PRIMARY ALERT served as the main connection between the WSP CAD system and the WSDOT TMC. This component filtered the CAD data and transferred those portions suited for receipt and used by the TMC. The key aspects of PRIMARY ALERT are as follows:

- Only specified fields are transferred from the WSP CAD system into the TMC system. Although there was a tremendous amount of data generated by the CAD system, only a small portion of that data was of interest to WSDOT, and similarly, only a portion could be shared with other public agencies.
- Information exchange between agencies is intended to be seamless and automatic, e.g., not requiring the operators to re-enter data in a different format or perform any intermediate tasks to exchange data. Data translations were accomplished using automated software code that performed required translations without user intervention.

Component #2 – RESPONSE SUPPORT

The intent of the RESPONSE SUPPORT component was to transfer any available information from WSDOT to the WSP that would support WSP response efforts. Unlike PRIMARY ALERT, this information transfer consisted of information about other external events near the incident. For example, when a crash was reported to WSP on I-5 just north of Tacoma, the PRIMARY ALERT component was intended to transfer information from WSP to WSDOT.

---

[7] Neither of the secondary interfaces was deployed during the FOT. More information on this fact is documented in section 4, Test Results.

RESPONSE SUPPORT displayed information to WSP about nearby events, such as slow traffic, construction, accidents, or other extreme events (i.e., pass closures, flooding, National Weather Service warnings, etc.) that might impede a patrol officer's response.

Component #3 – SECONDARY ALERT

The third component, SECONDARY ALERT, was intended to reach those event responders beyond the WSP and WSDOT jurisdictions, including local EMS providers, tow truck dispatchers, and local utility companies. The general philosophy regarding SECONDARY ALERT was described as:

> To provide as comprehensive and complete information in the most useful fashion to secondary responders across the entire State of Washington, recognizing that the dispatch systems of these secondary responders vary widely in complexity.[8]

At least one EMS provider (Skagit County EMS) was going to serve as a demonstration for the transfer of information to the CAD system of a non-WSP responder. However, for a variety of reasons discussed in section 2.3, Skagit County EMS did not participate in the FOT. The SECONDARY ALERT component was not included in the FOT.

The first two components identified above were based on the following principles:

- Information exchange was facilitated by using the latest ITS and Internet industry standards using open hardware and software platforms, allowing both primary and secondary responding agencies to exchange information as agreed upon.
- The system relied on institutional agreements (i.e., Memoranda of Understanding [MOU]) on information exchanged based on each agency's own operating requirements and needs.
- The integration of CAD and TMC systems used commercial, off-the-shelf technology and standard data exchange mechanisms.

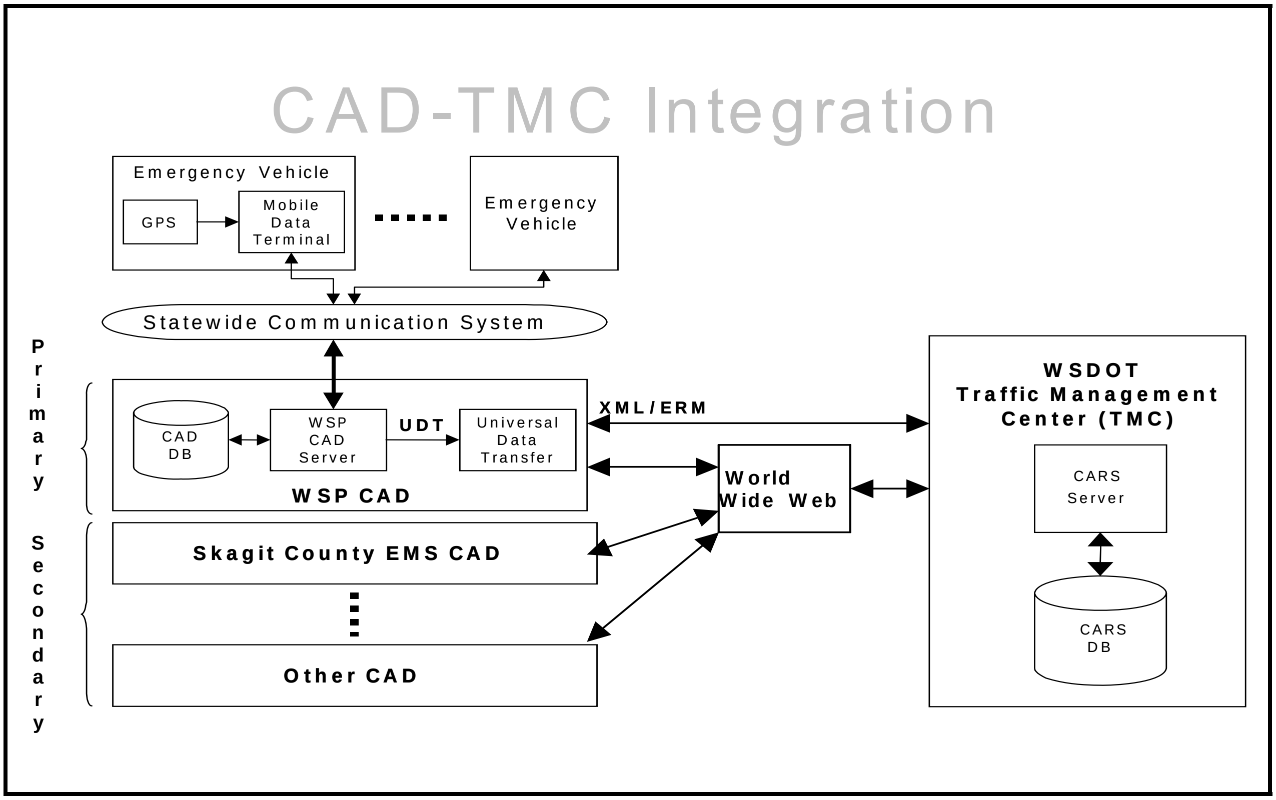
The vocabulary used for the exchange of incident management and traffic management information was based on industry-approved standards for data elements and messaging, specifically, Message Sets for External Traffic Management Center to Center (MSETMC2C) and the Institute of Electrical and Electronics Engineers (IEEE) 1512 standards:

- The system provides information security and privacy using standard Internet encryption mechanisms (at a 56-bit level or higher).
- Location-specific information uses location-referencing standards and coordinates normalization to allow different mapping systems to utilize and display incident information.
- The system is designed to allow easy testing and evaluation by an independent third party.
- The system is designed to allow open expansion to include additional participating agencies as required in the future, if practical.

[8] Adapted from: Legg, Bill, WSDOT, "Application for RFA Number DTFH61-02-X-00062, Computer-Aided Dispatch – Traffic Management Center Integration Field Operational Test."

- The system is designed to minimize communication latencies to provide information exchanges in a timely manner. Participating agencies were consulted to establish communications performance requirements.
- The system allows communications from CAD-to-TMC and TMC-to-CAD.

The proposed system architecture for the Washington State CAD-TMC FOT integration is shown in figure 1. The two-headed arrows originating from the World Wide Web signify its use as an interface for sharing information between the WSP CAD, Skagit Count EMS CAD, other CAD systems, and the WSDOT TMC CARS database.



Source: Incorporated from: Legg, Bill, WSDOT, "APPLICATION FOR RFA Number DTFH61-02-X-00062, Computer-Aided Dispatch– Traffic Management Center Integration Field Operational Test," p. 16.

Figure 1. Washington CAD-TMC System Architecture.

2.3 SYSTEM IMPLEMENTATION

The Washington State CAD-TMC integrated system was developed much as was intended and described above. There are several aspects of the implementation that are important to note, as described in sections 2.3.1 through 2.3.3.

2.3.1. Secondary Response Agency

Skagit County EMS was initially identified to participate in the FOT as a secondary response agency. However, this agency was not included in the implemented system. As a primarily rural county in Northwest Washington with one small urban area, Mount Vernon– Burlington, it was determined that it would be difficult to identify sufficient value for Skagit County EMS to participate.

Skagit County EMS handled all emergency response dispatch, except for WSP, in Skagit County. The original concept was that by informing Skagit County EMS about when, where, and how WSDOT and WSP were responding to traffic incidents, the Skagit County EMS dispatchers would be able to better route their emergency response units. As the project and discussions between WSDOT and Skagit County EMS progressed, this concept did not appear to really be a benefit. Skagit County EMS was too small, with too focused a mission to really be a good candidate as a secondary responder incorporated in the integrated system.

2.3.2. System Modification

The approach taken by WSDOT required some modification to the WSP CAD software. These modifications were needed to allow the WSP CAD system to export information from WSP CAD records to the WSDOT. The WSP and its CAD vendor modified the system to send this information every 2 minutes. It turns out that the latency built into this decision created issues with WSDOT operators in the major urban areas of Seattle and Tacoma. More discussion of this issue is included below and in subsequent sections of this document.

Originally, WSDOT was going to be able to populate event information in the WSP CAD system through a “hazard flag.” The idea was to have the WSP system show WSDOT actions and activities, which were defined as traffic conditions, event information, and construction and maintenance activities. However, the CAD application was primarily historical and tended to be fed by information internal to the CAD system. Having WSDOT systems feed the WSP CAD system did not turn out to be feasible in the manner originally intended. Instead, WSP could access WSDOT event information through a Web interface and congestion information through either a Web interface or TMC workstation software. The problem with this approach was that dispatchers needed to change their normal work processes to see this information. The dispatchers typically looked only at the WSP workstation screen.[9]

As a follow-on consideration to the FOT, WSDOT is now contemplating sending a map layer to the WSP dispatch terminals that could show events and perhaps traffic congestion. Also, WSP anticipates that vehicles will be equipped with AVL devices. WSP also has suggested that the WSDOT incident response vehicles and service patrols become equipped with AVL as well so as to display their locations in the WSP system. Together, these approaches will provide the functionality originally envisioned by WSDOT.

There also were changes made in the WSDOT CARS event reporting software. The WSP CAD system sent information every 2 minutes to a WSDOT translation program that converted the CAD data into standard IEEE 1512 messages and codes. The CARS system was modified to accept IEEE 1512 messages from external sources. The system was designed so that if the WSP CAD system is updated to send messages in IEEE 1512 format, the translation program can be removed to enable the CAD system to communicate directly with CARS.

In the WSDOT CARS, the event reporting configuration utilized periodic updates, originally on the order of once every 5 minutes. Combining the 2-minute cycle of the WSP system and the 5-

[9]It is important to consider the impact on dispatchers’ work processes for any agency planning to implement an integrated CAD-TMC system. This situation is discussed more in detail in the lessons learned portion in section 6 of this document.

minute update cycle within CARS presented some reporting latency problems for the WSDOT operators in the Seattle and Tacoma urban areas. The operators wanted the incident information and updates to go to the public via 511 and the WSDOT Web site as quickly as possible. With as much traffic and as many incidents occurring in the urban areas, coupled with shorter travel times than in rural areas, operators indicated that quick reporting was critical in providing efficient and timely emergency response.

WSDOT improved its servers and made other improvements to reduce the latency to an average of 4 minutes from the time the CAD system reported the incident to the time the incident was displayed on 511 or the Web site. Additional improvements could be made if the WSP output was already in IEEE 1512 format so the translation program could be deleted from the procedural loop. However, it is likely that some level of concern will continue as long as the WSP CAD system only exports information every 2 minutes.

2.3.3. Use of Standards and Data Translations

The modification to the WSDOT CARS system enabled the use of IEEE 1512 messages. The CARS reporting system also used the Traffic Management Data Dictionary (TMDD), Society of Automotive Engineers (SAE), Advanced Traveler Information System (ATIS), and geo-location referencing standards. The use of these standards in this system was a system requirement from the beginning. Using these standards will allow additional systems to provide input to the CARS system seamlessly, as long as the other platforms also conform to standards.

The use of geo-location referencing standards is worth mentioning. The WSP CAD system, like many State police systems across the nation, used State Plane Coordinates for location referencing. CARS used latitude-longitude. The CARS was modified to translate State Plane Coordinates to latitude-longitude. This enabled a relatively straightforward translation as long as the geographic area of interest is not too large. However, as the area increases, errors in the projection of locations on the globe to a plane get larger. These errors get larger with distance from the center of the projection. The translation, therefore, is not uniform. Making the translation from State Plane Coordinates to latitude-longitude took longer to make accurate than was originally envisioned.

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 WSDOT goals and objectives for the project. The goals and objectives for this evaluation were developed using an iterative approach involving extensive review by the ITS JPO and the two affected States: Utah and Washington.

The Evaluation Team reviewed all available project documentation, including the application submitted to the ITS JPO by each State in response to the 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 the ITS JPO's RFP of March 7, 2003. These proposed goals and objectives were reviewed with the ITS JPO's Contracting Officer's Technical Representative (COTR) and the Mitretek Analyst on May 6, 2003, and then again during a June 2, 2003 kick-off meeting with Washington State DOT representatives.

The proposed goals and objectives were revised based on these meetings, and presented to the ITS JPO COTR, the ITS 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 and 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.

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.

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

A comparison of the final evaluation goals as combined with the ITS JPO and WSDOT goals for the project is shown in table 4. This table also identifies the objectives that were developed to support the evaluation goals. As can be noted, the final evaluation goals and objectives were designed to enable the assessment of project performance against both ITS JPO and USDOT goals.

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

Table 4. Combined ITS JPO and WSDOT Evaluation Goals

ITS JPO	WSDOT	Evaluation Goal	Evaluation Objective
System Performance			
The FOT will automate the seamless transfer of information between traffic management workstations and police, and EMS CAD systems from different vendors.	Enable the automated electronic exchange of data between agencies on a real-time basis. This electronic data exchange will address the one outstanding need that still exists between WSDOT and WSP.	Document system component performance.	Determine the feasibility of automating the seamless transfer of information between traffic management workstations and police, fire, and EMS CAD systems from different vendors.
The FOT will incorporate ITS standards such as IEEE 1512 and 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 State has committed to using ITS standards and to develop a system that conforms to the National ITS Architecture.	Document system component performance.	Investigate the benefits of incorporating 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.
The FOT will extend the level of integration to include secondary responders such as utilities, towing and recovery, public works and highway maintenance personnel.	Integrate local, county, and municipal government emergency management and response agencies (fire and rescue, law enforcement).	Document system component performance.	Determine the benefits of extending the level of integration to include secondary responders such as utilities, towing and recovery, public works, and highway maintenance personnel.

ITS JPO	WSDOT	Evaluation Goal	Evaluation Objective
System Impact			
Computer requirements. FOT enhances communications among responders. FOT enhances efficiency in documenting incidents. FOT enhances on-scene operations. FOT reduces incident clearance times. FOT improves information available to traveling public and media.	Expected project impacts include: Reduce the time needed to deploy assets to respond to an incident. Reduce exposure of response personnel. Reduce secondary collisions resulting from the initial incident. Reduce the time needed to post incident-related information on the State's traveler information systems (Internet, 511), as well as provide information to the media. Improve the quality of information provided to the media and traveling public.	Conduct a system impact study.	Determine whether CAD-TMC integration improves: Productivity and efficiency. Mobility. Safety. Integration with 511/Internet interface.
Institutional and Technical Challenges			
Assess institutional and technical challenges.	Improved inter-agency relationships, in particular understanding of each agency's role and duties, to dissolve institutional barriers between the two agencies.	Identify institutional and technical challenges.	Document process by which institutional and technical issues were resolved.
Lessons Learned			
Document lessons learned.	Not specifically established, but fully supported.	Identify lessons learned.	Document lessons learned that would be of benefit for other jurisdictions considering similar deployments.
Benefits			
Summarize benefits.	Not specifically established, but fully supported.	Identify benefits from integrating the CAD-TMC system.	Identify qualitative and qualitative benefits achieved by the deployment that can be used by other jurisdictions to obtain support (programmatic, technical, funding) for similar deployment.

The Evaluation Plan articulated how to assess the degree to which the goals and objectives presented in table 4 would be met. The following studies and assessments were developed to assess these goals and objectives, as discussed in sections 3.2.1 through 3.2.5.

3.2.1. System Performance Study

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 need to 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 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.

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

- 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 (Skagit County EMS).
- Identify what information is shared, and how the agencies determined that this was the right information to share.
- Document how WSP and WSDOT 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 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.

3.3 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 WSDOT and WSP.

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.

WSDOT:

- Condition Acquisition and Reporting System (CARS) message logs:
    1. ROUTE
    2. MILEPOST FROM
    3. MILEPOST TO
    4. DATE REPORTED
    5. START DATE
    6. END DATE
    7. INCIDENT TYPE
    8. INCIDENT DESCRIPTION
- Incident Response Database:
    1. ACTION TAKEN
    2. AGENCIES INVOLVED
    3. CLOSURE REASON
    4. DATE OF INCIDENT
    5. DATE OF REPORT
    6. INCIDENT DESCRIPTION
    7. LANES OPEN
    8. MILE POST

9. RESPONSE TIME
10. CLEARANCE TIME
11. START OF INCIDENT
12. TIME ARRIVED
13. TIME CLEARED
14. TIME NOTIFIED

– Revenue Science Web Page Usage Reports:
  1. WSDOT All Web site Pages (Total)
  2. WSDOT Traveler Information Pages (Total)

WSP:

– CAD system message logs (“A” records):
  1. CREATE TIME INCIDENT
  2. EVENT NUMBER
  3. CLOSED TIME INCIDENT
  4. INCIDENT TYPE ID
  5. ADDRESS
  6. MAP X
  7. MAP Y
  8. PRIMARY UNIT ID
  9. ARRIVAL TO CLOSE
  10. CREATE TO ARRIVAL
  11. CALL SOURCE ID
  12. ARRIVAL TIME
  13. INCIDENT TYPE DESCRIPTION

– CAD system message logs (“C” records):
  1. EVENT NUMBER
  2. CHILD EVENT NUMBER
  3. ASSOCIATED INCIDENT TIME

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

WSDOT. Before and after interviews were conducted with WSDOT TMC and Information Technology (IT) personnel in August 2004 and October 2005. Before and after interviews were conducted with system development personnel in August 2004 and November 2005. Team members also observed the operation at the TMC in August 2004 and October 2005. Various field observations and interviews with field personnel occurred at different times during the evaluation periods.

WSP. Input was received from key field and dispatch personnel through interviews and meetings during the evaluation period.

3.4 INTERIM PROJECT REVIEW

An Interim Project Review (IPR) of the FOT was held in January 2005. Participants included the ITS JPO, the Washington State 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 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 be completed within the existing scope and schedule.

4. TEST RESULTS

This section of the report documents the results of evaluation tests for the Washington CAD-TMC FOT. This includes both quantitative and qualitative results. It should be noted that a couple of issues affected the results of the evaluation. First, the interface with the secondary responders was eliminated (see section 4.1.3). The second issue affected the extent to which the FOT resulted in impacts to traffic operations. Specifically, WSDOT TMCs already had WSP CAD data and terminals prior to implementing the integrated system. This fact limited the impact of the CAD-TMC integration, since TMC operators already had access to WSP CAD data before the deployment.

The data discussed in section 3.1 was collected and analyzed according to the 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 5 summarizes the system performance study 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 5. 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 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.	Achieved previously through placement of CAD terminals at TMCs. Enhanced through project.
	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.	Not achieved during the evaluation period.

4.1.1. Objective #1: Document the System Component 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.

Through interviews with the WSDOT system developers and the WSDOT project manager, the Evaluation Team obtained qualitative assessments verifying that the system performed according to expectations and the functional specifications. The only major concern, identified during direct observations of the integrated system, was regarding latency in the system from the time when an entry was entered into and displayed on the WSP CAD, until it was displayed in CARS, the integration platform. The existence of this latency was identified during the development of system requirements and design. As mentioned in section 2, the latency is a product of the way in which the WSP CAD system was designed. There was additional latency noted in presenting information in the 511 system or on the WSDOT traffic information Web site. This also was foreseen during the project conceptualization phase.

The latency was caused by several factors. As previously described, the WSP CAD system posted updates to the integrated system every 2 minutes. Thus, while an incident may well be identified by a WSDOT operator viewing a CAD terminal on a real-time basis, the WSP CAD system did not push this information to the CARS system for up to 2 minutes. A second factor is that the CARS system also has up to a 2-minute lag when pulling the information provided by the WSP CAD into CARS.

The latency did not affect whether the system met its functional specifications. However, it is important to note that the significance of the latency differed, depending on the area and the view of the WSDOT operators involved. Operators in more rural regions were reported to be satisfied with the system and its performance. In urban areas, there were more mixed feelings about the system and its inherent latency issues. Only one operator interviewed in the Seattle TMC said he used the integrated system. The other operators entered incident information directly into CARS as soon as they saw an incident of interest displayed on the WSP CAD terminal. They did not feel they could wait for the incident to display in the integrated system to complete the entry and send it to the travel information systems.

It is important to realize that the operators in the Seattle and Tacoma area had access to WSP CAD terminals before the integrated system was implemented. The operators were used to seeing incidents on the CAD terminal, deciding which ones were of interest, and entering the appropriate information into CARS. Because of this experience, any latency from the display on the CAD terminal to the integrated system would be noticeable. Operators in rural regions did not have access to WSP CAD terminals prior to the integrated system and getting the information, even with some latency, greatly improved the information and timeliness of incidents that they report to the travel information systems.

An incident entered in the WSP CAD system had a unique case number assigned to it. This case number allowed updates to a given incident to be easily tracked and linked to the original record. The integrated system used the case number to update records in the CARS system. In addition, operators had the ability to update information on an incident and link information manually.

It was difficult to determine to what extent incident response procedures were improved. Because of the close working relationship between WSDOT and WSP for years prior to the FOT, improvements in field response activities could not be observed. In fact, all those interviewed acknowledged that little if any improvement occurred in field procedures. However, this was expected going into the test.

There were some improvements in incident response procedures in the WSDOT operations centers. Improving the efficiency of documenting incident management is discussed covered in the next section. In addition to improved efficiency, there are two 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.

The time required to complete the entry of incidents into the WSDOT CARS reporting system was reduced for those incidents that operators accepted from the WSP CAD system. In some cases, the latency problem was significant enough that operators didn't wait for the incident to come through the integrated system. In those cases, no change in time to enter occurred.

Previously, all CARS incident data was entered manually. The operators who used the integrated system had most of the CARS fields populated by the integrated system, which saved them time and allowed them to focus on other duties. The operators who used the integrated system either had no access to a WSP CAD terminal, or they had other duties, such as radio dispatch or tunnel control system operation, in addition to monitoring and reporting incidents.

The operators who mostly entered the data directly into CARS without waiting for the integrated system to report generally had access to WSP CAD terminals and were dedicated to traffic management tasks. Minimizing the time to enter an incident was deemed important because the operators generally had multiple duties, even if they were dedicated to traffic management. The quicker an incident could be reported, the more time the operators had to perform their other duties.

Accuracy of the information included in the incident record was improved when the integrated system was used because information from the WSP CAD system was imported directly into the CARS system. This 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 the WSP 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 steps that were necessary for manual entry provided some probability of errors, especially in placing the incident. Even though the improved accuracy may not have been a major improvement, it is worth mentioning.

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, police, 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 functional specifications.

From observations and interviews, it was demonstrated that the integrated system reduced the reliance on manual methods for exchanging information when the operators chose to use it. Incidents reported by WSP CAD were transmitted to the integrated system and easily imported into CARS. For regions that did not have WSP CAD terminals, this information sharing was the only reliable way to receive incident information. Where CAD terminals were not available, WSDOT operators relied on scanners, calls from WSP, and radio calls from WSDOT field personnel to find out about incidents. It was very easy to miss incidents because the operators didn't hear scanner reports or because WSP dispatchers or WSDOT field personnel were too busy to call in the incident. WSP dispatchers or WSDOT field personnel were too busy to call in the incident.

From observations and interviews, integration increased the extent and reliability of information exchanges. Information passed from WSP directly through CAD to CARS so conversations were needed only to clarify information. There was a lower likelihood of misunderstanding basic aspects of the incident. In locations where WSP CAD terminals existed, this benefit was already realized. However, where the terminals weren't available, the ability to focus voice communication only on details that need clarification was valued as a tremendous benefit.

4.1.3. Integration of Secondary Responders

Secondary responders (ambulance, utilities, etc.) were not included in the FOT. Skagit County EMS was originally going to be included in the FOT, but did not participate because the agency could not see the value for its operation. Historically, there were not enough incidents in the Skagit area to be useful enough to justify the agency's participation.

4.2 SYSTEM IMPACT TEST RESULTS

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

- WSDOT CARS message logs.
- WSDOT incident response database.
- WSP CAD system message 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 6 summarizes the system performance study 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 6. 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 with WSDOT and WSP.
	CAD-TMC integration improves efficiency of on-scene operations.	Not measured during the evaluation.
	CAD-TMC integration enhances efficiency in documenting incident management.	Partially achieved; further reductions will enhance results.
	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 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.	Not directly measured. Increased number of incidents posted to traveler information systems indicates improved flow of information to public.

Although the impacts of the CAD-TMC FOT on productivity, mobility, safety, capacity, and throughput are further documented here, it is recommended that the reader takes care when interpreting these results.

The high degree of operational integration between WSP and WSDOT that existed before the CAD-TMC FOT meant that the impact of the FOT on operational productivity would be limited. Many of the operational benefits that could be achieved through the CAD-TMC integration had already been accomplished through other means, such as providing a CAD terminal in the individual TMCs.

Other potential benefits of the integration were negated by technical limitations of the integration. For example, most TMC operators reported that the long lag time before the automated system made CAD incidents available to CARS induced them to continue to use the manual, pre-FOT approach for populating CARS with incident data.

Thus, while this section documents the system impacts of the Washington CAD-TMC FOT, these impacts may under-represent the impacts that might be found in a similar integration at other locations.

4.2.1. Impact on Productivity

Initially, it was expected that there could be significant improvements in productivity resulting from the FOT. The availability of CAD data at the TMC could help TMC operators respond more quickly when an incident occurred, and that the automated inclusion of the CAD data in the TMC systems could help TMC operators respond to incidents more quickly and efficiently. Improved availability of traffic data for WSP dispatchers could improve their ability to manage incidents. The following sections address the impact of the FOT on the productivity of regional operations.

Impact on WSP Operations

The Evaluation Team had anticipated collecting after project data for the period of April through June 2005. However, the system deployment was somewhat delayed and data was collected for only May and June. Even with this limited amount of data, the data collected post deployment did show an impact on WSP operations as shown in figure 2. Overall, there was about a 10 percent increase in the number of WSP CAD incidents recorded following the integrated CAD-TMC deployment, which reflected the improved documentation function established through the FOT.

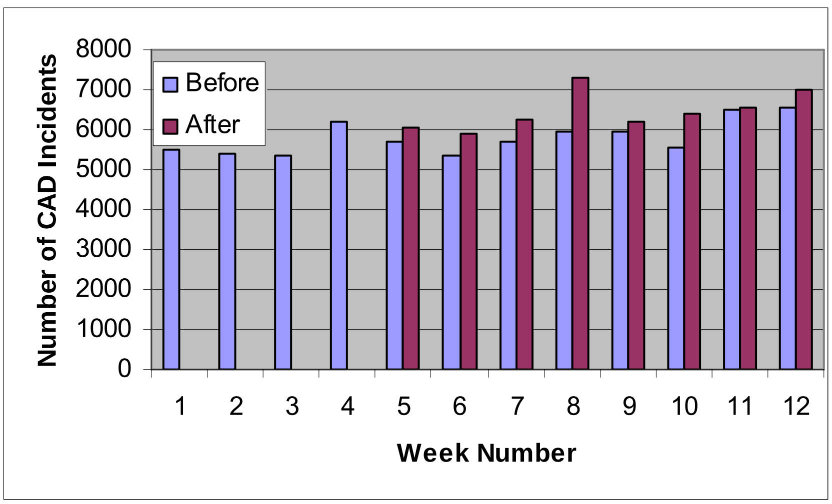
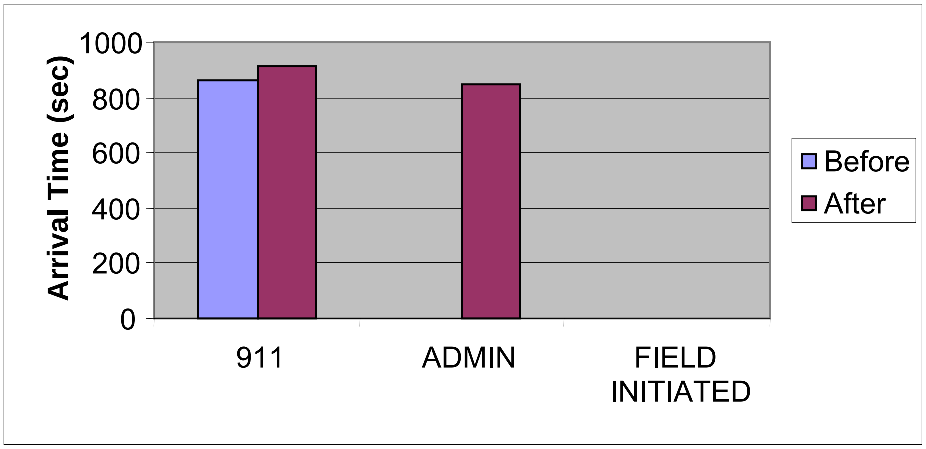


Figure 2. CAD Incidents Before and After the CAD-TMC Deployment.

Although there was an increase in the overall number of incidents recorded once the system became functional, the data do not show that there was any significant change in WSP incident response times before and after the deployment, as shown in figure 3.[12] This reflects the maturity of the Washington State incident response program and the significant operational benefits already achieved prior to the deployment, as discussed previously in the report.

[12]The incident logs included incidents with arrival times of more than 39,000 minutes (equivalent to about 27 days). These apparently errant arrival times were eliminated by including only incidents in which the total incident time was less than 1 hour. The "Field Initiated" arrival times were zero because these incidents were initiated by field officers arriving at the scene of an incident.



NOTE: 911 includes all incidents reported by 911 calls. Field initiated includes all incidents reported by radio or cellular phone calls from response personnel. ADMIN is a catch-all category that includes all other reported incidents.

Figure 3. Arrival Time for CAD Incidents.

Impact on WSDOT Operations

The CAD-TMC deployment was expected to improve WSDOT operations through:

- Quicker access to more complete CAD incident information.
- Automated inclusion of this information into the TMC CARS system.

These impacts were expected to result in more incidents included in CARS, with correspondingly improved traveler information. In addition, these impacts were expected to result in more efficient operations due to operators spending less time entering information into CARS.

As noted earlier in this report, technical difficulties limited the extent to which these potential benefits were achieved. However, the initial results obtained from CARS indicated that as system deployment progressed, the number of incidents included in CARS increased by about 25 percent in the last four weeks of data collection based on the “before” and “after” project data collected. Figure 4 shows the overall increase in reported incidents shown in CARS. The figure compares the before and after project data for the periods of April-June 2005 and April-June 2006, respectively. The slow build-up of after project reported incidents was the result of technical delays in system deployment and operation. The system was not completely implemented until about week 4 of the “after” data collection time period.

The results presented in Figure 5A demonstrated that the most immediate impact of the expected project benefits, as discussed earlier in this section, was obtained in highly urbanized I-5 corridor, which includes Seattle. The results presented in Figure 5b show that these same benefit has not yet been fully realized, due in part to the fact that the rural regions of the State do not have as many incidents to report.

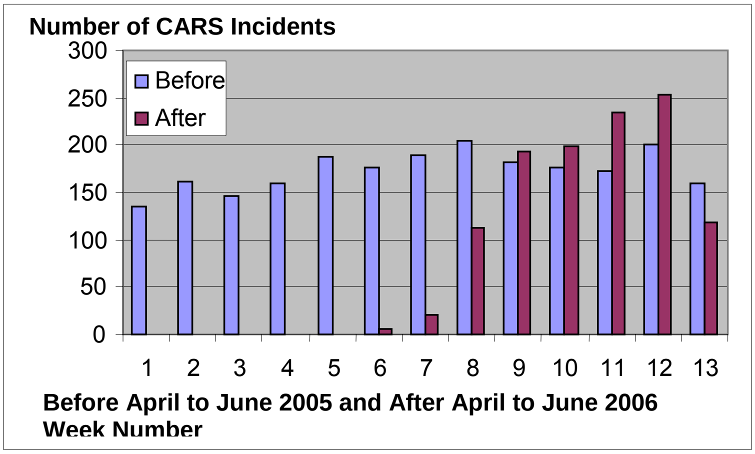


Figure 4. Number of CARS Incidents Before and After Deployment.

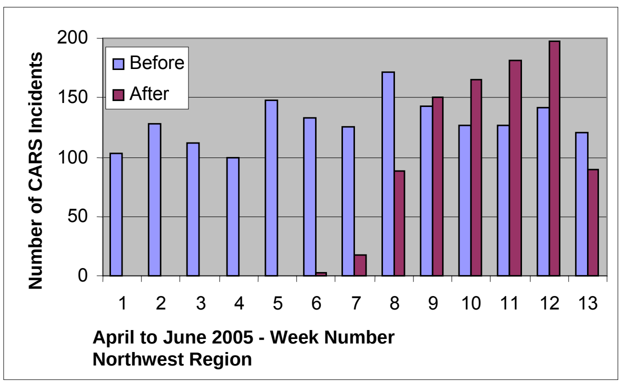


Figure 5A. Number of CARS Incidents, Northwest Region.

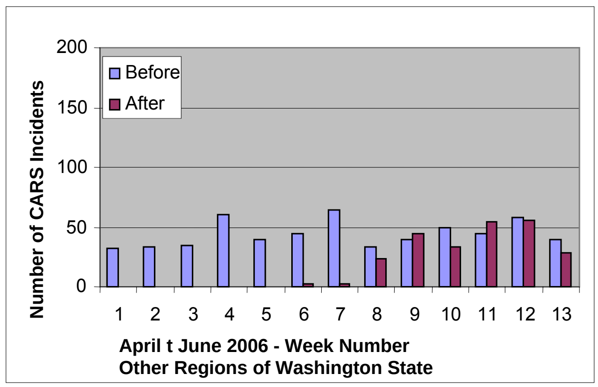


Figure 5B. Number of CARS Incidents, Rest of State

Figure 6 reinforces the observation presented in figure 5 by showing that the number of CARS incidents, relative to the number of CAD incidents, increased after the CAD-TMC deployment. A concern expressed by WSDOT personnel in the before deployment interviews was that prior to deployment, it did not appear that all WSP CAD incidents were being captured by WSDOT. The increase in CARS incidents recorded after the deployment indicated that the automated transfer of incident data did record those incidents not previously reported.

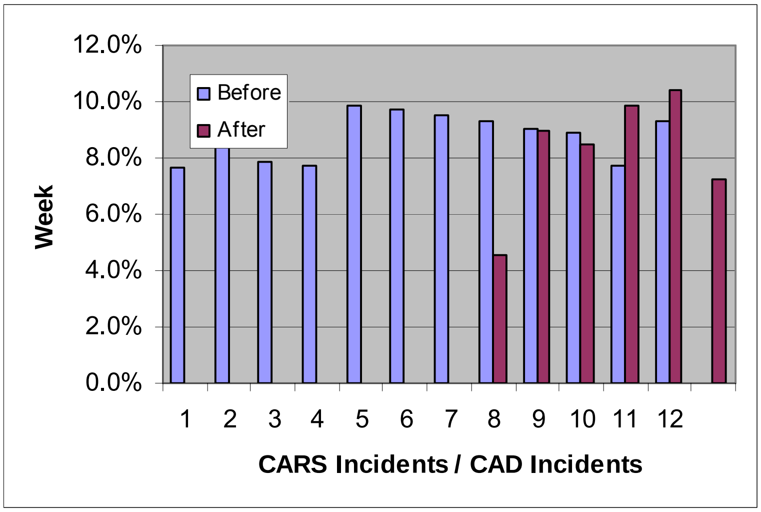


Figure 6. Number of CARS Incidents Relative to CAD Incidents.

The Impact on the Operations of Secondary Responders

The original design of the Washington CAD-TMC deployment called for development of a SECONDARY ALERT Interface that would make incident information available to secondary responders outside of WSP and WSDOT, such as local EMS providers, tow truck dispatchers, and local utility companies. Two types of SECONDARY ALERT interfaces were to be developed. The first was to insert information directly into secondary responder CAD systems (e.g., for Skagit County EMS), and the second was to be a special public responder Web site that would include information from CARS especially tailored for secondary responders. As the project progressed, the secondary responders did not show much interest in these interfaces, so the interfaces were not developed. Consequentially, the Washington CAD-TMC FOT did impact the operations of secondary responders.

4.2.2. The Impact on Mobility, Safety, Capacity, and Throughput

The original plans for the CAD-TMC evaluation called for an assessment of the impact of the CAD-TMC deployment on mobility, safety, capacity, and throughput. The concept behind these plans was that improved TMC and CAD operations (e.g., faster response because of access to CAD information and more reliable traveler information based on CAD information) could result in improved incident response. Further, the improved incident response was expected to improve mobility, safety, capacity, and throughput. Because the CAD-TMC deployment had little impact on TMC and CAD operations, an impact on mobility, safety, capacity, and throughput was not possible.

5. EVALUATION FINDINGS

5.1 SYSTEM PERFORMANCE

The primary system performance assessment findings are as follows:

- From interviews and observations, 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. When an operator used the integrated system (latency was not considered an overriding problem), the time it took an operator to enter an incident from the WSP CAD system into the WSDOT CARS system is reduced. The accuracy of the information in the incident record was improved because information from the WSP CAD system was imported directly into the CARS system, thereby reducing the chance of making an error compared to the operator entering the data manually.
- Geo-location data passed with the incident reduces the chance that the incident will be placed in the wrong location.
- From observations, the integrated system reduces the reliance on manual methods for exchanging information. Incidents from the WSP CAD system are automatically brought into the WSDOT system. In regions that don't have WSP CAD terminals, the integration system reduced operator reliance on searching for information from other sources.
- From observations and interviews, integration increased the extent and reliability of information exchanges. Information is passed from the WSP CAD system directly into the WSDOT system, so conversations are only needed to clarify information.

5.2 SYSTEM IMPACT

Washington State had implemented improved operational procedures between WSDOT and WSP prior to deploying the integrated system. Benefits from sharing data were previously realized. The CAD-TMC integration provides enhancements, not new benefits.

The integrated system was deployed for only a short time before after project data was collected. 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 an empirical estimate of system impact.

Evaluation findings related to system impact are qualitative, as follows:

- From empirical data, there was very little impact on system productivity. However, there was an increase in the total number of CARS incidents in the after data set compared to the before data set. The main reason identified for this increase was the focus on incident reporting as a result of the FOT. This increase should reflect an increase in the number of incidents reported to 511 and the Web site, which represents an improved flow of information to the public.
- As mentioned under system performance, in regions that did not previously have a WSP CAD terminal, communication between WSDOT operators and WSP dispatchers could be

more focused on clarifying details rather than gathering all the information needed to report and manage an incident.
From observations, efficiency in documenting incident management improved, especially for regions that did not have WSP CAD terminals. (See the similar finding under System Performance above.)

5.3 INSTITUTIONAL CHALLENGES

In general, Washington faced fewer institutional challenges than would be expected in most States in implementing an integrated CAD-TMC system. WSDOT and WSP have a very close working relationship. However, there were some institutional challenges that the agencies involved had to overcome. The institutional challenges are described in sections 5.3.1 through 5.3.4.

5.3.1. Inclusion of Secondary Responders

WSDOT wanted to include additional response agencies in the FOT. WSDOT looked for an agency that was interested and of a size that would not burden the initial implementation with too much complexity; therefore, Skagit County EMS was selected for that reason. The challenge with Skagit County EMS was in finding benefits worth the agency's participation. Originally, WSDOT thought that incident information might help in routing emergency response vehicles. It turned out that Skagit County EMS was too small, with too focused a mission to be a qualified candidate for this FOT.

5.3.2. WSP Use of WSDOT Data

As stated is section 2, WSDOT originally intended to be able to populate event information in the WSP CAD system through a "hazard flag." The WSP system would directly show traffic conditions, event information, and construction and maintenance activities. However, the CAD application did not lend itself to ingesting the WSDOT data in the manner originally envisioned. Instead, WSP dispatchers can access WSDOT event information through a Web interface and congestion information through either a Web interface or TMC workstation software. The problem with this approach is that dispatchers have to change their normal work processes to access and view this information.

5.3.3. Geographic Boundary Differences

The WSP districts and the WSDOT regions do not share completely common areas of the State. Therefore, when the WSP-CAD data is brought into the WSDOT system, a simple filter for WSP District does not work for many of the WSDOT Regions. It is more challenging to ensure that the WSDOT Region TMC operators see all incidents that apply to their specific regions. As a result, operators need to seek out incidents in more WSP districts as a result. A technical solution, additional filtering schemes, will be able to help with this institutional challenge.

5.3.4. Rural versus Urban Needs

One difference in urban versus rural needs, timeliness of information and problems with latency, has been discussed previously. In urban areas where trips typically are shorter, more information is typically available, and dedicated traffic management staff exist, latency on the order of 4 minutes as in the Washington CAD-TMC integrated system may not be tolerable by the operators involved.

However, in rural areas, where operators have many other duties in addition to traffic management, trips tend to be longer, and less information is available from other sources, the automation provided by the integrated system is a tremendous benefit. In fact, it is possible that a greater degree of automation in those areas might be beneficial. During many hours throughout the week, there simply were not enough personnel to effectively manage the incident information and “accept” the incidents that come from the WSP CAD system. It may be appropriate to establish filtering criteria that would automatically post certain types of incidents from the WSP CAD system directly into CARS for distribution to 511 and the Web site. In general, there may be reasons to have different approaches rural and urban areas based on the organizational, traveler, and operator needs in each.

5.4 TECHNICAL CHALLENGES

Even though the Washington CAD-TMC integration project was a technical success, there were some technical challenges. The way in which the WSDOT and WSP overcame these challenges may be instructive to other agencies considering a similar project. The technical challenges are described in sections 5.4.1 through 5.4.4.

5.4.1 Latency

As described in section 4, there is a latency of nearly 4 minutes from the time the WSP dispatchers enter an incident in the CAD system to when the information is presented in the 511 system or on the Web site. This latency does not appear to be a significant issue in rural areas, but is in urban areas, especially Seattle and Tacoma. WSDOT improved the latency by using more powerful servers. If the WSP system is upgraded to use IEEE 1512 codes and messages, the latency will be further reduced because the WSDOT system will not need to translate from the WSP codes to 1512 codes. However, there will continue to be some latency because both the WSP CAD system and the CARS system report information to external systems on a fixed periodic basis rather than as new information or updates are entered. In the case of the WSP CAD system, information is transmitted every 2 minutes. This leads some WSDOT operators to enter all of the CAD information into CARS manually.

It is important for other agencies considering the implementation of an integrated system to consider latency in the design of the system. What latency is acceptable? Are there different levels of latency that are acceptable in different areas of the State? Most likely, the answers will be different for each State.

5.4.2 CAD System Upgrade Schedules

The integration required that the WSP CAD system be modified. WSP contracted directly with its respective CAD vendor to upgrade its system. WSDOT and its integrator were dependent upon the CAD vendor schedules and software releases for the implementation of the overall project. This is a situation that other States that may be considering a similar integration need to be aware of and for which appropriate plans need to be made.

5.4.3 Geo-location

As discussed in section 4, WSDOT had to translate the WSP State Plane Coordinates to latitude-longitude coordinates. This is certainly technically feasible, and agencies need to recognize that the discrepancies in translation will change as the geographic area increases. Over a larger geographic area 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.

5.4.4 Use of Standards

The WSP CAD system does not use IEEE 1512 codes internally. WSDOT had to develop a translator to change the CAD codes into 1512 codes. The steps that WSDOT takes in this process are:

- The WSP CAD system pushes data to a File Transfer Protocol (FTP) site.
- Data is filtered to remove any sensitive data that should not be made available publicly.
- The WSDOT system then pulls the WSP CAD data from the FTP site and converts the CAD codes into IEEE 1512 codes.
- Data is then pushed to CARS by a 1512 message and Extendable Markup Language (XML).
- Data is incorporated into CARS and can be used by WSDOT for incident management activities and for providing information to the public (511, Web site).

The system was designed to allow the translation to simply be removed if the sending system (WSP CAD) uses IEEE 1512 codes and messages.

6. CONCLUSIONS AND RECOMMENDATIONS

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

The project participants involved in the Washington CAD-TMC integrated system FOT identified a variety of evaluation findings in interviews with the Evaluation Team that will be of benefit to other jurisdictions considering similar deployments. Many of these have been discussed in previous sections of this document. They are presented in this section to summarize important aspects of the project so other agencies can easily identify them.

6.1 CONCLUSIONS

It is important to note that WSDOT and WSP have a long-standing relationship for sharing details of incidents that occur on the roadway system. WSP has provided a CAD listing of incidents for several years to the WSDOT TMCs to monitor to which incidents the field patrols were receiving and responding. With cameras or detectors available to WSDOT operators, they could verify the incidents and provide information to the media. The WSDOT operators could also use Dynamic Message Signs (DMS) to advise motorists of the incidents. That system was manual, however, and required the WSDOT operator to create an entry based on the input from the WSPCAD system.

An important and frequent participant in all roadway incidents is the WSDOT Incident Response Team. Expanded in recent years to all regions with Interstate highways, these operators are dispatched by the WSP, have direct mobile to mobile communications with troopers, and with the maintenance personnel in their regions. They respond to incidents to provide a full range of incident management services to prevent secondary crashes, reduce congestion, and restore normal traffic flow as quickly as possible.

For the CAD-TMC FOT to show substantial improvement in accuracy and timeliness was recognized as a challenge because of the already existing procedures and relationships in place. The FOT has proven worthwhile for the agencies to continue their quest to develop a true real-time data exchange system.

6.2 RECOMMENDATIONS

6.2.1 General Recommendations

1. **Involve IT staff early-on in the project planning process.** Interviewees emphasized 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 ensure 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 interviewees commented on the importance of a close working relationship among the

agencies involved in this FOT. As is noted in section 2 of the report, WSP and WSDOT have established a Joint Operations Policy Statement governing incident response procedures, and conduct regular meetings to discuss operational issues. The two agencies had long-standing, well-established working relationships prior to the FOT that provided a forum for resolving issues encountered during the deployment.

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. **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. For example, as discussed in section 5, WSDOT originally intended to be able to populate event information in the WSP CAD system through a "hazard flag." The WSP CAD application did not lend itself to ingesting the WSDOT data as proposed and dispatchers would have to access WSDOT event information through a Web interface, and congestion information through either a Web interface or TMC workstation software. This approach would have required dispatchers to change their normal work processes to access and view this information.
5. **Coordinate deployment schedule with vendor schedule for system modifications and upgrades.** As stated in section 5, CAD systems are generally off-the-shelf products. Vendors have a fixed release schedule, so it is important to coordinate project schedules with the vendors' release schedules.
6. **Define what data is exchanged and when**. In Washington State, WSP had concerns about releasing all incident-related information recorded in the CAD system. The WSP did not want to provide WSDOT with information that might compromise the investigation of incidents or other proprietary information related to law enforcement activities. The two agencies eventually established a protocol on what information would be provided to WSDOT, and a filter was developed that selected only the agreed to information from the CAD system when incident information was pushed to the CARS system.

6.2.2 Technical Recommendations

1. **Coordinate deployment schedule with CAD vendor schedule for system modifications and upgrades.** There were times that the project schedule was not met because the vendor release schedule was unknown when the CAD-TMC project schedule was developed.
2. **Establish common incident location identifiers.** There was confusion and a potential problem identified with ability to correctly locate incidents because the WSP and WSDOT typically used somewhat different location identifiers. These location identifiers may be different names for the same landmark or may be different ways to describe the same location. It would be helpful to come to agreement on a method of describing locations among the parties involved. In addition, it would be beneficial to agree on as many common incident locations as practical.
3. **Consider system latency.** It is critical to consider what is acceptable for latency in the system. This may differ from region to region, agency to agency, even operator to operator. Latency should be considered early during the system approach development phase and needs to be considered a system requirement once the appropriate levels of latency are identified.

4. **Consider automation.** In general, the more automation, the better. Things to consider are whether operators sometimes or always need to verify incidents before the information is sent out. This may vary by situation, so the system needs to be designed with the needs of various operators and stakeholders in mind. There may need to be different approaches in rural and urban areas.

6.2.3 Institutional Recommendations

1. **Select response partners carefully.** There must be a clear benefit to the partner in the integration. As mentioned is section 2.3, Skagit County EMS was too small with too focused a mission to really be a qualified candidate as a secondary responder incorporated in the integrated system. WSDOT initially selected Skagit County EMS because it was small and WSDOT thought it would be a better initial step to incorporate a smaller, less complex response agency. In hindsight, WSDOT representatives indicated that they should have selected a response agency where there were more traffic problems. For example, on an urban freeway where roving incident response vehicles have just started operation, it might be beneficial to know when and to what location local police and fire are dispatching response units. It would be interesting to determine if knowledge about the actions and location of the WSDOT incident response vehicles would be a benefit for dispatchers at these local agencies.
2. **Focus on primary objectives.** In Washington State, the primary objective is providing improved traveler information. The primary view of success was whether or not information about incidents to the public is improved and provided on a more timely basis. By focusing on the primary objectives, trade-off decisions can be made more easily. Also, the focus on primary objectives helps determine the best design alternatives.
3. **Work process.** WSDOT initially thought that providing information about traffic conditions and WSDOT incident management activities directly to WSP dispatchers would be beneficial to the dispatchers. However, the information was not integrated into the dispatcher's applications well, so the dispatcher's work process would need to change to make use of this information. As a result, WSDOT is now considering sending a map layer to the WSP dispatch terminals that will show events and perhaps traffic congestion. Also, WSP will be equipping vehicles with AVL. WSP has suggested that the WSDOT incident response vehicles and service patrols be equipped with AVL to display their locations in the WSP system. Together, these approaches will provide the functionality originally envisioned by WSDOT, and would fit much better into the WSP dispatchers' work process as well.
4. **System training.** From interviews with development staff and operators, additional training would have been beneficial in the WSDOT system. There are some subtleties in how to configure the system to provide operators with the most benefits. Although it initially seems straightforward with little need for additional training, it is important to train operators on how to use the system features and to allow them to ask the developers how to use the system in specific situations to gain the desired results.

REFERENCES

1. ITS Evaluation Guidelines – ITS Evaluation Resource Guide accessed from the ITS JPO Web site at: <http://www.its.dot.gov/EVAL/eguide_resguide.htm>.
2. ITS JPO ITS Public Safety Program brochure “DOT Projects in Utah, Washington State Will Demonstrate Public Safety, Transportation Integration System.”
3. Legg, Bill, WSDOT, “Application for RFA Number DTFH61-02-X-00062, Computer-Aided Dispatch (CAD) – Traffic Management Center Integration Field Operational Test.
4. 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.
5. USDOT ITS Program Safety Web site: <http://www.its.dot.gov/pubsafety/index.htm> (February 7, 2006).