US-23 Active Traffic Management

ATM Software Evaluation

June 2015 | Version 3

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HNTB

Document Control

Document Control Panel				
File Name:	US-23 Active Traffic Management: Software Evaluation for ATM System			
File Location:				
Version No	Author	Reviewer	Date	
1	Amanda Good	Natalie Smusz-Mengelkoch	02/18/2015	Draft Deliverable
1.1		HNTB QA/QC	03/01/2015	Reviewed Draft
2	Amanda Good	Jeff Dale	4/3/2015	Revised Deliverable
3	Amanda Good	Jeff Dale/Mark Dunzo	06/18/2015	Final Deliverable

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1 Introduction

The Michigan Department of Transportation (MDOT) is considering an active traffic management (ATM) solution along the US-23 corridor from the western US-23/M-14 tri-level interchange to just south of M-36 (9 Mile Road), north of Ann Arbor. During the project development, several stakeholder meetings and workshops were conducted to establish the Concept of Operations and solicit design direction. During these meetings and workshops, specific conversations were focused on the software functionality necessary to operate the ATM system. The proposed ATM project includes the implementation of closed-circuit television (CCTV) cameras, dynamic message signs (DMS), microwave vehicle detection systems (MVDS), lane control signs (LCS), and variable speed advisory (VSA) signs. The operation of the ATM system will require a software solution that not only controls the existing and new device types, but also can receive and process traffic data and execute complex response plans along the corridor. Only a portion of this can be handled by the current Advanced Transportation Management System (ATMS) software. The ATM software solution will be critical to the safe and successful operations of the system.

Currently, MDOT has a statewide ATMS software solution that manages all of the devices throughout the state. The current ATMS software was not designed to operate some of the identified ATM components or manage response plans that include some of those components. The ATMS currently issues response plans that respond to various planned/unplanned events. In order for the current ATMS software to manage an ATM system, additional development and algorithms are necessary. As such, there are cost implications that may exceed budgeted funds. In response to this risk, MDOT is investigating whether the best option is to modify the current ATMS software or procure a new software solution that is specific to an ATM system. Regardless of the decision, the software solution for the ATM system must be a viable option for implementation across the state.

1.1 Purpose and Need

The purpose of this document is to present MDOT with information about existing ATM software solutions employed by other agencies such that the most effective, efficient, and appropriate software solution can be implemented for this project. This software evaluation document summarizes an assessment of different software solutions used to operate ATM systems across the country. Nine agencies were contacted and asked specific questions about their current ATM software solution and their experience with integration, operations, and the maintenance of the system. The responses from these agencies is compiled within this summary to provide MDOT with an overall comparison of possible approaches for an ATM software solution.

This information is intended to allow MDOT to make an informed decision on the most appropriate solution for the ATM project. Whether it is customization of the current statewide ATMS or a procurement of a new software package.

1.2 Agency Contacts

A number of agencies were contacted to gain a greater understanding of potential ATM software options, cost and integration expectations, and overall ATM software experiences. Some of the agencies contacted were not part of the initial best practices exercise; however, it was determined that their experience with respect to software development would be beneficial for MDOT. The following agencies (**Table 1**) were contacted as part of the outreach and their contact information is located in **Appendix A**:

Table 1. Agencies Contacted with ATM Software

Agencies Contacted
Minnesota DOT (MnDOT)
Washington DOT (WSDOT)
Colorado DOT (CDOT)
Oregon DOT (ODOT)
Nevada DOT (NDOT)
San Diego Association of Governments (SANDAG)
Virginia DOT (VDOT)
Norfolk DOT
Highways Agency-United Kingdom

2 MDOT Proposed ATM Solution Needs

The objective of the proposed ATM system is to gain the capability to dynamically adjust traffic operations along the corridor in real-time based on various weather, traffic, and/or event conditions. The system operators will utilize a robust ATM software solution that will monitor conditions along the corridor and alert them when deviations from the expected standard conditions occur. The operators then will be able to respond to the identified conditions based on recommendations from the software. The operators will utilize the software to provide information or instructions to motorists, such as lane closures or speed reductions. The ATM software recommendations need to be quick, precise, and fluid so that operators are able to respond in a timely manner.

The Federal Highway Administration (FHWA) provides ATM strategies that are meant to offer guidance when developing an ATM system. MDOT's proposed work along US-23 includes four of the ten strategies provided by FHWA (refer to **Table 2**). In addition, MDOT plans to incorporate several Intelligent Transportation System (ITS) strategies including: additional CCTV cameras and additional signs (either full- or side-mounted DMS). It will be critical that the ATM software manage and operate traffic safely and efficiently.

Table 2. MDOT Proposed ATM Strategies

ATM Strategy Description	US-23 *consideration*
Variable Speed Limits (VSL) - *Adjusts speed limits based on real-time traffic, roadway, and/or weather conditions.*	✓ (*advisory*)
Dynamic Lane Use Control - *Dynamically closing or opening individual traffic lanes and providing advance warning of the closures to merge traffic into adjoining lanes using lane control signs*	✓
Queue Warning - *Real time displays of warning messages along a roadway to alert motorists that queues or significant slowdowns exist ahead*	✓
Dynamic Shoulder Lane - *The use of the shoulder as a travel lane(s) based on congestion levels during peak periods and in response to incidents or other conditions*	✓
Adaptive Ramp Metering - *Traffic signals on ramps to dynamically control the rate vehicles enter the freeway*	
Transit Signal Priority - *Manages traffic signals by using sensors or probe vehicle technology to detect when a bus is approaching a signal; and elongating the green to allow the bus to maintain accurate schedules arrivals.*	

ATM Strategy	Description	US-23 *consideration*
Adaptive Signal Control - *Continuously monitors arterial traffic conditions and the queuing at intersections to dynamically adjust timing that optimizes capacity*		
Dynamic Junction Control - *Dynamically allocating lane access on mainline and ramp lanes in interchange areas with high traffic volumes*		
Lane Reversal - *Use of lane control signs to reverse the direction of travel for individual lanes in response to demand.*		
Dynamic Merge Control - *Dynamically managing entry of vehicles into merge areas*		

MDOT currently uses Intelligent NETworks (provided by Parsons) as their ATMS software. Intelligent NETworks is a commercial off the shelf (COTS) software solution that has been customized and integrated with MDOT's ITS network. Limited customization has been performed with Intelligent NETworks to date. This software does not include modules for posting variable speed limits or response plans for closing, merging, or reopening lanes. In addition, new device types/technology of the ATM system includes LCS and VSA. These systems will need to be integrated into MDOT's current operation, management, and maintenance procedures and processes.

3 Assessment Methodology

A project stakeholder meeting was held on December 8, 2014 to discuss project status and concerns. Stakeholders expressed interest in obtaining information about other ATM software developments. Stakeholders created a list of questions they thought would provide the best measurement in comparison to MDOT's current ATMS software.

Each peer agency was contacted via email, phone, or both. Even though every agency was unable to provide responses, several agencies did provide input to support the outreach effort. The response information received is provided in **Appendix B**.

The defined list of questions was asked of all contacted agencies. Minimal follow up was conducted to ensure the line of questioning would be consistent and as not to lead the answers from any individual agency. The assessment questions included:

- How software changes were handled?
- What was done to assist with making the operations easier and more efficient?
- What was the overall experience with the development of the software to operate the system?
- Was the process straightforward, timely, cost-efficient, and intuitive?

Assessment questions were categorized as quantitative or qualitative. The quantitative metrics solicit objective information, such as cost or time. The qualitative metrics are more subjective in nature and typically are based on the experience the client had with the software developer. The data requests from the stakeholders that was used to derive the questions for the software assessment are given in **Table 3** and **Table 4**.

Table 3. Quantitative Metrics

Initial cost
Implementation time
Ongoing operation/maintenance cost; by whom and how much?
Operation Center impacts
• ***Number of employees***
• ***Number of workstations***
• ***Impact to Standard Operating Procedures (SOP)s for normal operations (i.e. posting a message)***
Compatibility with Department of Technology, Management & Budget (DTMB) network/firewall/security
Availability of technical/software support (yes/no)
Major interaction/integration with other software (if applicable)

Table 4. Qualitative Metrics

Operation Center impacts
• ***Graphic User Interface (GUI) – is it dramatically different than current ATMS?***
• ***GUI – is it intuitive?***
Future expansion of the system – ease of modification and cost
Has the software been successfully used for this purpose (ATM) in other applications?
Availability of technical/software support (how helpful)
Lessons learned
Implementation track record of the firm

As previously mentioned, additional agencies other than those included within the Best Practice document were contacted. **Table 5** includes the list of agencies contacted for their experience and feedback, and indicates whether they were included in the Best Practice document and provided feedback to the software assessment.

Table 5. List of Agencies with ATM Software

Agencies	Best Practice	Feedback Received
Minnesota	✓	✓
Washington	✓	✓
Colorado		✓
Oregon		✓
Nevada		
San Diego		✓
Virginia	✓	*
Norfolk, VA Tunnel		
UK	✓	

Information received from Parsons (vendor), not the agency

In addition, it should be noted that the vendor for MDOT statewide ATMS (Parsons) is the primary vendor for the San Diego Integrated Corridor Management (ICM) project. Information was solicited from Parsons to gain an understanding of their current capability of providing certain technologies regarding an ICM/ATM system. Parsons provided information on what they developed for the San Diego ICM project and what they are currently developing for a VDOT ATM deployment.

Virginia and Nevada offered limited response because their software has not yet been deployed. Both projects are in the process of final software development for implementation in mid-to-late 2015.

4 Peer Agency Summary

This section is a quick highlight of each participating peer agency. Each peer agency response to the questions is included in **Appendix B**. The responses identify the strategies implemented; perceived advantages and disadvantages of their deployment; and the responses to the qualitative and quantitative assessment questions.

Minnesota DOT

Minnesota's ATM software, known as IRIS, was developed in-house. The software was developed in an open-source platform, which can easily permit other states to obtain and modify as necessary. Currently, of the nine districts in California with ATMS software, four are using IRIS. Arizona also uses this software code for their ATMS software. Wyoming and Nebraska are in the process of obtaining and modifying the source code for their ATMS software. There also are several local municipalities and other states interested in the source code.

Washington DOT

Similar to Minnesota, Washington State DOT's ATM software was developed in-house; however, the software is not open-source. Even though the software would not be available for purchasing or implementing in Michigan, **Appendix B** includes the answers to the questions as they relate to WSDOT's software development.

Colorado DOT

Colorado's ATM software is provided by Crytek. It is not part of an ATMS software package, but it was developed as a corridor management software.

Oregon DOT

Oregon's ATM software is provided by Parsons. The software was purely customized in response to the defined software requirements. Oregon has maintained a strong working relationship with their original developer who has been acquired by Parsons since the initial development. Since Oregon does not have an operations center to monitor changing conditions on the corridor, the software primarily is automated. The algorithms are filtered through a data acquisition service for verification and then automatically sent to a message service for display.

SANDAG / Virginia DOT

SANDAG was able to provide a high level institutional feedback of their software deployment. Due to time constraints and scheduling conflicts, it was not possible to coordinate feedback directly with VDOT or both SANDAG project managers. However as noted above, Parsons was contacted to provide feedback regarding the San Diego deployment as well as the Virginia ATM deployment. Parsons was asked the same assessment questions as the peer agencies and provided feedback regarding San Diego. Since the Virginia development was still undergoing, Parsons was unable to fully answer the questions.

5 Assessment Response Summary

In order to provide an initial assessment of the software solutions that were investigated, a methodology was developed based on a risk assessment. Risk assessments include the identification of a risk and quantify both the impact and the probability of the identified risk. Since MDOT cannot purchase Washington's ATM solution, this option was not included within the following assessment summary. Similarly, Virginia was not included in the assessment summary due to a limitation in the feedback provided.

For the US-23 corridor assessment, five risk categories were defined. These categories were selected as they tend to potentially pose the greatest risk to the overall success of the US-23 ATM project. Each risk also was assigned a specific impact value ranging from 1 to 5 (1=Trivial; 2=Minor; 3=Moderate; 4=Major; 5=Extreme). It is assumed that the impact of the risk is similar regardless of which software solution is selected. The five categories and their assigned impact value are presented in **Table 6**. :

Table 6. Impact Scale

Risk Category	Risk Description	Impact	Impact Score
Strategy Implementation	Ability to implement 6 strategies identified	Extreme	5
Operations Component	Ease of incorporating ATM into operations (use of the system, use of dual systems, etc.)	Major	4
Maintenance Component	Ease/simplicity of software maintenance (IT support, network compatibility)	Major	4
Cost	Cost (relative magnitude)	Moderate	3
Schedule Adherence	Likelihood of meeting project schedule	Extreme	5

the impact score will be applied to each software package consistently – as seen in* ***Table 8* *below.*

To obtain a probability score within each risk category, a methodology was defined to ensure the assessment of the various software packages was consistently applied and compared apples to apples. The methodology may vary between each category, but the evaluation of the software packages was consistent per each defined criteria explained below and shown in **Table 7**.

The Strategy Implementation risk category was based on the identification of the following technology strategies. Each of these technologies must be supported and integrated within the selected software platform to provide a comprehensive ATM solution. The probability score for each individual software solution is defined based on the number of strategies that currently are supported by the specific software package.

- Hard shoulder running (HSR)
- VSA
- Queue warning (QW) with detection
- LCS
- Large and small DMS
- CCTV cameras

Similarly, **Table 7** defines the scoring methodology for the probability score of the remaining 4 categories. Each probability score is attached to more descriptive approach to evaluate each category. Each software solution was assessed and scored on its potential probability of occurring with regard to the US-23 project. Based on its probability of occurring, a probability score was given.

Table 7. Probability Scale

1-5 (*to keep same scale as above*)

Risk Category	Probability – *as defined for each risk*				
	Rare (1)	**Unlikely (2)**	**Moderate (3)**	**Likely (4)**	**Very Likely (5)**
Strategy Implementation	Implements 6	Implements 4-5	Implements 3	Implements 1-2	Implements 0
Operations Component	Seamless incorporation (minimal training)	Easy incorporation (some training)	Somewhat easy to incorporate (consistent training)	Difficult to incorporate	Challenging to incorporate
Maintenance Component	No IT support/not compatible with the network		More IT support/ less compatibility issues		Dedicated IT support/ dedicated network and compatible
Cost	$	$$	$$$	$$$$	$$$$$
Schedule Adherence	Delivered early	On time	Slightly over on schedule	Minor delays likely	Delays highly likely

Table 8 summarizes the impact, probability, and overall risk score for each software solution evaluated. In addition, comments are provided to support the scores provided. For each software, the risk scores from each category were added together to estimate an overall total risk for the corresponding software solution. The higher the overall total, the greater the perceived risk for applying the solution on US-23.

Table 8. Compatibility Matrix

Agency	Risks	Probability	x	Impact	=	Risk Score*	TOTAL**	Comments
MDOT (current ATMS) (Parsons V3)	*Strategies*	4	x	5	=	**20**	72	- Only has implemented 2 of the 6 strategies (*DMS, CCTV*)
	Operations	2	x	4	=	8		
	Maintenance	3	x	4	=	12		
	Costs	4	x	3	=	12		
	Schedule	4	x	5	=	**20**		
MnDOT (IRIS)	*Strategies*	2	x	5	=	10	71	- Implemented 4 of 6 strategies (*HSR, VSA, LCS, DMS, CCTV*) - Delays are highly likely as there is a learning curve of having finding an IT person who can learn the code, figure out what needs to be changed to work with MDOT, then test, and implement
	Operations	3	x	4	=	12		
	Maintenance	3	x	4	=	12		
	Costs	4	x	3	=	12		
	Schedule	5	x	5	=	**25**		
CDOT (Crytek)	*Strategies*	2	x	5	=	10	66	- Implemented 5 of 6 strategies (*VSA, QW, LCS, DMS, CCTV*)
	Operations	3	x	4	=	12		
	Maintenance	3	x	4	=	12		
	Costs	4	x	3	=	12		
	Schedule	4	x	5	=	**20**		
ODOT (Parsons V8)	*Strategies*	2	x	5	=	10	63	- Implemented 5 of 6 strategies (*VSA, QW, LCS, DMS, CCTV*) - Costs receive a 3 if the ATM modules are considered as a separate S/W platform
	Operations	3	x	4	=	12		
	Maintenance	3	x	4	=	12		
	Costs	3	x	3	=	9		
	Schedule	4	x	5	=	**20**		
Parsons (San Diego) (Parson V8)	*Strategies*	2	x	5	=	10	59	- Implemented 4 of 6 strategies (*VSA, LCS, DMS, CCTV*) - Costs receive a 3 if the ATM modules are considered as a separate S/W platform
	Operations	2	x	4	=	8		
	Maintenance	3	x	4	=	12		
	Costs	3	x	3	=	9		
	Schedule	4	x	5	=	**20**		

Bold denotes risks with the highest score (15 or greater); ** the lower overall **TOTAL, the less perceived risk implied for applying the solution.*

During the development of the risk categories and application of the assessment above, additional risks were noted that could have significant impact on delivery of the software solution. **Table 9** presents these risks and potential mitigation strategies that could be implemented. Even though these elements were not defined as the highest risks to the success of the US-23 ATM project, they are crucial to the overall development of the software implementation. As the software implementation continues, it is important to manage these risks along with others that may be identified and continue to refine the potential mitigation strategies to support a successful software implementation.

Table 9. Overarching Risks for Implementation

Risk	*Mitigation*
Coordination between software development and field device construction	*Develop software requirements early on; start development of software prior to final design*
In-house staff	*In-house staff will need to be involved from the beginning of development*
24/7 operations	*Will need to have trained operators and supervisors on all shifts*
Testing environment	*Ensure there is a test bed environment with in-field devices and simulators to assist with testing the system*
GUI operator buy-in	*Operators should have a say in the GUI design to ensure comprehension with updates*
Software buy-in	*Bring both IT, operators, and steering committee to the table during software requirement development*

5.1 Decision Points

Based on the information summarized in **Table 8,** it is suggested that additional conversations should be conducted with Parsons regarding their ATM software solution, specifically related to the San Diego deployment. Prior to initiating the conversations with Parsons, MDOT should discuss and clearly understand the potential implications and impacts that a Parsons ATM solution could have on the US-23 ATM project. Some of these points:

- Contractual implications regarding the current contract with Parsons for the state's ATMS software.
- Determination on the acceptable schedule for software delivery. The shortest schedule option would be to align with the US-23 project implementation; a more generous schedule could allow additional software development time to potentially align with the possible upcoming Metro implementation.
- Discussion on whether MDOT is interested in upgrading the current version of the statewide software to the latest version of Parsons' ATMS software, which would include the ATM module.
- DTMB's capacity to provide staffing assistance to support changes within the software – either within the Parsons code or the IRIS code (option 2).

MDOT also should consider the potential implications related to not having a software solution in place to operate the ATM once it is operational. When the infrastructure installation is complete, what is the potential impact if the system is not live and the users traveling along US-23 are not provided with a fully functional ATM solution from day one?

Once fully prepared with the information surrounding risks and mitigation strategies related to the Parsons solution, MDOT should focus conversations with Parsons on the following topics.

- How much effort (cost/time) is required to add an ATM module within MDOT's current version of the ATMS software? Noting that the ATM module has been developed within a newer version.
- Is it feasible to operate the ATM infrastructure on the US-23 corridor with a solution that includes only the ATM module without integrating the module within the current version of the Statewide ATMS software? This solution would require operations to interact with two versions of the Parsons software.

5.2 Next Steps

In order to finalize a software decision to support ATM deployments in Michigan, several unanswered questions remain to be addressed; therefore, MDOT has decided to engage in a two-step approach. The first step includes a conversation with Parsons to inquire about their current capacity and capabilities with respect to enhancing Michigan's current ATMS software deployment to support ATM strategies. This includes an estimation of the cost and time necessary to implement the needed software development associated with the ATM project. The second step involves MDOT engaging with Parsons specific to the contractual obligations with the current ATMS software, risks related to the version in place, and mitigation strategies that can address those risks and possibly updating to a more current version. Once these conversations have been concluded, MDOT then will re-engage with the steering committee for a final determination regarding a software solution to support ATM in the state.

Appendix A – Contacted Agencies

Agency	Name	Email	Phone
Minnesota DOT	Brian Kary	brian.kary@state.mn.us	
Washington DOT	Chris Thomas	ThomaCP@wsdot.wa.gov	
Colorado DOT	Rob Bruening	rob.bruening@state.co.us	
Oregon DOT	Dennis Mitchell	dennis.j.mitchell@odot.state.or.us	
	Darrell Landrum	Darrell.LANDRUM@odot.state.or.us	
	Chad Mann	Chad.E.MANN@odot.state.or.us	
Nevada DOT	Rod Schilling	roschilling@dot.state.nv.us	
SANDAG	Alex Estrella	alex.estrella@sandag.org	619-699-1928
	Peter Thompson	Peter.Thompson@sandag.org	
Virginia DOT	Kamal Suliman	kamal.suliman@vdot.virginia.gov	
Norfolk Tunnel	Oliver Rose		757-424-9906
United Kingdom – Highways Agency	David Grant	David.Grant@highways.gsi.gov.uk	
Parsons	Joseph Brahm	Joseph.Brahm@parsons.com	847-485-1054
	Mark Conrad	Mark.Conrad@parsons.com	
	Richard Chylinski	Richard.Chylinski@parsons.com	905-943-0520

Appendix B

Appendix B includes the responses from each peer agency for the data points identified in **Table 3** and **Table** 4. These responses capture the experiences of each agency and were used to identify the probability score used in the risk assessment of the software solutions.

List of acronyms:

- HOT – high occupancy toll (lane)
- HSR – hard shoulder running
- RM – ramp metering
- VSL – variable speed limit (advisory or regulatory)
- LCS – lane control signs
- DMS – dynamic message signs
- CCTV – closed-circuit television (cameras)
- QW – queue warning – indication additional detection would be needed

Minnesota

Table 10 identifies the vendor, strategies, and the overall software advantages and disadvantages.

Table 10. MnDOT ATM Software

Vendor	FHWA ATM and ITS Strategy Capabilities	Advantages	Disadvantages
In-House (IRIS)	HSR, HOT, RM, VSL, LCS, DMS, CCTV	Open-source code – there are no license fees and MnDOT can do anything with the code; create, modify any modules they prefer.	Open-source code – there needs to be a dedicated person to maintain the code and make any modifications necessary.
		Dedicated software developer who can modify, tweak, and create whenever necessary.	Since there is only one person developing the software, it may take a little longer to fix more common problems as they may be more focused on new development.
		Dedicated ITS network – with dedicated personnel for IT network, maintenance, and installation (integrator) of the ATM system.	Although there is a dedicated person for software revisions, the said person does not work after hours.
		The software developer has been the same person the entire duration of IRIS (late 90s)	
		IRIS includes a message fail safe mode. The software will take the recommended message, and review them to be sure the proper message is displayed.	

Table 11 and **Table 12** include responses to quantitative and qualitative metrics respectively for their systems.

Table 11. MnDOT Quantitative Metrics

Metrics	Answers
Initial cost	*Since MnDOT has a dedicated person for the development, there were no other costs associated with the software development other than his salary.*
Implementation time	*9 months – included requirements, development, testing, and implementation; this was only for the additional LCS.*
Ongoing operation/maintenance cost; by whom and how much will it cost?	*Again, this is MnDOT's IT developer's full-time position. The same person has been in the position since the late 90s with the first deployment of IRIS.*
Operation Center impacts	*The operations center is not 24/7. During the evenings or off times either maintenance or the state patrol will access IRIS to*
• ***Number of employees***	

Metrics	Answers
• ***Number of workstations***	*review a CCTV or post a message.*
• ***Impact to SOPs for normal operations***	
Compatibility with DTMB network/firewall/security	*Since there are dedicated personnel and a dedicated ITS network, the coordination between the software and integration of field devices is much more fluid.*
Availability of technical/software support (yes/no)	*Yes, since this person is dedicated to MnDOT.*
Capable of Major interaction with other software (has it been done?)	*It does not interact with vendor software; however there is one county that has provided the IP address for several of their devices to MnDOT in order for IRIS to communicate to them.*

Table 12. MnDOT Qualitative Metrics

Metrics	Answers
Operation Center impacts	*The GUI was designed to match the other modules within IRIS. So no change. Also, the operators liked the GUI straight away – no complaints from the state patrol or maintenance on the ease of interface use.*
• ***Graphic User Interface (GUI) – is it dramatically different than current ATMS?***	
• ***GUI – is it intuitive?***	
Future expansion of the system – ease of modification and cost	*The software was set up as modular, so additional technology or additional needs can be added without affecting other modules.*
Has the software been successfully used for this purpose (ATM) in other applications?	*No, although California and Arizona are using IRIS – their use is for an ATMS software, not ATM.*
Availability of technical/software support (how helpful)	*The developer is very helpful with the software support.*
Lessons learned	*Auto-deploy LCS – when an operator identifies event location, messages are deployed to the LCS all at one time versus each one separately. This helps to put the messages on the LCS quicker. Also the operator can monitor and change the messages on the fly.*
Implementation track record of the firm	

Washington

Table 13. WSDOT ATM Software

Vendor	Strategies	Advantages	Disadvantages
In-House	HSR*, RM, VSL, LCS, DMS, CCTV	Three full-time staff for the software group dedicated to traffic management software.	The software is not available for other state agencies.

** denotes a future strategy*

Table 14 and **Table 15** include responses to quantitative and qualitative metrics respectively for their systems.

Table 14. WSDOT Quantitative Metrics

Metrics	Answers
Initial cost	*WSDOT estimated the cost for development of the software to be $250-$300K (just software and not hardware/support)*
Implementation time	*Software development covered 15 months. Field implementation on 3 highways took over 6 months.*
Ongoing operation/maintenance cost; by whom and how much will it cost?	*This is minimal, but it is wrapped into WSDOT other software costs and would be difficult to estimate. Less than $5,000/yr.*
Operation Center impacts	*There are four employees; no new workstations were added with the ATM system. A few extra steps were added to the current SOP, but it is mostly piggybacked on what was already done*
• ***Number of employees***	
• ***Number of workstations***	
• ***Impact to SOPs for normal operations***	
Compatibility with IT network/firewall/security	*This is not an issue.*
Availability of technical/software support (yes/no)	*Yes, as there are three full-time staff dedicated to the traffic management software.*
Major interaction with other software (if applicable)	*The WSDOT Traffic Management Software is modular by functionality (data collection, ramp metering, camera control, DMS control). ATM is another module that subscribes to the real-time traffic data and interacts with the DMS module as an operator. All WSDOT Traffic Management Software is maintained by the three-member software team.*

Table 15. WSDOT Qualitative Metrics

Metrics	Answers
Operation Center impacts	*There was an additional control window added to the traffic management software; but the GUI is still very intuitive and quick to deploy. Operators can post and update ATM signs in about 10 seconds.*
• ***Graphic User Interface (GUI) – is it dramatically different than current ATMS?***	
• ***GUI – is it intuitive?***	

Metrics	Answers
Future expansion of the system – ease of modification and cost	*The benefits of this system are hard to quantify. Only one small expansion is planned to the north end of the I-5 system. The software is easily scalable at minimal cost.*
Has the software been successfully used for this purpose (ATM) in other applications?	*No.*
Availability of technical/software support (how helpful)	*Very helpful.*
Lessons learned	*Need to have the system requirements fully defined. Prototyping allows for changes and customization during development (flexibility).*
Implementation track record of the firm	

Colorado

Table 16. CDOT ATM Software

Vendor	Strategies	Advantages	Disadvantages
Crytek	RM*, VSL, LCS, DMS, CCTV, QW	Custom software; was developed based on the specification of the client.	No control for CCTV usage, can only view video.
		When implementing a response plan, the system will activate and create an event automatically at the same time.	Not part of a statewide system, but more of a corridor management software – would like to combine all systems into one.
		State owns software; no fee.	

** denotes a future strategy*

Table 17 and **Table 18** include responses to quantitative and qualitative metrics respectively for their systems. CDOT has not fully deployed their system, so there are some questions he was unable to answer.

Table 17. CDOT Quantitative Metrics

Metrics	Answers
Initial cost	
Implementation time	*The software took about 6 month's development time; it is to be rolled out July 1 – waiting on construction to finish.*
Ongoing operation/maintenance cost; by whom and how much will it cost?	
Operation Center impacts	*The idea is to have a sole person monitoring the system. SOPs are currently under progress.*
• ***Number of employees***	
• ***Number of workstations***	
• ***Impact to SOPs for normal operations***	
Compatibility with IT network/firewall/security	*CDOT has a private ITS network throughout the state; The state consolidated their IT, but they have an IT team that was excluded from IT consolidation. They have their own ITS network – they maintain it. This makes it easier to get things done since they have the control.*
Availability of technical/software support (yes/no)	*Yes. Developers are under a long contract since CTMS has been under development truly for 10 years.*
Major interaction with other software (if applicable)	*Yes, vendor software.*

Table 18. CDOT Qualitative Metrics

Metrics	Answers
Operation Center impacts	*Not yet deployed.*
• ***Graphic User Interface (GUI) – is it dramatically different than current ATMS?***	
• ***GUI – is it intuitive?***	
Future expansion of the system – ease of modification and cost	*It is custom software, so not sure how easy – good development team; a good vision is important to be able to have a good product; if it was COTS then it may take more money to change.*
Has the software been successfully used for this purpose (ATM) in other applications?	*Unaware of any other deployments of this software elsewhere.*
Availability of technical/software support (how helpful)	*Crytek (Developers) – excellent company (very knowledgeable on ITS and software; they have been dealing with traffic)*
Lessons learned	*There are none at this time.*
Implementation track record of the firm	*Very good.*

Oregon

Table 19. ODOT ATM Software

Vendor	Strategies	Advantages	Disadvantages
Parsons	RM, VSL, LCS, DMS, CCTV*, QW	Purely customized software based on the requirements specified.	No continuous monitoring of the system.
		ODOT owns the code.	
		Dedicated IT team for ITS.	
		Automated system since there are no operators.	

** denotes a future strategy*

Table 20 and **Table 21** include responses to quantitative and qualitative metrics respectively for their systems.

Table 20. ODOT Quantitative Metrics

Metrics	Answers
Initial cost	*$1 million - $500K for ATM, $500K for RM and Data Acquisition.*
Implementation time	*2 yrs. (for needs, requirement, development, testing, and implementation); also going through a modernization – changing signs to full matrix (with graphics); April- Modernizing ramps & data collection. Updated communications w/ fiber.*
Ongoing operation/maintenance cost; by whom and how much will it cost?	*Under warranty – currently have an 18 months performance warranty with Parsons for adding of devices within the field.*
Operation Center impacts	*No operations center; there are only two-three people that use system for administrative changes so no need to make intuitive.*
• ***Number of employees***	
• ***Number of workstations***	
• ***Impact to SOPs for normal operations***	*Created a new message queue manager and added a new priority level message (created new message it didn't have before).*
Compatibility with IT network/firewall/security	*Added O&M to their system – dedicated IT team for ITS – operations and field. This was helpful because the team was dedicated.*
Availability of technical/software support (yes/no)	*Yes.*
Major interaction with other software (if applicable)	*Message service software and a data acquisition software – Software pushes to the message service that goes to the message control system. Data Acquisition collects all data (a separate Travel Times system calculates the travel times and pushes via service).*

Table 21. ODOT Qualitative Metrics

Metrics	Answers
Operation Center impacts • ***Graphic User Interface (GUI) – is it dramatically different than current ATMS?*** • ***GUI – is it intuitive?***	*The GUI is a server based user interface using SQL servers.* *There is an Admin setup for new device w/configuration per device, or to change parameters.* *The GUI does takes some knowledge to use – one has to know what they are doing, how to make a change, and the results of making those changes.*
Future expansion of the system – ease of modification and cost	*Although ODOT owns the source code, they are currently contracting Parsons to continue to make revisions to the software. ODOT did note that not having a Test bed makes expansions a bit harder, but having a simulator did help. The RM system was complicated for an expansion within the software. ODOT did recommend more access to field devices for testing – would have possibly found defect in the program that didn't see in test.*
Has the software been successfully used for this purpose (ATM) in other applications?	*Yes – other ATM deployments within Oregon have been completed on various corridors with this ATM software. There has not been a before/after review, but early indications suggest there are less incidents along the corridors.*
Availability of technical/software support (how helpful)	*Yes – depends upon how busy the vendor is - if it is a major problem however, they are quick to respond. If the request is for a new function, then it gets in their queue. They originally had two groups working: IDI (ATM expertise) and another.*
Lessons learned	*1: Ability to test is critical. It is best to have the system central and a really good test environment in the field.* *2: Consider how much time development will take – it took longer than anticipated. It is best to coordinate field device construction with software development. The construction was completed prior to software for this installation.* *3: The GUI is different from other applications because different vendors were used – would re-do so it would have same look and feel to make it easier for everyone to use.*
Implementation track record of the firm	*ATMS experience primarily. Several transitions with the primary ATMS vendor. Started out with one firm, which was bought by Delcan, then Delcan was bought by Parsons (working since 1996).*

San Diego

Table 22 identifies the vendor, strategies, and the overall software advantages and disadvantages.

Table 22. Parsons ATM Software

Vendor	Strategies	Advantages	Disadvantages
Parsons	RM, VSL, LCS, DMS, CCTV, Arterial Management, Bus Priority, Traveler Information	It was one of the USDOT Integrated Corridor Management (ICM) deployments	Large scale and very public since this was one of the USDOT ICM deployments – it went live at ITS America a couple of years ago
		There was a designated SANDAG, IT person. He had counterparts at each of the other agencies.	

Alex Estrella was contracted. He was one of the two project managers for the ICM project. His responses are more institutional in nature and are provided in **Table 23** and **Table 24** below.

Table 23. SANDAG Quantitative Metrics

Metrics	Answers
Initial cost	*Budget was between $3 and $4 million – this included the design (modeling, integration, testing, training, management, and maintenance). Maintenance was only for 1 year and was 0.05% of the total cost.*
Implementation time	*Went a little over schedule – due to both the software development and partner buy-in. Also this was new and there were challenges that they felt they spent too much time working on when they probably did not need to*
Ongoing operation/maintenance cost; by whom and how much will it cost?	*The first year was to ensure the system was stable; Parsons would fix problems when the local IT resources were unable to. Currently in the process of negotiations for another year for Parsons to update the modeling conditions. Original historic data was 2012.*
Operation Center impacts	*N/A*
• ***Number of employees***	
• ***Number of workstations***	
• ***Impact to SOPs for normal operations***	
Compatibility with IT network/firewall/security	*Yes – also SANDAG had an IT dedicated staff that assisted with managing the subsystems which assisted with ensuring compatibility.*
Availability of technical/software support (yes/no)	*Yes, very responsive to issues*
Major interaction with other software (if applicable)	*The majority of the project entailed an interface with several existing subsystems such as transit management system and arterial management system (signals).*

Table 24. SANDAG Qualitative Metrics

Metrics	Answers
Operation Center impacts • ***Graphic User Interface (GUI) – is it dramatically different than current ATMS?*** • ***GUI – is it intuitive?***	*The GUI is fairly user friendly. The idea behind the interface development was for one consistent GUI interface for all subsystems.*
Future expansion of the system – ease of modification and cost	*This was something that was considered when developing the ICM. Due to the complexities of the business rules for the modeling aspect, as many future expansions were identified although they have not been built – this will help with developing those future enhancements. Otherwise, if they were not, then making those changes later could have a huge ripple effect on the logic used – then the system may not work as well or there might be more development costs involved.*
Has the software been successfully used for this purpose (ATM) in other applications?	*Portions of the development have been used in other deployments.*
Availability of technical/software support (how helpful)	*Yes and have been very helpful.*
Lessons Learned	*1. Follow a structured platform – this was a complicated concept and the systems engineering process provided check-ins to be sure the development matched the design;* *2. Do not push your partners for decisions. It was a new system and so they were not always sure what sort of outcome they would get. Continue to meet constantly and work with the partners so everyone is comfortable with the solution;* *3. Make the terminology relatable to all stakeholders. Not all of the stakeholders had the same background, so using terminology that they could relate to helped move decisions along quicker;*
Implementation track record of the firm	*SANDAG already had Delcan (Parsons) under contract prior to the development of the ICM project – and based on that relationship SANDAG just extended the current contract to include the ICM development.*

Joseph Brahm, Richard Chylinski, and Mark Conrad, of Parsons were contacted. They provided responses to the assessment questions which are provided in **Table 25** and

Table 26 below.

Table 25. Parsons Quantitative Metrics

Metrics	Answers
Initial cost	*Budget was $3.8 million – including design, software, hardware, modeling, integration, testing, training, and management. The system was completed within budget. There were a lot of first time development costs on the ATMS and model side.*
Implementation time	*28 months. Original was 20 months. Final design details buy off, and coordinated testing took more time than expected.*
Ongoing operation/maintenance cost; by whom and how much will it cost?	*The base ICM support annual cost is $96K. But there is also traffic modeling support of ~$100K. The first year also included about $200K of additional modifications and enhancements. With a project of this scale it is good to assume there will be some desired modifications based on actual operational experience.*
Operation Center impacts	
• ***Number of employees***	
• ***Number of workstations***	
• ***Impact to SOPs for normal operations***	
Compatibility with IT network/firewall/security	*With several agencies involved there were some IT issues with interfaces to other agencies. There were cases where the IT staff from other agencies would change firewalls/network and not advise SANDAG resulting in broken interfaces and leaving SANDAG and Parsons scrambling to repair.*
Availability of technical/software support (yes/no)	*Yes.*
Major interaction with other software (if applicable)	*Interfaced with multiple systems – signal systems (both timing and monitoring), parking, transit, travel time, legacy devices, ramp metering for bypass lanes, third party systems for real-time modeling.*

Table 26. Parsons Qualitative Metrics

Metrics	Answers
Operation Center impacts	*Have not received any complaints.*
• ***Graphic User Interface (GUI) – is it dramatically different than current ATMS?***	
• ***GUI – is it intuitive?***	
Future expansion of the system – ease of modification and cost	*The system was built to be flexible – the parameters were built within the system providing easier modifications. The cost would depend on what the expansion included.*
Has the software been successfully used for this purpose (ATM) in other applications?	*Yes, some of the capabilities have been used for the ATM portion of the software for Virginia.*
Availability of technical/software support (how helpful)	*N/A*
Lessons Learned	*Stakeholder coordination at all levels, operational, IT, management, is important. Everybody must buy-in to the program. Also good to have traffic operations and IT people at the table from the beginning.*
Implementation track record of the firm	