

Research Report
Agreement T2695, Task 73
ITS Evaluation Framework Phase 2

**ITS EVALUATION FRAMEWORK —
PHASE 2 CONTINUATION (2009)**

SEVENTEEN PROJECTS

by

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EXECUTIVE SUMMARY

This is the third report on a project for the Washington State Department of Transportation (WSDOT) that started in 2004 with the objective of developing a methodology for evaluating advanced traveler information systems (ATIS) and testing it on a group of five projects. Phase 2 then applied the evaluation methodology to a diverse group of 16 intelligent transportation systems (ITS) projects covering everything from ITS planning to safety improvements.

The evaluation approach was based on a structured interview script that addressed the following topics: project background, system features, system operations, system usefulness, public response, project management, and lessons learned. The interviews were able to elicit the information needed to meet the evaluation requirements.

This continuation of Phase 2 used the same interview script in questionnaire form to elicit the same information. Follow-up discussions were used for clarification and to obtain additional information. Seventeen ITS earmark projects were evaluated, and individual reports were prepared to document the following project aspects:

- background
- project description
- system usage and benefits
- cost, operations and maintenance
- architecture and standards
- lessons learned.

The lessons learned were similar to those previously documented and fell into the following four categories:

- planning
- maintenance

- rural development
- project management.

The majority of the lessons learned in this evaluation fell into the area of project management. The reason for this was that these projects were not funded by the normal WSDOT transportation planning and programming process. Funds and personnel for project management were therefore in short supply, and as a result, traffic operations engineers were often given the responsibility of managing these projects in addition to their regular duties. Problems in coordinating multi-jurisdictional projects—getting consensus from a multi-agency board, for example—occurred on several of these projects.

ITS EVALUATION—PHASE 2 CONTINUATION (2009): 17 PROJECTS

1: INTRODUCTION

This is the third report on a project for the Washington State Department of Transportation (WSDOT) that started in 2004 with the objective of developing a methodology for evaluating advanced traveler information systems (ATIS) and testing it on a group of five projects funded in FY 1999-2000.

After the development and application of the evaluation methodology (*ATIS Evaluation Framework*, WA-RD 606.1, May 2005, WSDOT), a review of remaining WSDOT intelligent transportation systems (ITS) projects found 16 that were completed and ready for evaluation. The same methodology developed in the framework project, with minor modifications, was successfully used to evaluate that diverse collection of projects. That report was published in June 2007 (*ITS Evaluation Framework – Phase 2*, WA-RD 672.1, June 2007, WSDOT).

This continuation of Phase 2 evaluated 17 additional ITS earmark projects using a similarly structured interview process except that, in this case, the interview questionnaires were distributed to the project managers to complete. Where there were questions or if more information was needed, follow-up telephone conversations took place. These projects were funded between 1999 and 2004. They were a diverse collection that involved the deployment of traffic management systems, traveler information systems, and communications systems. Most of the lessons learned were similar to those that were documented in the previous evaluations.

1.1: The Federal Requirements

Evaluations of federally funded ITS projects are required as part of partnership agreements between the U.S. Department of Transportation (USDOT) and local agencies receiving the funds. Each agency agrees to produce a local evaluation report funded from

project resources. The report must include two major parts: 1) a general, overall assessment of the project and 2) two or more specific evaluation products/activities. In addition, the report must contain an executive summary.

The general overall assessment of the project must include a discussion of the major benefits anticipated from achieving project goals. It should also address key aspects of the project such as

- system and subsystem performance
- resolution of institutional issues, especially those associated with contracting procedures, liability, privacy, regulation, and intellectual property
- implications of achieving consistency with the National ITS Architecture
- consumer acceptance
- life-cycle costs.

In addition to the general overall assessment component of the local evaluation report, two or more of the following evaluation products/activities must be undertaken:

- Evaluate the institutional issues associated with achieving cooperation among public sector agencies and document how they were overcome. This is suitable for evaluation of architectural products.
- Provide a brief lessons learned report on the technical and institutional issues encountered in integrating ITS components.
- Provide an evaluation report on the lessons learned in employing innovative financing or procurement and/or public-private partnering techniques.
- Produce a lessons learned report on the experiences, challenges, and approaches used in achieving consistency with the National ITS Architecture and regional architecture and/or implementation of ITS standards. This is suitable for evaluation of architectural projects. Where regional ITS architectures are developed, the USDOT reserves the right to share them with other locations as examples of good practice.
- Produce a case study on the planning process used to achieve integration into an approved plan and program developed under an area-wide (statewide and/or metropolitan) planning process that also complies with applicable state

air quality implementation plans. This is suitable for evaluation of architectural projects.

- Provide the appropriate metropolitan planning process with data generated by ITS technologies and services, and provide a report on plans or intentions for archiving or using the data.

1.2: The Projects to Be Evaluated

This report collects and summarizes the individual evaluation reports for 17 ITS projects deployed by WSDOT. Construction has been completed on these projects and the installed systems are currently in operation. Approximately 17 ITS projects are still under construction and remain to be evaluated.

As mentioned previously, the projects were evaluated by using a methodology that was developed in the Phase 1 evaluation of five traveler information projects and further refined for use on a more diverse collection of projects in Phase 2. For data collection, that methodology relies on structured interviews based on a script designed to address a range of project development issues. No actual interviews were conducted in this continuation. Instead, questionnaires based on the previous interview script were sent to the WSDOT project managers by e-mail in September 2008. (A copy of the questionnaire template is included in Appendix A.) Telephone conversations followed to answer respondents' questions or elicit additional information.

Each individual evaluation report includes the required "general overall assessment," which addresses the key aspects of the project and a discussion of the institutional issues associated with multi-agency projects, if applicable, or a discussion of the technical and institutional issues encountered in integrating ITS components. A discussion of the use of the ITS architecture and standards is also included.

1.3: Report Organization

The report contains three main sections: an Evaluation Summary, Individual Evaluation Reports and appendices.

The Evaluation Summary includes two tables, one that lists the 17 projects included in this evaluation and a second that summarizes the lessons learned from each project.

The Individual Evaluation Reports provide the general overall assessment and the specific lessons learned for each of the 17 projects.

The appendices include:

- Appendix A: a questionnaire template that was modified to fit each project and sent by e-mail to each WSDOT project manager
- Appendix B: references to three evaluations of various aspects of the Road Weather Information Systems Enhancement program
- Appendix C: a list of Feature Sets developed and approved by personnel from the traffic management centers of the six WSDOT regions for development of a new statewide Highway Advisory Radio system.

2: EVALUATION SUMMARY

2.1 Evaluation Process

Table 1 lists the projects included in this evaluation, and Figure 1 shows the approximate locations of the projects. They can be grouped under the following application areas:

- Arterial Management Systems
- Freeway Management Systems
- Traveler Information
- Road Weather Management
- Communications Systems.

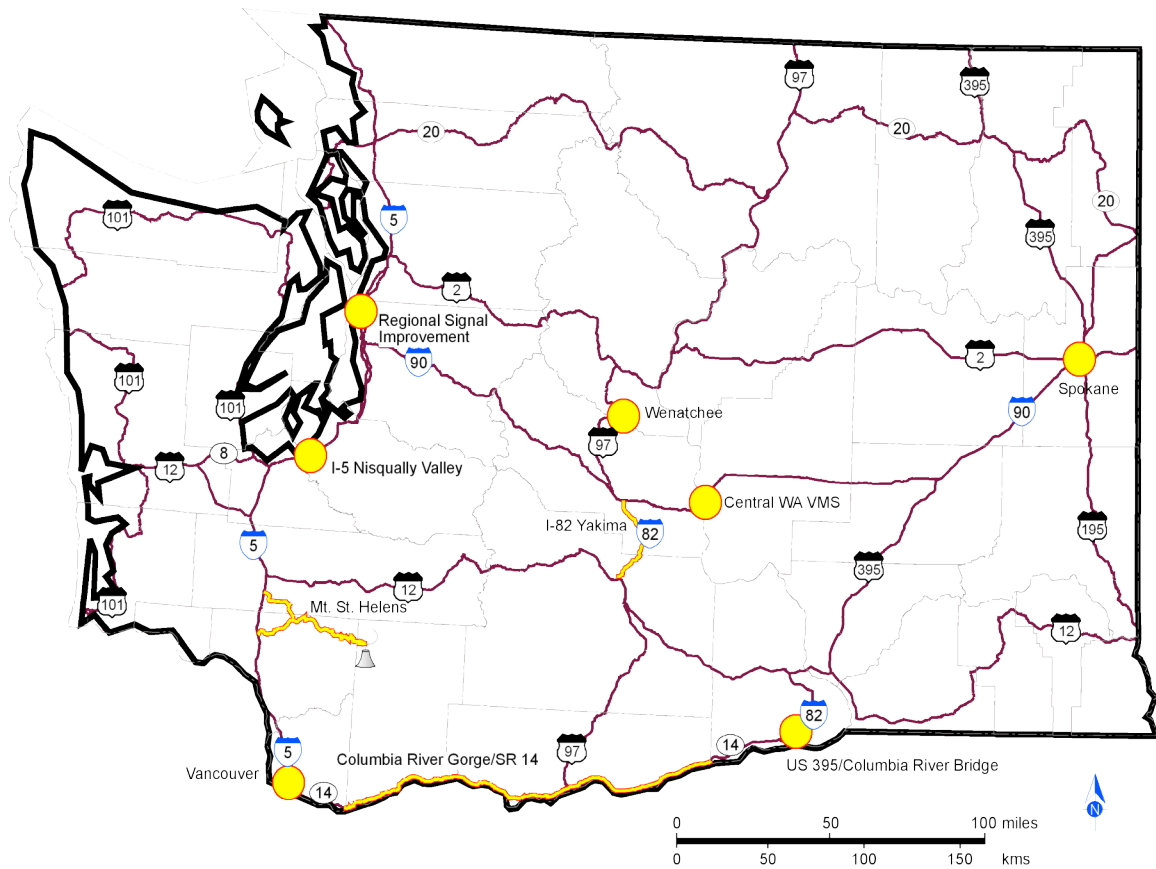


Figure 1. Approximate Locations of Evaluated Projects
(Statewide projects are not shown)

Table 1. Projects Evaluated in This Report

	Project Name	WSDOT Office	Federal Fiscal Year	Pin	Federal Aid No.
1. 2.	Road and Weather Information System Enhancement & Road and Weather Information System Expansion	Headquarters (HQs)	1999 & 2004	000042Q 000057Q	ITS-9853(002) & ITS-2004(053)
3. 4.	Columbia Gorge Traveler Information System Pilot Program & SR 14 Traveler Information System Enhancements	Southwest Region (SWR)	1999 & 2003	152510Q 401432Q	ITS-1999(014) & ITS-2003(062)
5.	Spokane Regional Traffic Management Center Enhancement	Eastern Region (ER)	2000	600001Q	ITS-2000(009)
6.	Spokane Area Intelligent Transportation Integration	Eastern Region (ER)	2001	600010Q	ITS-2001(028)
7.	Mt. St. Helens Traveler Information	Southwest Region (SWR)	2002	450421Q	ITS-2002(033)
8.	Washington Statewide Emergency Advisory Radio Coordination	Headquarters (HQs)	2002	000025Q	ITS-2002(034)
9.	US-395/Columbia River Bridge Traffic Operations	South Central Region (SCR)	2003	539533Q	ITS-2003(056)
10.	Central Washington Traveler Information VMS	North Central Region (NCR)	2003	209733Q	ITS-2003(062)
11.	Critical Data Communications Systems Enhancement	Headquarters (HQs)	2003	000043Q	ITS-2003(062)
12.	I-82 Yakima Area Traveler Information Systems	South Central Region (SCR)	2003	508232Q	ITS-2003(062)
13.	I-5 Nisqually Valley Ice Warning System	Olympic Region (OR)	2003	300531Q	ITS-2003(062)
14.	Vancouver Area Smart Trek Expansion	Southwest Region (SWR)	2003	400531Q	ITS-2003(062)
15.	Wenatchee Advanced Traffic Management System	North Central Region (NCR)	2004	209743Q	ITS-2004(051)
16.	Regional Traffic Signal Interconnect	Northwest Region (NWR)	2004	000053Q	ITS-2004(057)
17.	511 Travel Information, Phase 3	Headquarters (HQs)	2004	000052Q	ITS-2004 (058)

The framework methodology, developed by the Washington State Transportation Center (TRAC) in a previous ITS evaluation project, was effectively applied to this group of 17 projects. The structured interviews were turned into a questionnaire that addressed the following seven topics:

- project background
- system features
- system operations
- system usefulness
- public response
- project management
- lessons learned.

The questionnaires were able to elicit the information needed to meet the evaluation requirements. Minor modifications to the questionnaires to account for specific project components or attributes were usually required. Follow-up telephone calls were used to obtain clarification or more information.

2.2 Lessons Learned Summary

The individual evaluation reports include background and project description information for each project, as well as detailed discussions of the technical and institutional issues. Table 2 summarizes the lessons learned from each project. The evaluation framework developed in the previous evaluation used seven categories of lessons learned:

- Planning
- Maintenance
- Rural Deployment

- Project Management
- Staff, Training and Support
- Customer Response
- System Data.

This time the lessons learned from the deployment of the projects in the current phase fell into just the first four categories. It is probably not surprising that the majority of lessons learned and, therefore, the majority of technical and institutional issues, fell into the area of Project Management. The reason is that the normal WSDOT transportation planning and programming process was not followed to obtain the funding for these projects. Rather, all of these projects were funded from ITS earmark funds appropriated by Congress. In fact, WSDOT does not have a dedicated source of funding for ITS projects of this type, so without an ITS earmark appropriation, these projects would not have been implemented. As a result, initial cost estimates were often guesses, and in most cases the projects were not assigned to a design office or a construction office for those phases of deployment. Instead, this work was usually done by traffic engineering personnel assigned to a region or headquarters traffic operations office. It was usually added to their existing workload, and rarely were personnel assigned solely to manage these projects. Consequently, project funding was usually just barely adequate, and projects were frequently delayed. This situation was the same for all ITS earmark projects, so it is no surprise that these same problems have continued to occur.

As more data collection and traffic management infrastructure is deployed, more emphasis is placed on the sharing of information and operations coordination. This results in more multi-jurisdictional projects and also more project management problems. The need to plan for the slower decision making process encountered in multi-jurisdictional projects was the most frequently observed lesson learned.

Table 2. Lessons Learned

Lessons Learned	Road and Weather Projects	Columbia River Gorge & SR 14 Projects	Spokane TMC	Spokane Area ITS	Mt. St. Helens	Emergency Radio	US 395	Central WA	Critical Data	I-82	I-5 Nisqually	Vancouver Area	Wenatchee	Regional Traffic Signals	511
Planning															
Making the institutional and jurisdictional changes necessary to use new technology is the difficult part of the process of implementing new technology.			X												X
Try to anticipate what technology will be used in the future					X	X			X						
Maintenance															
The Automated Real-time Road Weather System (ARROWS) may have been too complex.	X														
The effort that went into developing ARROWS had many beneficial results for WSDOT	X														

Lessons Learned	Road and Weather Projects	Columbia River Gorge & SR 14 Projects	Spokane TMC	Spokane Area ITS	Mt. St. Helens	Emergency Radio	US 395	Central WA	Critical Data	I-82	I-5 Nisqually	Vancouver Area	Wenatchee	Regional Traffic Signals	511
Maintenance															
Maintenance should be considered during project design										X					
Rural Deployment															
Having a good communications network that is flexible and redundant is particularly important for implementing ITS projects in rural areas.													X		
Project Management															
Trying to meet the needs of all of WSDOT's regions and HQs for weather information with one system was probably unrealistic.	X														
Allocate funds to handle the additional maintenance necessary because of vandalism		X													

Lessons Learned	Road and Weather Projects	Columbia River Gorge & SR 14 Projects	Spokane TMC	Spokane Area ITS	Mt. St. Helens	Emergency Radio	US 395	Central WA	Critical Data	I-82	I-5 Nisqually	Vancouver Area	Wenatchee	Regional Traffic Signals	511
Project Management															
The more time devoted to developing the project scope and budget, the better the resulting project.		X		X	X						X				
For multi-agency projects, it is important to clearly define the roles and responsibilities of each agency and make sure all parties are working toward the same objectives.			X	X	X		X	X	X						
Responsibility for contract administration should be identified at the start of a project and remain the same throughout.						X									
The use of products with proven performance and reliability records can help ensure the completion of a project on time and within budget.						X									
The division of responsibility between the system operators and the system maintainers needs to be determined.						X									

Lessons Learned	Road and Weather Projects	Columbia River Gorge & SR 14 Projects	Spokane TMC	Spokane Area ITS	Mt. St. Helens	Emergency Radio	US 395	Central WA	Critical Data	I-82	I-5 Nisqually	Vancouver Area	Wenatchee	Regional Traffic Signals	511
Project Management															
All of the regions need to be committed to a statewide project.						X									X
WSDOT's contracting and construction management processes are not designed for small ITS projects							X			X					
Large fiber projects need to have large contingency amounts to cover unknown surface and underground conditions												X			
Assembling a team of talented folks who have worked together and are committed to the project will ensure a successful project													X		

2.3: Application of ITS Architecture and Standards

The project descriptions clearly show that these 17 projects were based on the principles of data sharing and coordinated operations promoted by WSDOT's Statewide ITS architecture, particularly with respect to sharing information between WSDOT and the Washington State Patrol. Several projects involved the installation of fiber optic cable to enable data to be shared with other transportation agencies. Enabling the sharing of video images from closed-circuit television (CCTV) cameras was a frequent goal, and the "consumers" of this video were fire departments, ports, law enforcement agencies, TV and radio stations, and the public via websites.

To demonstrate that the projects discussed in this report conform to the Washington State ITS architecture, the appropriate market packages from the 2006 state ITS architecture are listed for each project. Market packages provide a deployment-oriented way of describing how projects fit within the national ITS architecture. A market package is essentially description of a group of the physical ITS elements that are needed to provide a particular ITS service. For example, the Regional Traffic Control market package describes the elements necessary to provide the service of regional traffic control. The package lists the ITS equipment necessary for analyzing, controlling, and optimizing area-wide traffic flow. These capabilities allow control of a network signal system to be integrated with control of freeway devices, with the goal of providing real-time traffic adaptive control. The market package also specifies a data flow that indicates that traffic control and information will be coordinated with other traffic management systems. In summary, market packages include descriptions of all the equipment, data flows, and procedures necessary to make an ITS project function as desired. Listing the appropriate market packages for each project may be the most concise way of showing where the project infrastructure and data flows fit into the framework provided by the

WSDOT Statewide ITS architecture. These projects also used the appropriate ITS standards when available. NTCIP¹ standards for variable message signs (VMS) closed-circuit TV (CCTV), and environmental sensor stations (ESS)—the old terminology, road weather information systems (RWIS) stations, is used in this report —were used on several projects.

¹ * National Transportation Communications for ITS Protocol

3: PROJECT EVALUATION REPORTS

3.1: Road and Weather Information System Enhancement, ITS-9853(002) and Road and Weather Information System Expansion, ITS-2004(053)

WSDOT's efforts to improve the way weather information is used and distributed to the public started with funding provided by the federal Intelligent Transportation Systems (ITS) program through an earmark in FFY 1999. An additional phase of work was completed in the 01-03 Biennium by using mostly state funds, and additional ITS earmark funds were obtained in FFY 2004. Three evaluations of various aspects of this program were prepared, and they are listed in Appendix B. This evaluation will summarize this effort and the lessons learned during the course of these three projects.

Background

WSDOT's weather system at the beginning of the project consisted of about 14 automated weather stations, all but a few of which were in poor repair. The weather stations communicated with the local maintenance office that was nearby and the data from them were available to only that local office. This greatly limited the usefulness of the weather data.

This project, as originally conceived, would repair the existing weather stations, install several more of them, and find a way to collect all of the weather data in a central location. The centralized data would be shared across the state and could be provided to the public as traveler information. An ITS earmark and state matching funds were obtained to start the work. WSDOT Maintenance was adamant, however, that it did not have the resources to maintain a large network of road weather information system (RWIS) stations. It was convinced, moreover, that it would be impossible to install enough stations to provide the detailed weather information necessary to determine conditions across a state like Washington, which has abundant "microclimates."

Coincident with obtaining the project funding, WSDOT hired a person through the Governor's Intern program who had experience as a WSDOT radio operator, so he was somewhat familiar with WSDOT winter maintenance operations and the way weather information was used. Therefore, with dedicated funding and project management resources, it was possible to expand the project beyond the original goal of centralizing weather data and develop a true information system. The intern discovered that the University of Washington (UW) Department of Atmospheric Sciences was the lead member of the Northwest Weather Consortium. This group collected the data from approximately 400 (now 700) weather stations from various agencies in Washington, Oregon, Idaho, and British Columbia, Canada, and made them available on the Internet. The data from these weather stations were fed into the UW's weather prediction models, which provided some of the nation's most accurate and detailed forecasts. WSDOT joined the nine federal, state, and local agencies that formed the Consortium. During this time, WSDOT provided resources to improve the resolution of the Washington State weather model that the UW operated. The resolution was improved from 32 km to 4 km statewide. (This means that instead of providing one forecast for each square zone that is 32 km on each side, there is one forecast for each zone that is 4 km on each of four sides.) At the time, this was the finest resolution of any operational weather model in the world.

The UW Atmospheric Sciences Department was given the task of developing a way to present the weather data in a meaningful fashion to both WSDOT users (mainly Maintenance workers) and the public. This information system was called rWeather (a trendy contraction of "road weather" that, when pronounced, would evoke a personal connection, as in "our weather"), and the Web pages included one that used color codes to indicate road temperatures. Later, a page was developed to show current and predicted road temperatures over a 24-hour period for a few major state routes.

This emphasis on the use of weather models to provide road temperatures was an attempt to provide the information that the public and WSDOT Maintenance needed

without installing a large number of weather stations around the state. WSDOT's existing and new RWIS stations were mostly installed on roadways leading to or in mountain pass areas, and these were areas for which the UW database lacked data, so a connection between WSDOT's central weather server and the NW Weather Consortium database was installed to fill these data gaps and improve the accuracy of the model.

The rWeather name was subsequently dropped, and the Automated Real-time Road Weather System (ARROWS) was substituted. It was specifically designed to provide short-term (24 hours) weather and pavement forecasts for WSDOT Maintenance workers. ARROWS forecasts include point forecasts along state and Interstate highways in both graphic and table formats. Statewide and zoom views show where precipitation is likely to fall within 4-hour intervals throughout the 24-hour prediction period.

WSDOT attitudes toward the installation of additional RWIS stations changed, and subsequent funding was used to further expand and improve the WSDOT RWIS. WSDOT was one of the first to implement the new NTCIP standard for environmental sensor stations (ESS)—the new term for RWIS—and test its ability to allow communications between one vendor's weather stations and another vendor's server system. Further development work on ARROWS and the model was funded at the UW.

Project Description

The goals of the project were the following:

- Collect statewide road and weather data.
- Provide access to historical, real-time, and forecast data.
- Provide road condition information, probably based on models.
- Provide an Internet platform for both a traveler information tool and a decision tool for snow and ice control operations.
- Increase and improve statewide road weather information and forecasting efforts.

The deployment of a centralized system of servers to collect RWIS data was the project element that enabled all of the other aspects of the project.

All of WSDOT's previous RWIS stations had been purchased from Surface Systems Inc. (SSI), so SSI's Scanweb was chosen for the central server. This occurred before the development of NTCIP protocols, so the RWIS stations were all using SSI's proprietary protocols, which limited the choice of vendor for the server system to SSI.

Initially a server was placed in every region but one, which shared a server. Each region's server polled the RWIS stations within its area, stored the data, and sent them to the central server in Olympia.

The original server software was based on Windows 98 and SQL 6.0, both of which were already obsolete at the time. Problems associated with data replication between servers appeared to be related to the SQL version, which was so old that Microsoft no longer supported the product. Replication failures disrupted the data flow and made portions of the system unavailable until corrected. This type of failure happened with alarming frequency. Eventually, databases were eliminated at all but one region's server (Spokane also supported city and airport RWIS stations and required a local connection). Region servers continued to poll the sites, but only temporarily stored the data until they could be pushed to the Olympia server. This eliminated many of the problems. In 2005, state funding upgraded the central server software to a version that used a more up-to-date operating system and SQL database software and replaced most of the server hardware.

Each of these efforts to improve the weather server system resulted in a substantial reduction in network down time.

Field Hardware and Communications Improvements

The number of field installations has greatly increased since 1999. WSDOT started out with 14 RWIS stations, some of which were shared with the City of Spokane.

Since 1999, federal earmark funding has been used to add 16 RWIS stations to the WSDOT network. During the same period, WSDOT funded the addition of 43 sites, and Yakima County installed five RWIS sites that were connected to the WSDOT weather server system. (See WSDOT report WA-RD 672.1, *ITS Evaluation Framework, Phase 2* for the evaluation of the Yakima County projects.) Currently WSDOT operates 95 RWIS stations.

In 2001 WSDOT published a Request for Quotation for RWIS installations across the state. The specification was intended to promote competition among vendors in an attempt to minimize costs. The effort resulted in a cost reduction of approximately \$10,000 per RWIS station. To allow the existing server system to communicate with other vendors' RWIS stations (or to avoid the need for a second server system), the procurement required compliance with NTCIP communications protocols, which enabled multiple vendors to bid. The NTCIP requirement was easily met by the new vendor and did not cause any other problems.

In addition to the land-based RWIS stations, WSDOT installed atmospheric RWIS stations for temperature and wind speed/direction on seven ferry boats, just part of the 22-vessel ferry fleet operated by WSDOT as part of the state highway system. Wind speeds and directions are corrected to "true" by subtracting the vessel speed (based on an on-board GPS) from the measured wind speed and direction. A dedicated radio system relays the data to WSDOT.

University of Washington Contributions

Collaboration with the UW Department of Atmospheric Sciences was vital to the development of the advanced weather products generated throughout this project.

The UW developed the original set of weather information pages for the WSDOT website. The UW team generated most of the features that make the WSDOT pages a huge success with the public.

The original rWeather page developed by the UW team displayed data from both WSDOT RWIS stations and several hundred non-DOT sources (already collected by the UW) to provide a complete weather picture across the state. The entry screen featured a map with representative air temperatures on it. Clicking on a temperature brought up the most recent weather sensor data from the site, as well as a link to the National Weather Service forecast for that area. Weather stations could also be selected from a list. Originally, the location for a site selected from the list was shown as a circle on the map, a feature no longer available. The original rWeather site has been replaced with a new WSDOT-developed page that has retained all but a few of the features from the original rWeather page.

Along with the rWeather page, a special page was developed to display data from the RWIS stations installed on seven WSDOT ferryboats. The UW team developed a Web page that displays the data at the point they are collected as the vessels move across Puget Sound. A toggle selects wind or temperature data to be displayed. The original Ferry Weather page developed at the UW remains in use today. The page provides marine travelers and WSF operations personnel with real-time and predictive data on weather and marine conditions.

Road surface temperatures are plotted on a third Web page. Surface temperatures are displayed across a state map. State highways on the map are color-coded on the basis of the actual surface temperatures calculated by algorithms developed at the UW to estimate temperatures across the state. The color codes indicate the following:

- Red = temperatures below freezing
- Yellow = 33°F to 37°F
- Green = temperatures above 37°.

Road surface temperatures are also displayed for a few major routes. These are shown in cross-section and use the same color coding that is used for the statewide Web

page. In addition to current conditions, these “route” displays offer predicted pavement temperatures for 6-hour intervals over a 24-hour forecast period.

National Weather Service (NWS) forecasts are presented on yet another Web page. Moving the mouse across the state highlights the NWS forecast zones within Washington State. Clicking on one of the zones brings up the NWS forecast, which is augmented by weather symbols inserted by WSDOT.

ARROWS was the primary product developed by the UW since the first Web page efforts. ARROWS was developed specifically to support WSDOT winter maintenance operations (snow and ice control). ARROWS provides map-based statewide and zoomed views that indicate precipitation, temperature, and wind forecasts across the state in 4-hour increments over a 24-hour forecast window. ARROWS also provides point forecasts for precipitation, air temperature, and pavement temperature for all state routes.

Over the course of the project, ARROWS forecasts, based on a 12-kilometer grid, improved from a single numerical (computer-based forecast) to a 16-member ensemble forecast. Efforts continue to improve the quality of the forecasts.

In addition to ARROWS, the UW has continued to maintain and supply WSDOT with weather data and to maintain a few of the Web pages. Recently, UW Atmospheric Sciences developed a scheme to attach quality flags to all the weather station data it collects. Output from the system is being fed back into WSDOT’s weather station maintenance system to improve data quality.

*Summary of Funding and Project Deliverables**

Funding

99-01 Biennium

Federal FY 1999 – Road and Weather Information System Enhancement	Federal funds	\$1,253,000
	State matching funds	\$315,000
	Additional State matching funds	\$150,000

01-03 Biennium

Additional work on Statewide Road and Weather Information System	State matching funds	\$978,000
	Federal Target Zero safety funds	\$150,000

03-05 Biennium

Federal FY 2004 – Road and Weather Information System Expansion	Federal funds	\$250,000
	State matching funds	\$250,000

Total of all funds	\$3,346,000
Federal	\$1,653,000
State	\$1,693,000

Project Deliverables

99-01 Biennium

- Installation of 12 new RWIS stations with at least one in each WSDOT region. These stations collect data on atmospheric and roadway conditions such as wind speed, air temperature, road temperature, and precipitation.
- Consolidation of existing RWIS stations, which previously reported only to local maintenance offices, into a single Road Weather Information System that provides access to all sites from any WSDOT office that has access to the WSDOT intranet.
- Upgrade of servers at the UW Dept. of Atmospheric Sciences to enable its weather model to provide more detailed and more frequent weather forecasts.
- Integration of the data from WSDOT's RWIS stations into a database, maintained at the UW, that combines those data with the weather data from over 700 stations operated by agencies around the state.

* Senn, Larry; Washington State Road Weather Information Systems Summary Report; Washington State Department of Transportation; WA-RD 624.1

- Development of a website to display the data from these weather stations, thereby giving WSDOT Maintenance personnel access to this weather information from office or home, around the clock, via the Internet. The website also provides this information to the public to aid in travel planning.
- Development of a road surface temperature model to display current and predicted road surface temperatures so that WSDOT Maintenance and the public will be warned of potential problems. Because it is not possible to observe the road conditions on all 7,000 miles of state highway in real time, it was decided to rely on modeling to predict the surface temperature, which can give the best indication of what conditions are like.
- Development of a Web page to display the road surface temperature information as well as “corridor views,” which integrate all available road condition information and roadside camera views into one Web page for the major travel corridors in the state.
- Development of the Condition Acquisition Reporting System (CARS) website, which allows statewide accidents, road conditions, and construction or maintenance closures to be displayed on electronically. This system also supports the 511 travel information phone line.

01-03 Biennium

- Installation of four additional RWIS stations and hardware, including additional cameras and sensors, and upgrade to the software in both the field and server systems.
- Support for two project FTEs from WSDOT’s Office of Information Technology for development work on the website for one year. (The weather-related websites were originally developed at the UW, and further work was needed for WSDOT to support them in-house.)
- Development of ARROWS, a Web-based system that provides information specifically tailored to WSDOT winter maintenance managers to assist them in keeping highways safe and passable during the winter. The information is organized by WSDOT maintenance area. Forecasts are provided in 4-hour increments. Warnings of localized snow, frost, fog, or other weather conditions that will adversely affect highways are provided. ARROWS is designed to give maintenance managers a way to anticipate when freezing pavement or air temperatures will occur, when snow or rain is likely to occur, when to expect a transition between rain and snow, and if frost is likely to occur. This information is critical if WSDOT is to successfully use proactive methods of snow and ice control, such as anti-icing treatments. An evaluation after its first season indicated that field personnel generally liked ARROWS, but more development work was needed.

03-05 Biennium

- Installation of six additional RWIS stations around the state. Approximately 90 of the planned 130 stations have been or are being installed
- Further development work on ARROWS to respond to the improvements requested in the evaluation conducted after the first winter of operation.

System Usage and Benefits

It would be difficult to measure the usage of the public Web pages on the WSDOT website that were developed by this project or that use data generated by the systems deployed as part of this effort. Some specific websites are listed below:

- ESS and weather data: www.wsdot.wa.gov/traffic/weather
- National Weather Service forecasts: www.wsdot.wa.gov/traffic/forecast
- Statewide current pavement temperatures:
www.wsdot.wa.gov/traffic/roadtemps
- NexRad doppler radar composite:
www.wsdot.wa.gov/traffic/forecast/radar.aspx
- Link to National Oceanic and Atmospheric Administration (NOAA) satellite photos: www.wsdot.wa.gov/traffic/forecast/satellite.aspx
- Ferry weather: <http://i90.atmos.washington.edu/ferry/Ferryjs/mainframe1.htm>
- Cross-state travel routes: www.wsdot.wa.gov/traffic/travelroutes

WSDOT estimates that during the winter months these websites are viewed hundreds of thousands of times.

ARROWS was never a public website. Navigation through the ARROWS site is based on WSDOT organization codes, as requested by WSDOT maintenance. This makes it difficult for the public to navigate through the site. In addition, ARROWS is no longer officially in use by WSDOT, which terminated funding to maintain the site. However, ARROWS has not been turned off and is still available for use by WSDOT personnel. If the system were to experience a hardware or software failure, however, no funding would exist to support work to restore the application.

Because ARROWS is no longer being maintained, no user data are available. The scientists who developed ARROWS estimated winter usage by WSDOT maintenance staff to be about 100 unique users per day. A graph of ARROWS usage from August 2002 for a little over four years is shown in Figure 2.

An evaluation of ARROWS was conducted in February 2005.* A questionnaire was sent to ARROWS users in all of WSDOT's regions to determine whether ARROWS was meeting their needs. Approximately 150 surveys were distributed, and 38 were returned. One of the questions asked whether people were better able to do their jobs

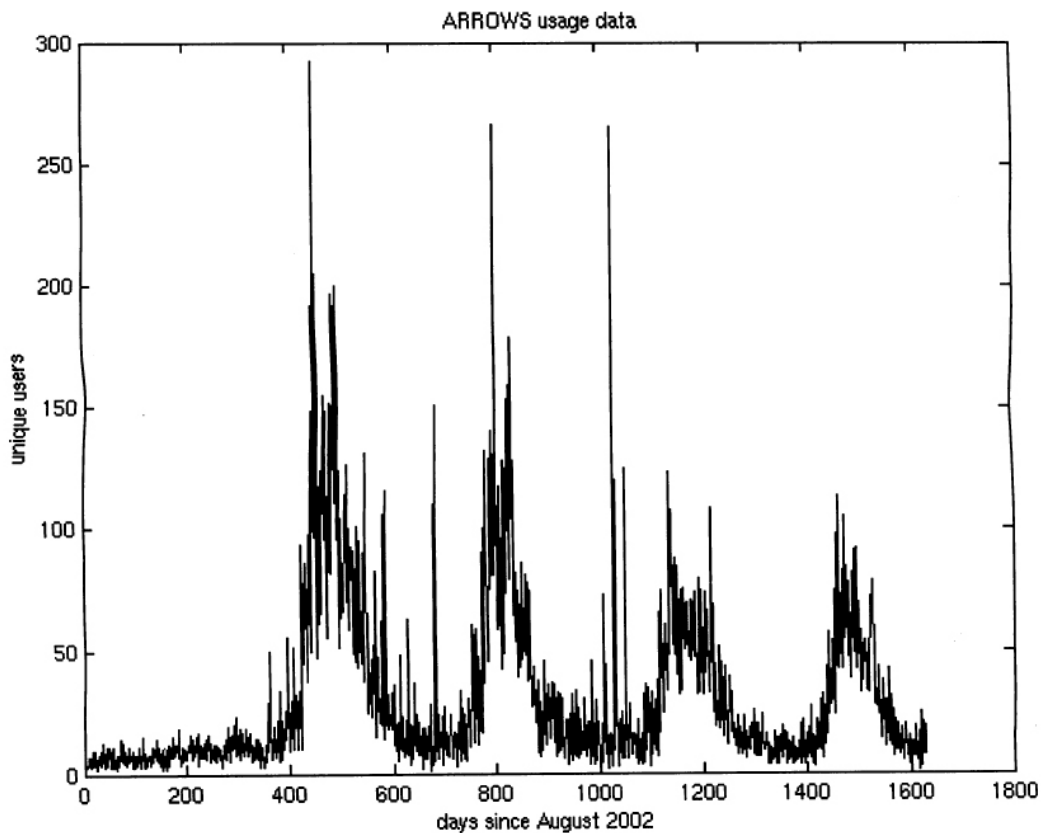


Figure 2. ARROWS Usage Data

* Senn, Larry and Boselly, Ed; ARROWS Evaluation; Washington State Department of Transportation, WA-RD 608.1

because of ARROWS. Twenty-seven said “yes” and nine said “no.” A similar question asked whether WSDOT should continue with the development of ARROWS. Thirty replied “yes” and three said “no.”

Architecture and Standards

The following Washington State ITS Architecture market packages are represented in this project:

- Road Weather Data Collection (MC03)
- Weather Information Processing and Distribution (MC04)
- Winter Maintenance (MC06)
- Roadway Maintenance and Construction (MC07)
- Broadcast Traveler Information (ATIS1)
- Interactive Traveler Information (ATIS2)
- Early Warning System (EM07)
- Disaster Traveler Information (EM10).

WSDOT was the first agency to demonstrate that the NTCIP standards for RWIS stations could be used to allow RWIS stations from one vendor to communicate with an existing system server from another supplier. As mentioned previously, in 2001 WSDOT published an RFQ for RWIS installations across the state that required compliance with NTCIP standards. The specification was intended to promote competition among vendors in an attempt to minimize costs. The NTCIP requirement was easily met by the new vendor and did not cause any other problems. The effort resulted in a cost reduction of approximately \$10,000 per RWIS installation.

Lessons Learned

1. There is no one way of doing things at WSDOT. This is most apparent in relation to maintenance practices. In a geographically diverse state like Washington, there is no reason to expect “one way” to work everywhere. Washington State has temperate zone rain forests in the west and deserts in the east. In between stands

the Cascade Mountain range, which, in places, gets hundreds of inches of snow in a year. The people responsible for maintaining this roadway system obtain weather information from a diverse array of sources: the Weather Channel, UW Department of Atmospheric Sciences, National Weather Service, Northwest WeatherNet, newspapers, television newscasts, Data Transmission Network (DTN), radio, NOAA Weather Radio, and others. The two most frequently used sources were television newscasts and the National Weather Service. Trying to develop a system that would meet all of WSDOT's weather information needs was probably an unrealistic goal. ARROWS was never intended to replace any or all of the existing sources of weather information. It was intended to be a supplementary source that could be used to back up or confirm the information that other sources were providing. ARROWS had an impressive debut and correctly predicted some conditions that other information sources did not. Unfortunately, ARROWS did not forecast the extended freezing rain and subsequent ice storms that occurred in southwest Washington in January 2004. Similar problems occurred on the east side of the Cascades during mid-January 2004. Despite previous warnings about placing too much reliance on ARROWS, many users stopped consulting the system when it failed to predict these storms. Unfortunately, many people developed the impression that ARROWS was unreliable and not worth the money to maintain it.

2. ARROWS may have been too complex. New anti-icing and de-icing treatments are expensive. When people are injured or killed in collisions during periods of bad weather, lawsuits are often filed that blame WSDOT for failing to provide safe travel conditions. Judgments in these cases can be very expensive. So it is not surprising that maintenance workers, who are not trained to interpret weather data and predictive models, want to speak with a human who provides advice tailored to the area and situation of concern. Companies like Northwest WeatherNet provide this service, and ARROWS did not. WSDOT planned to hire a meteorologist to provide training to maintenance workers on weather terminology and interpretation of the information provided by various weather websites and forecasting services. This position would also have evaluated the accuracy and usefulness of the ARROWS information. However, this position was never filled.
3. The people interviewed for this evaluation thought that the effort that went into the development of ARROWS had many beneficial results. Some of these are as follows:
 - a. WSDOT employees have a much better understanding of weather effects.
 - b. The marine community is very pleased with the Ferry Weather pages.
 - c. Some interviewees thought that private sector weather services had improved. Others thought that they had gotten worse.

- d. There has been a “dramatic decrease” in WSDOT court cases related to weather. It is impossible to know whether this is due to improved traveler information, improved road treatment, or changes in weather.

3.2: Columbia Gorge Traveler Information System Pilot Program, ITS-1999(014) and SR 14 Traveler Information System Enhancements, ITS-2003(062)

Background

Washington SR 14 runs between Vancouver and the Tri-Cities along the north bank of the Columbia River. It parallels I-84, which runs east from Portland, Oregon, along the south bank of the Columbia River, so it serves as an alternative route for commercial vehicle traffic heading east. For much of its length, SR 14 is within the Columbia River Gorge National Scenic Area, so it is often heavily used by recreational travelers. The Columbia River Gorge traverses the full range of geographical conditions experienced on a drive across Washington or Oregon: wet coastal forests in the west, mountain passes in the middle and dry desert conditions in the east. As a result, SR 14 can experience flooding, mud slides, snowy and icy road conditions, and high winds. Most of these conditions also affect I-84, so the Washington and Oregon departments of transportation try to coordinate the management of those roads so that traffic can divert to an alternative route. Therefore, it is easy to see the importance of providing good travel information to motorists along SR 14. Information on closures or restrictions due to weather, slides, or incidents can help motorists plan their travel and increase the safety of their trip.

Project Description

This evaluation covers two ITS earmark projects (see Figure 3) that developed an SR 14 traveler information system in two phases. Phase 1 (Columbia Gorge Traveler Information System Pilot Program – ITS 1999(014)) installed the following equipment:

- a VMS on eastbound SR 14 at milepost 17.5
- a VMS on westbound SR 14 at milepost 64.86
- a highway advisory radio (HAR) station and one RWIS station with a CCTV camera at the junction of SR 14 and SR 97, at milepost 2.19 on SR 97.

Phase 2 (SR 14 Traveler Information System Enhancements - ITS-2003(062))

installed the following equipment, as proposed:

- a HAR station at the junction of SR 14 and the Bridge of the Gods, milepost 41.55
- a VMS on westbound SR 14 at milepost 43.1.

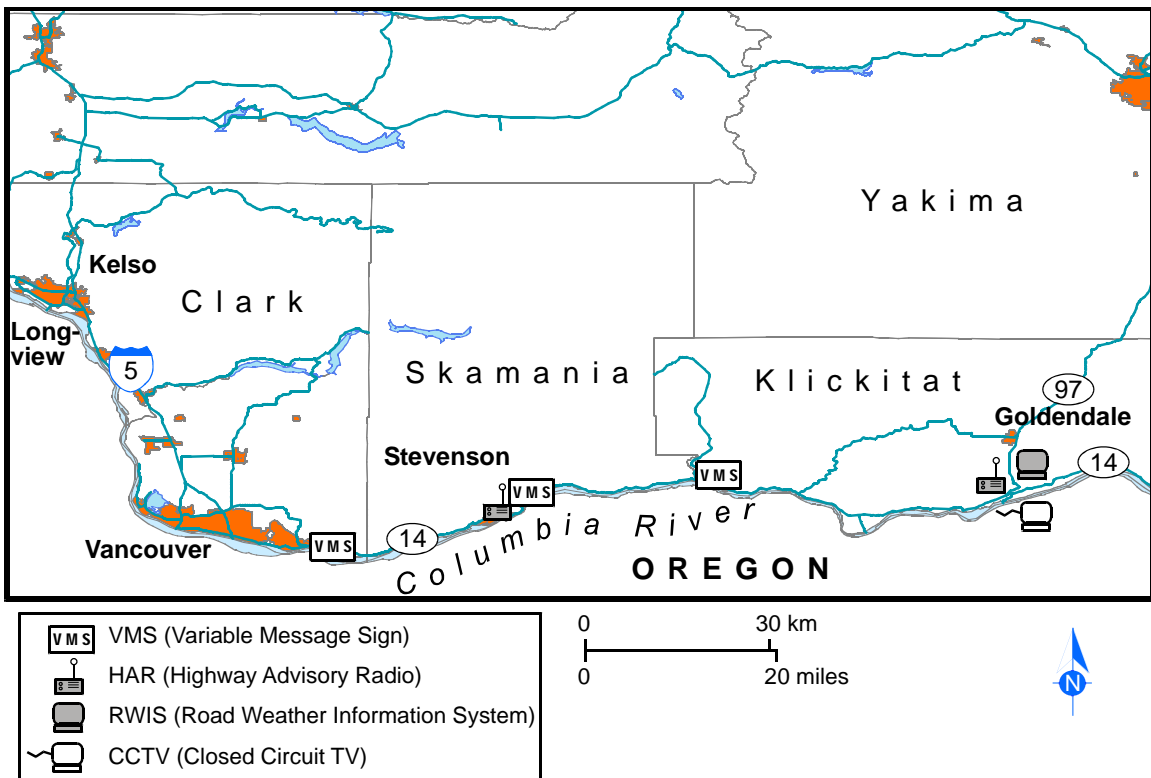


Figure 3. Columbia Gorge Traveler Information System Pilot Program and SR 14 Traveler Information System Enhancements

System Usage and Benefits

The devices provide information to the Southwest Region traffic management center (TMC) in Vancouver, Washington, to aid WSDOT personnel in managing the roadway. Weather information from the RWIS station is available to WSDOT maintenance crews and is provided to the public via the WSDOT website. The CCTV camera image is also posted on the WSDOT website. The HAR stations and VMSs provide highway advisories on traffic, weather, and incidents, as well as provide tourist-related information.

The information is used by WSDOT traffic operations and maintenance personnel, the Washington State Patrol, trucking companies, and the public.

The information is available throughout the year but is most heavily accessed during the winter months, when there are more weather-related events.

Cost, Operations and Maintenance

The cost of the Phase 1 project was \$300,000. The Phase 2 project cost approximately \$211,300.

The Southwest Region Traffic Operations Office is responsible for operating the system. This group has a staff of two support engineers/technical specialists. The TMC operators, who provide round-the-clock staffing for the TMC, actually operate the system. Southwest Region's ITS Maintenance Office maintains the field equipment with a staff of two ITS/Electronic Technicians.

No additional staff or funding was provided for operations or maintenance of this project.

Architecture and Standards

The following Washington State ITS Architecture market packages are represented in this project:

- Network Surveillance (ATMS01)
- Traffic Information Dissemination (ATMS 06)

- Road Weather Data Collection (MC03)
- Weather Information Processing and Distribution (MC04)
- Wide-Area Alert (EM06)
- Disaster Traveler Information (EM10)

The following NTCIP standards were used on this project:

- NTCIP 1203 – Communications to VMS
- NTCIP 1204 – Communications to Environmental Sensor Stations (ESS)
- NTCIP 1205 – Communication to CCTV.

The Washington Statewide ITS Architecture was available at the time that this project was deployed. It provided a generic framework that was used during project planning and design. A completed Vancouver Area Smart Trek (VAST) program architecture, which covered the Vancouver urban area, was also available. The Southwest Region was just starting to develop an architecture that would cover the entire region and provide specific, local guidance.

Lessons Learned

1. Minor vandalism and some weather-related damage to field devices resulted in additional expenses for repair and replacement parts. If field equipment can't be shielded or protected from vandalism or catastrophe, then funds should be allocated to handle the additional maintenance that is likely to be needed.
2. There are still gaps in coverage along the 80-mile length of SR 14. The project manager estimated that several more of CCTV cameras, HAR stations, and VMSs would be needed to provide adequate coverage for the entire length of SR 14.
3. The project experienced some communications problems, especially with the mechanism that turns the HAR stations' flashing beacons on and off. (These beacons indicate that the HAR station is broadcasting a message, telling motorists to tune their radios to a specific frequency when they are activated.)
4. Higher costs, due to inflation and remote work sites, made it difficult to keep the project within budget and still complete all of the proposed work. The more time devoted to scoping and developing a good budget estimate, the

better the resulting project will be. If time is short, then more contingency funding should be built into the budget.

3.3: Spokane Regional Transportation Management Center Enhancement, Federal Aid No. ITS-2000(009)

Background

Spokane is located on the Spokane River in eastern Washington and is 110 miles south of the Canadian border and approximately 20 miles from Washington's border with Idaho. It is Washington State's second largest city, with a population of just over 200,000 (2007). Spokane is the largest city in Spokane County and is the county seat. The county, with a population of just over 456,000 (2007), is the metropolitan center of the Inland Northwest region.

The Spokane Regional Traffic Management Center (SRTMC) was created as a regional partnership to provide area-wide ITS coverage during peak travel periods, to monitor and respond to incidents, and to share data. The SRTMC was formed by an inter-local agreement among the City of Spokane, City of Spokane Valley, Spokane County, Spokane Regional Transportation Council, Spokane Transit Authority, and WSDOT's Eastern Region.

Traffic and transportation data had been collected and stored by the agencies that generated the data, which made it difficult to share the data. Researchers, transportation engineers, planners, and the public had experienced difficulty in accessing data that should have been simple to obtain.

By using the SRTMC as an information and communications hub, each jurisdiction can now maintain its own operations systems and also be connected to the others to provide interoperability. The SRTMC hardware and software enable real-time monitoring at both the SRTMC, as well as at the operations offices of each agency.

The Spokane area ITS was deployed through a series of five earmark projects that were funded by Congress between 2000 and 2003. Two of these projects were evaluated

in a previous study (*ITS Evaluation Framework – Phase 2*, WA-RD 672.1, June 2007).

These were

- Spokane Regional Data Warehouse – ITS2003(026)
- Spokane Regional Transportation, Construction and Weather Website – ITS2002(018).

Two other projects are being evaluated in this report, and the fifth remains to be evaluated in the next phase when the project is complete. Below is a simplified view of how these projects fit together.

- The Regional Data Warehouse deployed the PeMS data monitoring and archive software.
- The Regional Transportation, Construction, and Weather Website project built the website that uses data from the PeMS software to provide information to agency traffic managers and the public.
- The Regional TMC Enhancements project, ITS-2000(009), (evaluated here) purchased an arterial traffic signal control system for WSDOT.
- The Spokane Area Intelligent Transportation Integration project, ITS-2001(028), (see section 3.4) built a fiber optic communications trunk line and communications links to other agencies.
- The Traffic Operations for Arterials project, ITS-2003(062), (to be evaluated in the next phase) will connect the arterial system purchased previously with the County's and Cities' signal systems.

Project Description

The original proposal for the Regional TMC Enhancements project listed the following components:

- Provide the necessary equipment to establish communications with each participating SRTMC agency.
- Obtain the base module and signal control modules for the SRTMC software.
- Incorporate the different transportation-related Web pages from each agency into a regional website.
- Upgrade and relocate the Spokane area RWIS server.

- Upgrade the SRTMC video switch.
- Relocate the Broadway/I-90 Interchange HAR station or install simulcasting equipment.
- Purchase a workstation and signal software for the City of Spokane traffic signal system.
- Collect, process, and store tag data from the Spokane Transit Authority buses to provide corridor travel time estimates.

This project actually consisted of the following components:

- implementation of a traffic signal control system that could operate a system of traffic signals from a central location
- an upgrade of traffic signal controllers
- relocation of the Broadway HAR station.

The large discrepancy between what was discussed in the original earmark proposal and what this project actually deployed occurred because the original proposal specified far too much work to accomplish with the funding that was provided. The proposal was actually more of a planning document that discussed all of the ITS projects that the Eastern Region would like to implement, rather than a design report that detailed what would be done with the funding.

The following components were implemented by other ITS earmark projects:

- the regional transportation, weather and construction website: ITS-2002(018) – evaluated previously*
- the RWIS server upgrade: ITS-9853(002) – evaluated in this report (See section 3.1)
- the regional HAR control module: ITS-2002(034) – evaluated in this report (See section 3.6).

The first of these three was implemented by another Eastern Region ITS earmark project, and the other two were completed as part of statewide ITS earmark projects. The

* *ITS Evaluation Framework – Phase 2*, WA-RD 672.1, June 2007

component to gather, process, and store the transit tag data was not implemented because the technology in use was obsolete.

The objectives of the Regional TMC Enhancements project were to integrate signal systems between jurisdictions and to improve incident response and management. Spokane County and WSDOT traffic signals were either stand-alone, pre-timed signals, or they were semi-actuated. The City of Spokane had a centrally controlled system. WSDOT had five freeway CCTV cameras and no freeway detectors. There was a need for a central system that could control all of this: multiple traffic signal systems and several ITS components. Siemens' i2TMS™ was purchased for the county's and WSDOT's signals, and a center-to-center communications link was established to the city's ACTRA™ system (also a Siemens' product). County signals on Argonne Road were the only ones connected to this system with this project's funding.

System Usage and Benefits

SRTMC agencies can monitor signals connected to the system and control CCTV cameras within their jurisdictions. The CCTV cameras are used for incident detection and verification. The system is used on a daily basis.

Cost, Operations and Maintenance

The total cost of the Spokane Regional TMC Enhancements project was \$1,238,679. SRTMC operators, employed by WSDOT, operate the system. The SRTMC's IT manager maintains the software system. Maintenance of the field equipment is the responsibility of the agency that owns it. Between one and two WSDOT staff members are necessary to maintain the system. Annual life-cycle costs are estimated to be \$500 per workstation and \$1,000 per server. The annual maintenance fee for the i2TMS software is \$15,000.

Architecture and Standards

The Spokane regional ITS architecture and ITS Implementation Plan were developed in May 2000, given a minor update in July 2000, and completely updated in March 2007. The ITS architecture reflects the longstanding regional interest in cooperatively managing transportation and data sharing. This project is a step toward implementing the vision reflected in the ITS architecture.

The following ITS architecture market packages are represented in this project:

- Surface Street Control – ATMS03
- Freeway Control – ATMS04
- Regional Traffic Control – ATMS07
- Traffic Incident Management System – ATMS08.

Lessons Learned

1. The Spokane Regional TMC Enhancements project demonstrates a lesson that has been identified before in these evaluations and in ITS evaluations from around the world; that is, that the technology is the easy part of the project. Making the institutional and jurisdictional changes necessary to use the technology is the difficult part of the process of implementing new technology. In this case, the technology to view and control CCTV cameras, giving the agencies the ability to confirm and monitor incidents, was provided. The region requires the development of some incident response plans, three to five at a minimum, to make effective use of the technology. At the time of this evaluation, no response plans had been developed.
2. As discussed in previous evaluations, multi-agency projects have the potential to greatly improve travel for motorists. Coordinated traffic signal control, freeway and arterial coordination, and incident response are three of the many areas that benefit from interagency cooperation. Multi-agency projects, however, are more difficult to successfully complete because of the longer, more difficult decision-making process. In the case of this project, the monthly SRTMC operations board meetings were not frequent enough to provide the decisions needed to keep the project on schedule.

3.4: Spokane Area Intelligent Transportation Integration, ITS-2001(028)

Background

Spokane is located on the Spokane River in eastern Washington and is 110 miles south of the Canadian border and approximately 20 miles from Washington's border with Idaho. It is Washington State's second largest city, with a population of just over 200,000 (2007). Spokane is the largest city in Spokane County and is the county seat. The county, with a population of just over 456,000 (2007), is the metropolitan center of the Inland Northwest region.

The Spokane Regional Traffic Management Center (SRTMC) was created as a regional partnership to provide area-wide ITS coverage during peak travel periods, to monitor and respond to incidents, to share data, and to provide traveler information to the public. The SRTMC was formed by an inter-local agreement among the City of Spokane, City of Spokane Valley, Spokane County, Spokane Regional Transportation Council, Spokane Transit Authority, and WSDOT's Eastern Region.

The goals of this project were to integrate existing and new ITS field devices into the existing fiber communications system and to provide real-time video and data from those devices to emergency response agencies.

Project Description

The original proposal for the Spokane Area Intelligent Transportation Integration project listed the following project components:

- creation of a traveler information system – a Web-based subscription system to distribute information by e-mail and pager
- development of a regional data warehouse
- the following software enhancements:

- a regional HAR control module
- a data station control module
- center-to-center communications between the SRTMC and the City of Spokane arterial management system, police, and fire dispatch.
- enhancement of the region's RWIS– upgrade the RWIS server to automatically alert operators
- the addition of communications trunk lines on the following routes:
 - Sprague corridor
 - Division (SR 2) corridor.
- coordination of incident response
- development of a regional transportation, weather, and construction website.

The project actually constructed the following communications links:

- a fiber optic trunk line on Division (SR 2) from Houston Avenue to Farwell Road
- a microwave link to the Washington State Patrol (WSP) offices on Geiger Avenue to provide access to CCTV images
- a fiber optic link to the Combined Communications Campus (CCC). The CCC is the joint City/County police, fire, and 911 dispatch facility. The Campus also houses Spokane County's emergency operation center (EOC).

The large discrepancy between what was discussed in the original earmark proposal and what this project actually deployed occurred because the original proposal specified far too much work to accomplish with the funding that was provided. The proposal was actually more of a planning document that discussed all of the ITS projects that the Eastern Region would like to implement, rather than a design report that detailed what would be done with the funding.

The following components were implemented by other ITS earmark projects:

- the regional data warehouse: ITS-2003(026) – evaluated previously*
- the regional transportation, weather and construction website: ITS-2002(018) – evaluated previously*
- the regional HAR control module: ITS-2002(034) – evaluated in this report (See section 3.6)
- the RWIS server upgrade: ITS-9853(002) – evaluated in this report (See section 3.1).

The first two were implemented by other Eastern Region ITS earmark projects, and the latter two were completed as part of statewide ITS earmark projects. The data station control module listed in the proposal was implemented as part of the Spokane Regional Data Warehouse ITS earmark (ITS-2003(026)), which provided SRTMC with its freeway management system software. The Web-based subscription system had already been implemented as part of a previous website project.

What remained was basically a project to provide center-to-center and trunk line communications upgrades to improve coordination between agencies, thereby improving incident response. This project also provided more communications capacity so that video and data coverage could eventually be installed on north Spokane freeways and coverage could be expanded on I-90.

System Usage and Benefits

The system is used by the SRTMC partner agencies, WSP, police, and fire dispatchers at the CCC, and EOC personnel. The CCTV images carried by the fiber network are available to the public via the SRTMC website.

WSP and CCC personnel can select any camera on the system to view and have access to real-time CCTV images. They can configure the system to show a sequence of camera images or view an individual camera image. These cameras are used to verify the

* *ITS Evaluation Framework – Phase 2, WA-RD 672.1, June 2007*

occurrence and location of incidents so that the dispatchers can send appropriate resources to the scene in the most efficient way. The system is in constant use by these agencies.

Cost, Operations and Maintenance

The total cost of the Spokane Area Intelligent Transportation Integration project was \$1,837,251.

WSDOT operates the SRTMC and maintains the systems there. Each agency is responsible for maintenance of the system components at its facilities.

WSDOT estimates that it takes about 50 hours per year to maintain the video feeds to the other agencies. This is the equivalent of .03 FTE per year. The total cost for labor, parts, and equipment is estimated to be \$5,000.

Architecture and Standards

The Spokane regional ITS architecture and ITS implementation Plan were developed in May 2000, given a minor update in July 2000, and completely updated in March 2007. The ITS architecture reflects the longstanding regional interest in cooperatively managing transportation and data sharing. This project is a step toward implementing the vision reflected in the ITS architecture.

The following ITS architecture market packages are represented in this project:

- Network Surveillance (ATMS01)
- Traffic Incident Management System (ATMS08).

Lessons Learned

1. This project was delivered within budget but took more time than anticipated. This was due to a lack of staff to work on this project because of other, higher priority projects. This delay actually resulted in a better project for the following reasons:
 - Several other ITS earmark projects were subsequently funded, as mentioned previously, allowing the scope of work for this project to be focused on the remaining items.

- Some of the fiber installation was done in conjunction with a paving project, thereby reducing costs.

As mentioned in previous evaluations, the use of ITS earmarks to fund an ITS program is not optimal. There is neither the predictability of funds nor sufficient time to allow a detailed, accurate scope of work and cost estimate to be developed before funds are requested. The result is often a large discrepancy between what is proposed and what actually gets built. In this case the delays that contributed to the discrepancy actually resulted in a better project and an improved ITS program.

2. When working with agencies that are not familiar with the capabilities of ITS technology, such as police and fire agencies, it is often necessary to spend time to educate them so that they have realistic expectations. Several technical problems that occurred on this project might have been avoided if all parties had been more experienced with ITS. For example:
 - The WSP video is transmitted over a microwave link. The video has to be compressed and, therefore, is of lower quality. A fiber link would have eliminated the need for compression and improved the video quality.
 - The original design for the system to provide video to the CCC did not work as planned and had to be reworked by field staff while the system was under construction. More experience with the design of these systems, and more testing of proposed designs, would have eliminated the need to redesign the system.

3.5: Mount St. Helens Traveler Information, ITS-2002(033)

Background

Washington SR 504 connects I-5 and the Mt. St. Helens National Volcanic Monument. The road is a breathtaking mountain highway through the area devastated by the Mt. St. Helens volcanic eruption. The road is heavily used by tourists and is often subject to closures due to weather, slides, or accidents. The distance between I-5 and the Monument is almost 50 miles, and there are no alternative routes or other destinations served by SR 504, so motorists must return the same way they arrived. It is important, therefore, to provide travel information to motorists as soon as they exit I-5 onto SR 504. The U.S. Forest Service uses static signs to indicate whether the various visitor centers are open.

Project Description

The original proposal was for the installation of an RWIS station, a HAR station, a CCTV camera, and a VMS. These devices were supposed to communicate with WSDOT’s Southwest Region TMC in Vancouver, Washington.

The actual implementation was as proposed. The equipment deployed included an RWIS station on SR 504 at Bear Creek (milepost 35), a HAR station on I-5 at the junction of SR 504 in Castle Rock, a CCTV camera on SR 504 at the U.S. Forest Service Learning Center (milepost 33), a VMS on eastbound SR 504 at Milepost 0.75 (just off of I-5), and a wireless communications system to transmit the data to the TMC (see Figure 4).

System Usage and Benefits

Information from the field devices is used by the Southwest Region TMC for traffic management. The weather information is available to both WSDOT maintenance crews and the public via the WSDOT website. The camera image is also posted on the WSDOT website.

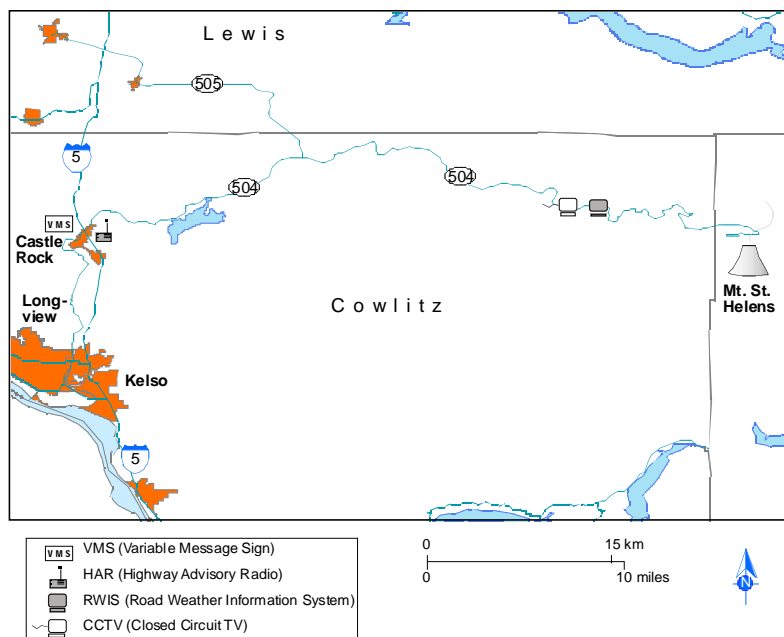


Figure 4. Mt. St Helens Traveler Information

The HAR and VMS messages provide weather and traffic advisories, as well as recreational or tourist related information.

The information is used by the public, WSDOT traffic operations and maintenance personnel, U. S. Forest Service employees, and the Washington State Patrol.

The information systems are available throughout the year, but they receive more use during the winter months, when there are more weather and traffic alerts, than in the summer months.

Cost, Operations and Maintenance

The total cost of the project was approximately \$499,526.00.

The Southwest Region Traffic Operations Office is responsible for operating the system. This group has a staff of two engineers/technical specialists. The TMC operators, who provide round-the-clock staffing for the TMC, actually operate the system. Southwest Region's ITS Maintenance Office maintains the field equipment with a staff of two ITS/Electronic Technicians.

No additional staff or funding was provided for operations or maintenance of this project.

Architecture and Standards

The following Washington State ITS Architecture market packages are represented in this project:

- Network Surveillance (ATMS01)
- Traffic Information Dissemination (ATMS 06)
- Road Weather Data Collection (MC03)
- Weather Information Processing and Distribution (MC04)
- Wide-Area Alert (EM06)
- Disaster Traveler Information (EM10).

The following NTCIP standards were used for this project:

- NTCIP 1203 – Communications to VMS
- NTCIP 1204 – Communications to Environmental Sensor Stations (ESS)
- NTCIP 1205 – Communication to CCTV.

The Washington Statewide ITS Architecture was available at the time that this project was deployed. It provided a generic framework that was used during project planning and design. A completed Vancouver Area Smart Trek (VAST) program architecture, which covered the Vancouver urban area, was also available. The Southwest Region was just starting to develop an architecture to cover the entire region and provide specific, local guidance.

Lessons Learned

1. The backbone communications system that was used for this project is jointly owned and operated by WSDOT and WSP. For this project to be able to communicate with the TMC, it was necessary to complete the upgrade of the microwave backbone to the OC3 capability that was implemented in another ITS earmark project, the Critical Data Communications System Enhancement, ITS-2003(062). That project experienced delays because of agency coordination issues, and those delays affected this project. As mentioned in the evaluation of that project, it would have been better to have developed a multi-agency communications plan and agreed upon all of the capacity and usage issues prior to starting work on specific implementation projects.

Below are some additional comments from the project managers on partnerships:

- Have the details of the partnership specified by a memorandum of understanding or an agreement.
 - Make sure that there is high level agreement between the partnering organizations.
 - Get a full understanding of what the partnership will cover: what will be shared, what will be individually owned, and who will take care of maintaining the shared items.
2. The more time and attention that can be devoted to preparing a good scope of work, the better the chance of successfully delivering a project that meets the original goals and stays within the original budget and schedule.

- As much as possible, try to anticipate what technology will be used in the future. Consider the user benefits and the overall life cycle cost, including operating and maintenance costs. This may mean choosing technology that is not the lowest initial cost.

3.6: Washington Statewide Emergency Advisory Radio Coordination, ITS-2002(034)

Background

Highway advisory radio (HAR) stations consist of a radio transmitter, a sign indicating that motorists should turn their vehicle radio to the indicated frequency when a set of beacons are flashing, and a set of beacons mounted over the sign. The WSDOT currently operates 55 HAR stations around the state. These HAR stations are distributed among WSDOT's six districts, as shown in Figure 5.

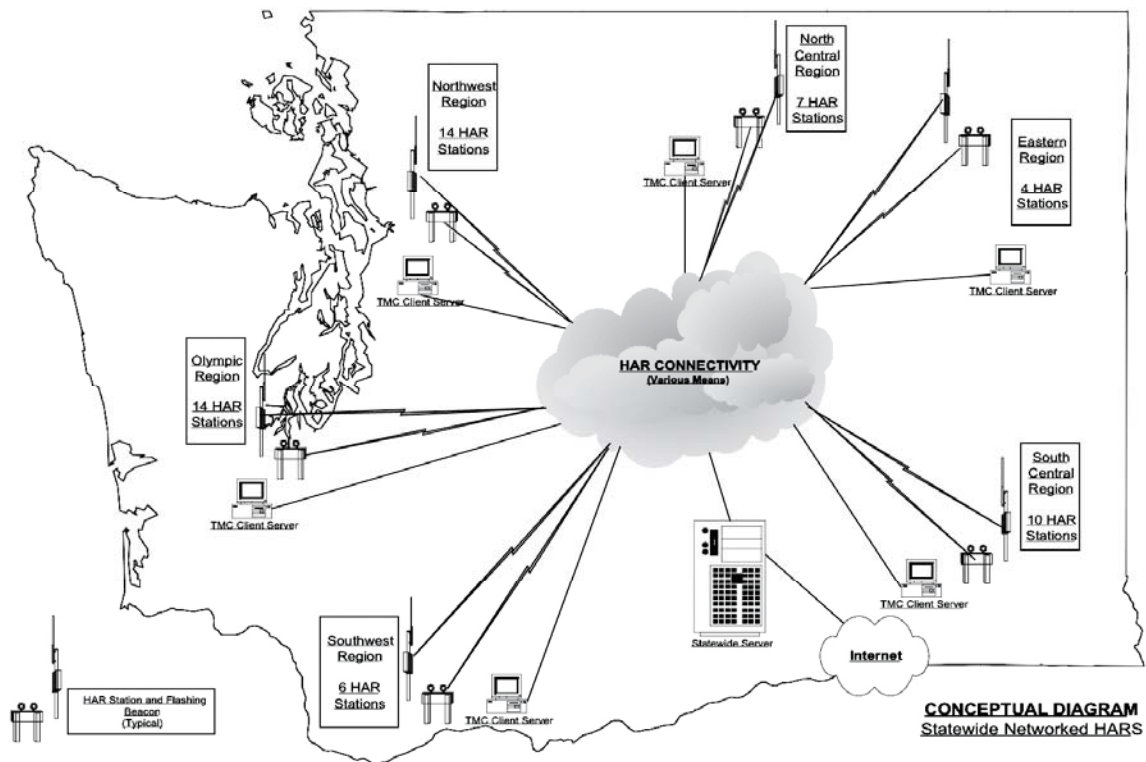


Figure 5. Concept Diagram: Statewide HAR Network

The HARs provide information about highway construction closures, road and weather conditions, and traffic incident information. HARs can also be used during emergency situations to provide information on road or bridge closures, evacuation routes, and other public safety alerts. HARs can provide longer and more detailed messages than variable message signs, which are also typically used by traffic management agencies to provide en-route driver information.

When originally installed decades ago, HAR transmitters were controlled by telephone lines. Each site was called individually, and operators used the telephone keypad to gain access and set the station for broadcasting. Then the operator recorded a message, reviewed it, and again used the telephone keypad to activate the transmitter. They then continuously broadcast the message until the operator called again to turn the station off or record a new message. The broadcast was usually transmitted on the AM radio band at 530 MHz. To activate the flashing beacons also required a telephone call. This process could sometimes take 30 minutes. As WSDOT emphasis on traffic management and traveler information increased, the number of HAR installations grew. At the same time, the need developed to provide statewide and regional alerts, such as Amber Alerts, for emergency management and other public service actions. Clearly, using the old system to deliver a statewide message on all 55 HAR stations in a timely manner was impossible.

Project Description

A project was funded in FFY 2002 with Federal ITS Deployment Funds and state ITS matching funds to improve and expedite the way in which messages were recorded to and delivered from the HAR sites. The project began in late 2004. After a review of available hardware and software systems, it became apparent that no existing commercial off-the-shelf system could meet WSDOT's needs. A Request for Information (RFI) was issued and produced encouraging responses from six sources. On the basis of these RFI

responses, WSDOT developed a Request for Proposals (RFP). A steering committee, consisting mainly of traffic management center personnel who had experience with HAR operations, was established to develop a list of Feature Sets.* The Feature Sets called for innovations such as “text-to-speech” capabilities, allowing faster and consistent creation of broadcast messages. Considered the backbone of the anticipated system, the Feature Sets specified requirements in the following areas:

- messaging
- scheduler
- status
- logs
- maps
- beacons
- security, site and system software
- hardware.

By mid 2005, an RFP had been written, and the search for qualified vendors began. The process concluded in mid-2006 with the selection of Highway Information Systems (HIS) of Durham, North Carolina, from a field of five qualified respondents.

The original project was intended to cover the entire state; however, the system was initially deployed in only two of WSDOT’s six regions. The costs for the other Regions to implement the system will be less, however, because the development costs have already been paid, and the vendor provides lifetime, free client use of the software.

WSDOT’s Southwest Region was chosen for Phase I as a test bed. The Southwest Region covers seven counties in southwest Washington. The headquarters and TMC are located in Vancouver, which is considered part of the Portland, Oregon, metropolitan area. To demonstrate the networking features that would indicate that the system could

* See Appendix C for details on the Feature Sets

really function statewide, the South Central Region's system was developed concurrently. The South Central Region encompasses all or parts of ten counties in south central Washington. The headquarters and TMC are located in Union Gap, just outside of Yakima.

The major element, the software that would control the HAR stations, the flashing beacons, and meet the requirements detailed in the Feature Sets, was custom built for this project. No commercial off-the-shelf software was available to meet the requirements. The project scope of work that was developed required the vendor to be NTCIP compliant.

Phase I implementation was completed in the two southern regions. In addition, the North Central Region, with a TMC in Wenatchee, began to install the system in April 2008 with Region funding. Funding for the implementation of the system in the Eastern Region, with a TMC in Spokane, was approved in June 2008, and implementation was completed during the 2008/2009 winter. Implementation in the Northwest and Olympic regions has been delayed until funds become available.

System Usage and Benefits

Figure 5 provides a schematic representation of the system architecture. The regions with the new system can use the networked connection to coordinate HAR operation. Additionally, the autonomous servers in each region can connect through the central HAR server in the WSDOT headquarters office in Olympia. This interaction allows one region to control another region's HAR functions, should the need arise. For example, the South Central Region TMC operates the North Central Region's HAR stations after normal working hours in the summer when the North Central Region reduces staff and does not provide 24/7 coverage of its TMC.

The obvious major benefit of this project is the improvement of the speed with which messages can be delivered to the HAR stations for transmission to motorists. It is

now possible to deliver regional messages in a timely manner, and when funding to implement the system in the remaining regions has been provided, it will be possible to deliver timely statewide messages. In addition, the new system allows operators to verify that the beacons are flashing. This was not possible before, and having this capability eliminates the possibility that motorists are unaware that a message is being transmitted.

Architecture and Standards

The following Washington State ITS Architecture marketing packages are represented in this project:

- Traffic Information Dissemination (ATMS 06)
- Regional Traffic Control (ATMS 07)
- Traffic Incident Management System (ATMS 08)
- Broadcast Travel Information (ATIS 01)
- Wide-Area Alert (EM 06)
- Disaster Travel Information (EM 10).

The system provided by the vendor is NTCIP compliant, as required by the contract specifications.

Lessons Learned

1. Between the conception and the implementation of this project, software applications changed. The initial design was client based, and the implemented system is server based. While this did not affect the course of the project, future projects should be flexibly designed so they can deal with the short-term life of software platforms and design standards. If this is not possible, contingency funds should be set aside to deal with the cost of design changes.
2. Contract administration needs to be identified at the start of the project and should remain the same throughout the life of the project. This project consisted of several technology components (software, radio transmitters, Internet connectivity) that fell under the administration of several agencies, so there was confusion over who should administer the contract. In this case the Southwest Region Information Technology Section took over the administration in midstream from the Department of General Administration. Project coordination was affected, and delays occurred.

3. Product detail needs to be specified before installation. Highway Information Systems (HIS) supplied flashing beacon controllers that used a dual-tone multi-frequency (DTMF) signal at the HAR station to activate the beacon. This was accomplished by placing an AM radio receiver at the beacon that hears the DTMF tone and actuates a relay that sends voltage to the flasher, thereby turning it on. The software sent the DTMF tone sequence five times, in effect, bombarding the beacon in the hope that one of the signals turned it on (or off). However, once the beacon had been activated in this method, such an intense amount of electrical noise was generated that it affected the radio. Attempts to turn the beacon off were futile because the signal could not be heard over the noise. Attempts to fix the DTMF/AM radio combination caused other problems. Finally, it was concluded that this method of signaling would not work, and HIS replaced all of the AM radio controllers, at no cost, with cellular modems that work flawlessly. Some of the problem could be attributed to the variable distances between the HAR transmitters and the beacons (some were 4 miles and some were between 1 and 2 miles). WSDOT guidelines for beacon placement should be developed.
4. All the beacons installed were designed to run on solar power. WSDOT was assured that the solar capacity was adequate and battery reserve would allow four days of operation during prolonged overcast or in the case of a solar panel/controller failure. However, when installed, the sites lasted only one day on solar power. This battery drain, exacerbated by the situation described above in which the radio noise prevented the flashing beacons from turning off, resulted in battery failure.

The solar panels were installed at an angle to the summer sun of approximately 45°. This reduced the charging current from the panels in the winter, when the sun angle is approximately 25°. The Southwest Region decided to upgrade these solar sites with more capacity and reserve. The vendor credited the amount spent on the upgrade to WSDOT in the final billing.

A WSDOT guideline should be developed for beacon installation when the sites will be solar powered. This might have prevented one site from being installed behind a tall pine tree that blocked the sun at its zenith.

5. During the design of the system, participation and input from the Southwest Region Information Technology (IT) Section was solicited and received. A lot of confusion existed in the Region, however, regarding the HAR server. The IT Section has authority and inventory control over any “server” in the Region so it installed this project HAR server in its server room. Access by the project engineer and Southwest Region traffic engineers and intelligent transportation systems (ITS) personnel was then restricted. During development of this project, the Southwest Region HAR Administrator sometimes required immediate access to this server and wasn’t able to obtain it. Future projects of this type need to determine the division of responsibility between ITS (the system operators) and IT (the system maintainers) personnel.

6. For a statewide project of this type to succeed, all of the regions need to be committed to the project and participate. The goal was to provide one type of HAR station, thereby
 - reducing the need for a broad inventory of replacement parts
 - providing a common software platform, thus reducing the need to train personnel to handle different software.

During this project, a number of new HAR sites were established. Some used the state contract with HIS for procurement. Others sought independent bids. Any cost savings from lower independent bids were offset by the need for an interface with the installed system. This independent procurement also provided other vendors with an unfair advantage, since the contracted vendor (HIS) could not alter its price but the competing vendor, knowing the price, could easily underbid the contract price.

Some Thoughts on HAR Use of the AM Band

While not necessarily a lesson learned from this project, it is important to note two problems experienced with HAR use of the AM radio band. First, the FCC has only one radio channel (530) that is designated for HAR transmissions. Agencies can license other AM radio channels; however, the FCC classifies these licenses as “secondary.” Commercial broadcast stations are classified as “primary.” What this means is that if primary users have complaints about interference from secondary users, the secondary users are shut down, and no mitigation is offered.

The second problem is that HARs on the same channel (530) are often placed too close to each other, which causes a great amount of interference. A frequency plan should be developed to provide sufficient space between stations by alternating frequencies.

It appears that future telecommunications developments, such as the use of roadside communications equipment proposed as part of the Vehicle Infrastructure Integration (VII) program, may provide a solution to these problems and replace the current HAR system, thereby providing better information to motorists.

3.7: US-395/Columbia River Bridge Traffic Operations, ITS-2003(056)

Background

This project was originally proposed for the “Blue Bridge,” which is located in the Tri-Cities area (Kennewick, Pasco, and Richland) of eastern Washington (see Figure 6). The bridge crosses the Columbia River on US-395 and is the major connection between the cities of Pasco and Kennewick. It is a critical transportation link, experiences heavy congestion, and has a high accident rate. The goal of the project was to improve traffic operations and provide better traveler information.

For reasons described below, the project location was changed to a section of I-82/US-395 between the Washington/Oregon border and the Tri-Cities. Improving

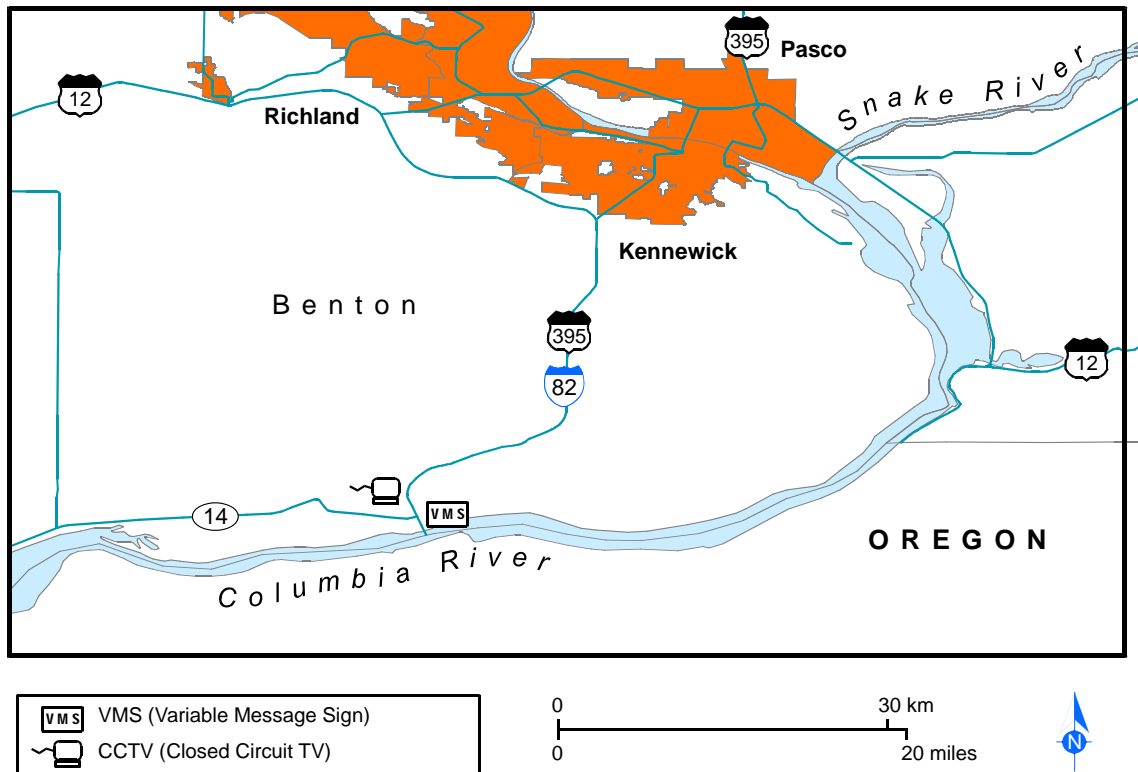


Figure 6. US-395/Columbia River Bridge Traffic Operations

traffic operations and providing better traveler information remained the goal of this revised project. The focus of these efforts, however, became travelers entering Washington from Oregon, particularly motorists driving large vehicles such as recreational vehicles and carriers transporting manufactured homes. This stretch of roadway experiences high winds that produce hazardous conditions for these large vehicles. The road is frequently closed because of these high winds, and motorists need to be notified of these closures.

Project Description

This project was originally proposed to install traffic surveillance equipment, VMSs, and associated communications infrastructure on the Blue Bridge to help manage traffic there. The communications infrastructure would connect the field devices to WSDOT's South Central Region TMC at Union Gap, near Yakima.

This project was also one of those included in WSDOT's "Nickel Package," which was funded by a 5-cents per gallon gas tax increase in 2003. When that funding became available, approval was obtained from FHWA to instead install the same equipment at another location on US-395. That location is on I-82, which runs concurrently with US-395 for a short segment near Umatilla. A CCTV camera was also installed at the SR 14/I-82 interchange as part of this project.

System Usage and Benefits

The system is used in the following instances:

- It provides traveler information, particularly information on road closures due to high winds.
- This route is used to transport nuclear waste to/from the nearby Hanford Nuclear Reservation, and the Washington State Patrol uses the TV cameras to determine whether the road has been cleared before allowing the waste to be transported.
- The system is also used to divert traffic between I-82 and SR 221, depending on conditions.

- Amber Alerts are displayed on the variable message signs.
- The system will also be used in the event of an evacuation required because of an accident at the Umatilla Nerve Gas Depot. The Depot is in the process of incinerating the nation's stockpile of nerve gas weapons.

The system is used an average of once per week. Dust storms cause road closures several times per week in the spring. High winds cause closures once a week for seven or eight weeks in the spring.

WSDOT TMC personnel at Union Gap operate the system. Both the WSP and the Army rely on WSDOT to operate the system in the event of emergencies.

Under normal circumstances, the public is able to view the TV camera images on the WDOT website.

Cost, Operations and Maintenance

The project cost approximately \$358,000. The South Central Region has two Maintenance Technicians who are assigned to maintaining the region's ITS equipment, including the equipment installed by this project. No additional maintenance personnel were added to handle this increased workload.

Architecture and Standards

The following Washington State ITS Architecture market packages are represented in this project:

- Network Surveillance (ATMS 01)
- Traffic Information Dissemination (ATMS 06)
- Traffic Incident Management System (ATMS08)
- Roadway Closure Management (ATMS21)
- Wide-Area Alert (EM06)
- Early Warning System (EM07)
- Disaster Response and Recovery (EM08)

- Evacuation and Reentry Management (EM09)
- Disaster Traveler Information (EM10).

The following NTCIP standards were used on this project:

- NTCIP 1203 – Communications to VMS
- NTCIP 1205 – Communication to CCTV.

The WSDOT Statewide ITS Architecture, particularly the CVISN* Architecture, provided information that was used to design the communications system for this project. The CVISN communications system that connects the nearby weigh station to the CVISN network was used for communications to the field devices installed by this project.

Lessons Learned

1. Several events occurred that resulted in schedule delays. The most obvious was the change in project location. This project was combined with another ITS earmark project on Alpowa Summit (evaluated in the previous report) in order to allow a WSDOT construction project office to cost effectively manage the project. However, having a project office manage such a small project, even in combination with others, increased the cost of the project.

3.8: Central Washington Traveler Information VMS, ITS-2003(062)

Background

Interstate-90 is the major east/west route in Washington State. It crosses the Cascade Mountains at Snoqualmie Pass. The highway is sometimes closed because of severe winter weather, avalanches, or avalanche control operations. There is a need to alert motorists to these closures in advance of the affected section of roadway and at a place where they can easily turn around. A series of variable message signs (that also serve as variable speed limit signs) alert eastbound motorists to pass closures. Prior to the completion of this project, however, westbound motorists had to rely on a highway HAR message to inform them of pass closures. This HAR station was located close to

* Commercial Vehicle Information Systems and Networks – A program that weighs and checks the credentials of commercial vehicles at freeway speeds as they pass weigh stations.

the pass, so motorists had to backtrack for a considerable distance to access connecting highways or obtain services.

Project Description

The project was originally proposed to install VMSs at several locations in central Washington. Proposed locations were I-90 near Moses Lake, US-97 near Oroville, and SR 543 near Beverly. The project actually installed two VMSs on I-90: one at Vantage and one at Dodson Road (Milepost 165) (see Figure 7). The sign that was installed at Vantage was actually part of the I-90 Truck Wind Warning System project, ITS-2003(039), which was evaluated in a previous study (*ITS Evaluation Framework-Phase 2, WA-RD 672.1, June 2007*). Since this sign could also be used to provide pass information to westbound motorists it was decided to purchase the two VMSs under one

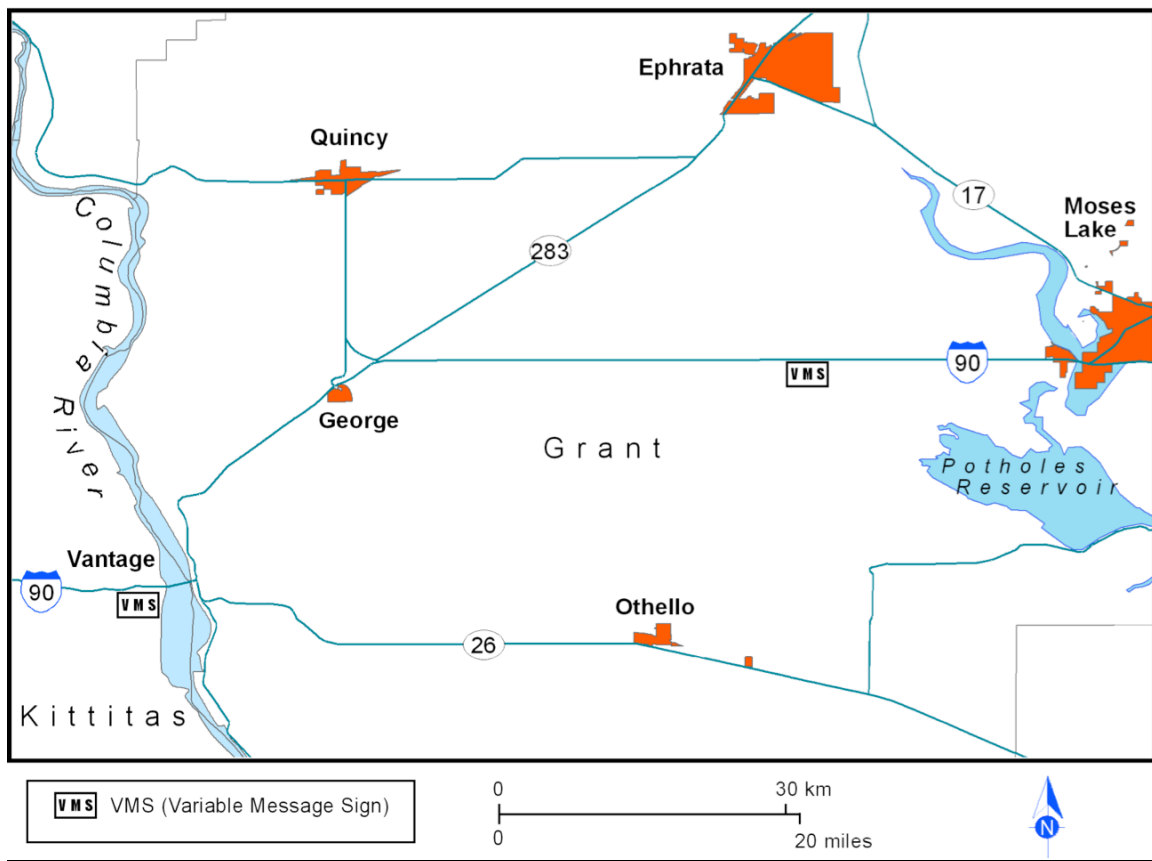


Figure 7. Central Washington Traveler Information VMS

contract in order to obtain a better price. Both signs were installed on I-90 in WSDOT's North Central Region, and both are controlled by operators in the Region's TMC in Wenatchee or the South Central Region's TMC in Union Gap, near Yakima, depending on the season and time of day.

System Usage and Benefits

The signs are used to provide information on weather and road conditions on westbound I-90. The signs are used daily in the winter and less frequently in the summer to provide information to motorists. The signs are operated by the North Central Region's TMC operators during normal working hours. Outside of those hours, the South Central Region TMC in Union Gap handles their operation.

The Vantage sign is also used to warn of high winds on the bridge crossing the Columbia River at this location.

The sign is maintained by the Region's ITS and IT technicians. No additional staff or funding was provided for maintenance of this system.

Cost, Operations and Maintenance

The total cost of the project, including the purchase of the sign that was installed at Vantage, was \$666,000.

Architecture and Standards

The following Washington State ITS Architecture market packages are represented in this project:

- Traffic Information Dissemination (ATMS 06)
- Roadway Closure Management (ATMS21)
- Wide-Area Alert (EM06).

The following NTCIP standards were used on this project:

- NTCIP 1203 – Communications to VMS.

The Statewide ITS Architecture was used to obtain information on other systems that operate in the Olympic Region.

Lessons Learned

1. WSDOT's North Central and South Central regions share operational responsibility for ITS field equipment in central Washington. During normal working hours, the North Central Region operates a TMC in Wenatchee, and the South Central Region operates a TMC in Union Gap, near Yakima. After hours, the Union Gap TMC takes over for both regions. The North Central Region VMSs are controlled through software on the TMC computer. Several laptops can connect independently or in a client/server relationship with the TMC computer. The operators in the South Central Region use the same software to control the signs as the North Central Region operators do. Each region maintains a separate database of sign messages. The region in control can tell what message is being displayed, but the other region cannot until it logs into the VMS control software. This situation of two databases can cause problems. Reserved messages can be overwritten unless they are noted in both databases. Different formats or sizes could be specified in each database for the same message. This could be fixed by having the South Central Region operate in a client/server relationship, like the laptops, with one database maintained on the North Central TMC computer. This would require that computer to be accessible all of the time. This change is being considered.

3.9: Critical Data Communications Systems Enhancement, ITS-2003(062)

Background

The WSDOT and the WSP share a statewide microwave communications network. WSP owns and maintains most of the network, but WSDOT utilizes approximately one-third of the channels for voice communications. The system carries business, operations and public safety voice communications and data. It is critical infrastructure both for routine activities and emergencies. The Joint Operations Policy Statement (JOPS), signed by WSDOT and WSP in January 2005, pledged both agencies "to support a shared vision to create a coordinated and integrated wireless transportation communications" system. It also stated "The WSP and the WSDOT agree to view their respective wireless communications systems as a single wireless system..."

The existing analog and digital microwave systems had reached capacity. Various projects were under way to deploy higher capacity digital microwave, but these did not connect to provide a higher capacity backbone. This project was designed to connect these higher capacity communications and allow interoperability between the two agencies.

Project Description

This project was designed to enhance the statewide system's most critical link, between Vancouver, Washington, and Olympia, in order to increase data capacity and make data transmission more secure. Both WSDOT and WSP wanted to upgrade their microwave networks to OC3 capability.

Originally designed to provide a microwave system with OC3 capacity that uses time division multiplexing (TDM) equipment, the project actually deployed a system with OC3 capacity that uses asynchronous time multiplexing (ATM) equipment.

System Usage and Benefits

WSDOT, WSP, the Washington Military Division (WMD), and CAPCOM use the system to provide voice, video, and data communications between Vancouver and Olympia. The system is used for routine communications and is available during emergencies.

A strength of microwave communications systems is their reliability, which is further enhanced in this case because it is part of the WSP network, which uses a ring configuration. This configuration, and the use of the ATM equipment, allows critical communications to be rerouted around the ring in the event of break.

The microwave system is limited, however, to certain public safety frequencies. While the WSDOT/WSP system is not currently at capacity, it is expected to reach capacity in the near future.

Cost, Operations and Maintenance

This part of the system is operated and maintained by WSDOT. This work is being absorbed by current staff.

Architecture and Standards

While this communications system makes the implementation of many other market packages possible, it does not constitute a market package by itself. It is not specifically mentioned in the WSDOT Statewide ITS Architecture.

No ITS standards were used on this project. It provides Ethernet connectivity and will meet any legacy connectivity requirements. The microwave infrastructure was designed to be transparent to the connecting ITS equipment.

Lessons Learned

1. The project involved coordination with several other agencies. This coordination needed to take place on several levels: the type of technology, leases for the use of the microwave site, and the development of the site. Agency priorities were not the same. It would have been better to have a multi-agency communications plan in which all of these issues were agreed upon prior to work starting on specific implementation projects.
2. Develop a process for quickly evaluating technology. Consider its flexibility and the ability to upgrade as factors when choosing technology. This may mean choosing technology that is not the lowest initial cost.

3.10: I-82 Yakima Area Traveler Information Systems, ITS-2003(062)

Background

The City of Yakima is near the center of Washington State, and four major highway routes converge here: I-82, US-12, US-97 and SR 24. Three of these four routes lead to mountain passes:

- I-82 leads to Manastash Ridge and connects to I-90, which leads to Snoqualmie Pass.

- US-12 leads to White Pass and connects to SR 410, which leads to Chinook Pass and Mount Rainier National Park.
- US-97 leads to Satus Pass.

It is not uncommon for at least one of the mountain passes to have a travel restriction during the winter (Chinook Pass is closed for the winter), and construction or maintenance activities occur frequently on these roadways in the summer. Currently, these travel restrictions cannot be communicated to drivers until they have traveled several miles on their chosen route, thereby missing a chance to divert to another route.

Project Description

WSDOT's South Central Region proposed a project to install a HAR station in the Yakima area and an RWIS station in the vicinity of South Umtanum Ridge. The Yakima area HAR station would provide information on road and weather conditions that will help motorists decide whether to divert to a different route. Umtanum Ridge is the first of three ridges that I-82 crosses between Yakima and Ellensburg. These three ridges were recently declared a mountain pass by WSDOT and the WSP. An RWIS station already existed on the northern ridge, and this project proposed to add one on the south ridge. It would also include a CCTV camera. A VMS had been previously installed on the southern approach to Umtanum Ridge. A cellular modem was used to communicate with this sign. Because the proposed RWIS station was going to be located close to this sign, use of the RWIS communications system was proposed for communication with the VMS.

The project also planned to install a CCTV camera at the US-12/I-82 interchange. A HAR station had been previously installed at this interchange, and the proposal was to install the CCTV in this same location and use the HAR communication backbone to transmit the CCTV images to the South Central Region TMC at Union Gap, near Yakima.

In addition, a HAR station already existed on US-12 near the town of Naches, but it did not have flashing beacons to indicate that the HAR was transmitting a message. This project proposed to install flashing beacons for this HAR station.

The project deployed the devices and communications systems as proposed (see Figure 8). The following system components were installed:

- RWIS station and CCTV camera at the westbound Selah Rest Area (South Umtanum Ridge), I-82 MP 22.4
- CCTV camera at the I-82/US-12 interchange, I-82 MP 31.37
- HAR station on I-82, MP 36.5, HAR repeater on I-82, MP 31.0, and associated flashing beacons on US-12, SR 24, and I-82/US-97
- microwave communications from the South Central Region TMC at Union Gap to Lookout Point
- multipoint radio from Lookout Point to the Yakima and Selah valleys
- high speed microwave connection to the HAR and VMS in Selah
- actuated flashing beacons for a HAR station on US-12 near Naches.

System Usage and Benefits

In general, the devices and communications systems deployed by this project are used to collect information on road and weather conditions, deliver it more reliably to the Region TMC, and deliver it to the public so that they can plan their routes through the various mountain passes that they need to traverse. The RWIS station and accompanying CCTV camera on the South Umtanum Ridge provide road and weather condition information to TMC operators that they can provide to motorists heading toward that area on I-82. The I-82 HAR station can transmit information on the four major highways that converge in the Yakima area and the mountain passes those roads traverse.

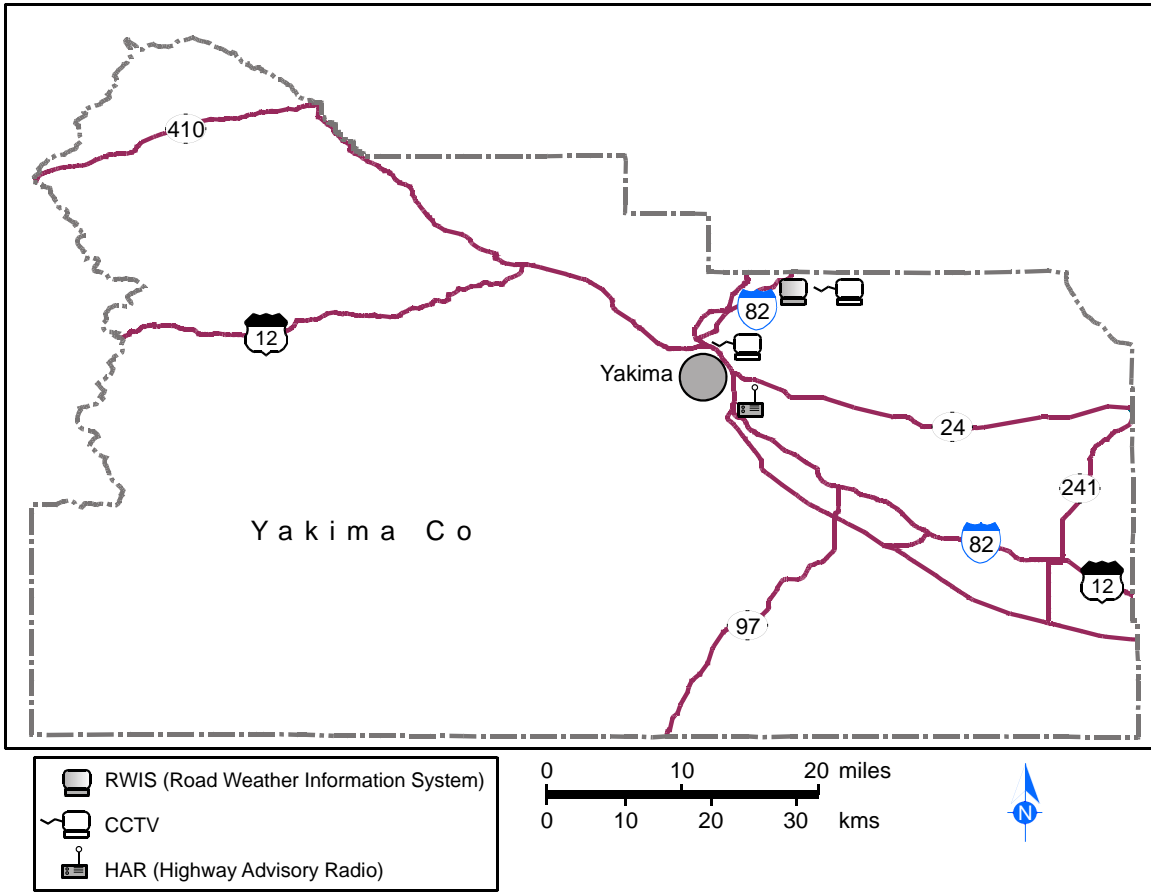


Figure 8. I-82 Yakima Area Traveler Information Systems

Operators at WSDOT’s South Central Region TMC at Union Gap, near Yakima, control the systems. They use the weather and road condition data from the RWIS stations and the CCTV images when making HAR messages to alert motorists of problems.

The HAR stations transmit a general message all of the time. Sign-mounted beacons are activated and flash when a traffic message is posted.

The road conditions, weather information, and CCTV images are available on the WSDOT website. Citizens requested that WSDOT provide video images from the I-82 corridor. There has been little feedback from the public on the information. However, when the information is missing from the website, the public is quick to notice and

comment. In two instances, when a camera failure and a communications failure resulted in the broadcast of an out-of-date camera image, the public very quickly noticed and notified WSDOT.

Cost, Operations and Maintenance

The project cost approximately \$333,000. The only component that has been a problem, so far, is the RWIS installation roadway sensor that determines pavement temperature and chemical concentrations. Every time the road is paved, this sensor is destroyed. It costs \$6,000 to \$10,00 to replace, and this cost is typically included in the cost of the paving project.

The South Central Region has two Maintenance Technicians who are assigned to maintain the region's ITS equipment, including the equipment installed by this project. No additional maintenance personnel were added to handle this increased workload.

Architecture and Standards

The following Washington State ITS Architecture market packages are represented in this project:

- Network Surveillance (ATMS01)
- Traffic Information Dissemination (ATMS 06)
- Traffic Incident Management System (ATMS08)
- Road Weather Data Collection (MC03)
- Weather Information Processing and Distribution (MC04)
- Wide-Area Alert (EM06).

The following NTCIP standards were used on this project:

- NTCIP 1203 – Communications to VMS
- NTCIP 1204 – Communications to Environmental Sensor Stations (ESS)
- NTCIP 1205 – Communication to CCTV.

The Statewide ITS Architecture was used to obtain information on other systems that were operating in the South Central Region.

Lessons Learned

1. The procurement contract that was used to purchase the RWIS station included the option of contracting with the vendor to install the equipment. The vendor charged an equipment-only price and an installed price. The RWIS station was purchased at the installed price. Although this worked very well, it made paying for unforeseen problems difficult. For example, on this contract some existing conduit that had been planned for use could not be used, requiring that the vendor install new conduit, which was not covered by the procurement contract. As a result, either the vendor had to install this conduit at its expense, or WSDOT had to negotiate another contract to pay the vendor.
2. It is important to consider maintenance needs when locations for RWIS stations and other field devices are determined. For example, maintenance personnel need to be able to park a vehicle nearby. In addition to providing site access, this also provides access to tools or other equipment either carried or mounted on the truck. For example, one of the RWIS stations recently installed in the region was located very close to a guardrail, and there was no safe place to park a truck nearby.

3.11: I-5 Nisqually Valley Ice Warning System, ITS-2003(062)

Background

The Nisqually Valley is a low-lying river valley located between the cities of Tacoma and Olympia in Washington State. The U.S. Army's Fort Lewis Military Reservation borders this river valley. I-5 crosses the Nisqually Valley, and it is the major north/south link between Portland, Oregon, and Seattle, Washington. The average daily traffic volume on this stretch of I-5 is 100,000, and this volume is split evenly between northbound and southbound traffic.

Winter weather in the Nisqually Valley creates the potential for hazardous driving conditions. Heavy rain, cold temperatures, and winds that blow through the valley frequently combine to create icy roads and associated adverse travel conditions. These weather conditions plus the high traffic volumes and high freeway speeds increase the potential for serious accidents.

Project Description

Prior to this project, no weather or road condition information for this stretch of I-5 was available to WSDOT’s Olympic Region TMC. This project was proposed to deploy an RWIS station, a CCTV camera, and a VMS on I-5 in the Nisqually Valley. These devices would be used to monitor weather, road, and traffic conditions and to provide information on icy roads or other potentially hazardous road conditions to WSDOT Maintenance workers and motorists. The project actually installed only the RWIS station and the CCTV camera. The VMS was installed as part of another project that had not been completed at the time of this evaluation (see Figure 9).

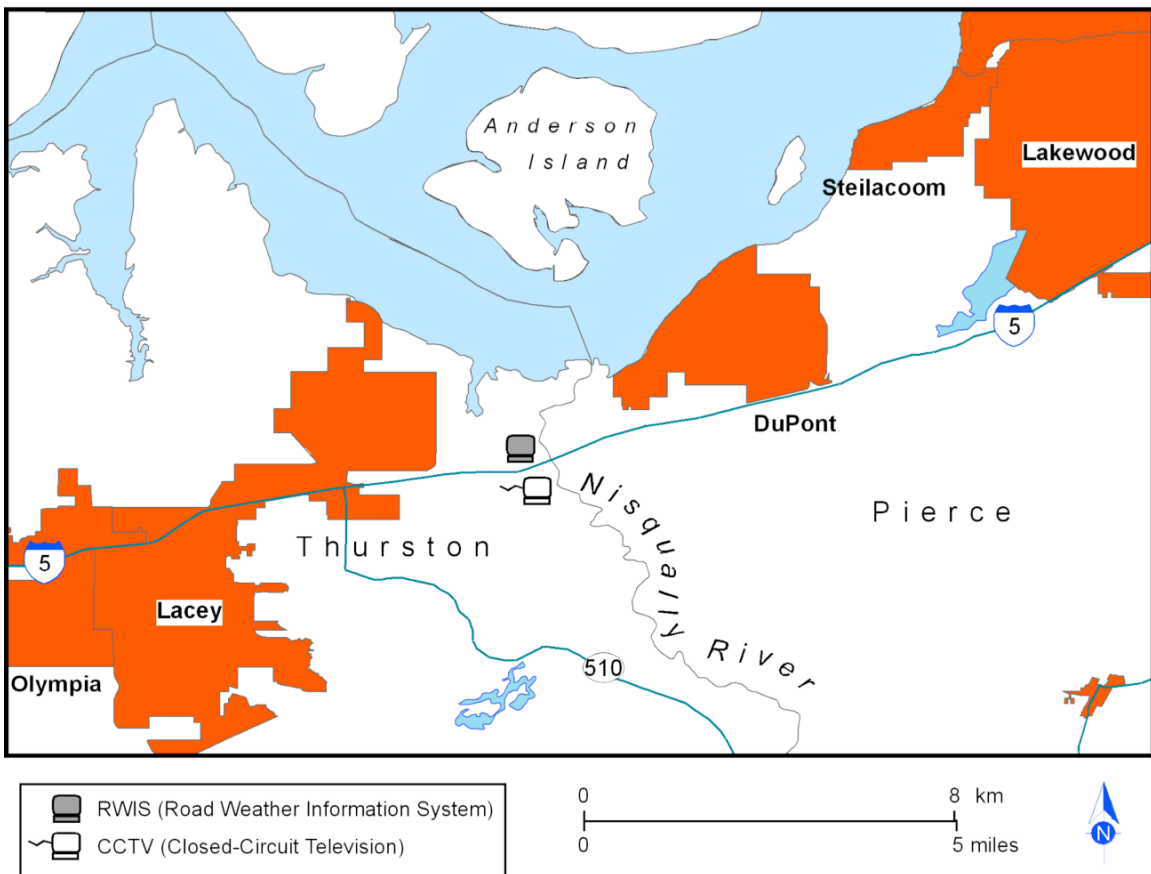


Figure 9. I-5 Nisqually Valley Ice Warning System

System Usage and Benefits

Data from the RWIS station and images from the CCTV camera are sent to the Olympic Region TMC in Parkland, near Tacoma. Weather information and the camera images are available to the public via the WSDOT website. This information is also available to WSDOT Maintenance workers to use in winter snow and ice control operations. The information is continually available to the public and WSDOT workers and is used daily.

Cost, Operations and Maintenance

The cost of construction was \$165,500. The annual cost to operate and maintain the system is approximately \$1200.

The operators at the Olympic Region TMC operate the system. Electronic Technicians at the Olympic Region Traffic Signal Maintenance office maintain the system.

Architecture and Standards

The following Washington State ITS Architecture market packages are represented in this project:

- Network Surveillance (ATMS01)
- Traffic Information Dissemination (ATMS 06)
- Road Weather Data Collection (MC03)
- Weather Information Processing and Distribution (MC04).

The following NTCIP standards were used on this project:

- NTCIP 1204 – Communications to Environmental Sensor Stations (ESS)
- NTCIP 1205 – Communication to CCTV.

The Statewide ITS Architecture was used to obtain information on other systems operating in the Olympic Region.

Lessons Learned

1. The original grant application included only a planning level cost estimate. Because there was a great deal of uncertainty regarding the funding, a greater level of effort to develop a more detailed estimate was not warranted. When funding was obtained, it took two years to complete the design work and get the project ready to advertise for bids. During this time, inflation increased the price of construction materials and there was plenty of work in the area for electrical contractors. As a consequence, the construction bids were 20 percent higher than the WSDOT engineer's estimate. Since there was no funding available to make up the shortfall, the cost had to be reduced. That was done by moving the VMS purchase and installation to another project. The process of funding ITS projects by earmarking ITS Deployment funds has been discontinued so this problem should no longer occur.

3.12: Vancouver Area Smart Trek Expansion, ITS-2003(062)

Background

Vancouver, Washington, is a city of a little over 160,000 people. It is located on the north bank of the Columbia River directly across from Portland, Oregon. The Pacific Coast is less than 90 miles to the west. The Cascade Mountain Range rises on the east. Mount St. Helens National Volcanic Monument and Mt. Hood are less than two hours away. The spectacular Columbia River Gorge National Scenic Area lies 30 minutes to the east. Vancouver is the largest city in Clark County, which has been one of the fastest growing counties in Washington State. The population of Clark County is slightly over 383,000.

Clark County is in the WSDOT's Southwest Region. The urban roadway system in the county consists of two major north/south routes (I-5 and I-205) and two major east/west routes (SR 14 and SR 500). These roads represent approximately 35 miles of urban freeways. SR 500 is currently being reconstructed to eliminate all at-grade intersections, and the transition to a limited access freeway is expected to be complete by 2013.

The Southwest Region has a TMC, which is co-located with the WSP dispatch center, in Vancouver. The Region is implementing a freeway management system that includes field devices to monitor and control traffic and to provide traveler information to the public.

Project Description

Prior to 2003, the Clark County urban area had a small number of freeway traffic detectors and cameras, which communicated with the WSDOT TMC over a fiber optic communications system. Field devices were needed on additional segments of I-5, I-205, SR 14, and SR 500. These field devices were essential for improved freeway management, including expanded incident detection, faster incident response, and improved traveler information regarding traffic conditions or alternative routes. In order for these freeway management improvements to occur, a communications system was necessary to bring information to the TMC and deliver control commands to the field devices. This project was designed to fill critical gaps in the Region's communications system. The project was intended to install over 6 miles of the Region's fiber optic communications backbone. The specific project elements included the installation of fiber

- along SR 500 between I-5 and Andresen Road
- along I-205 from SR 14 to 83rd Street
- along city arterials to connect the I-5 corridor to the City of Vancouver/Clark County transportation office
- along city arterials to connect the City of Vancouver and the City of Camas with the Southwest Region's TMC.

This provided a complete fiber optic communication backbone that now runs as follows:

- on I-5 between the Columbia River Bridge and the 134th St. interchange

- on I-205 between the Glen Jackson Bridge and the 83rd St. interchange
- on SR 500 from I-5 to SR 503/ Fourth Plain Blvd.

This communications system also included connections to other agencies involved in regional traffic management efforts. These agencies were the Oregon Department of Transportation and several local agencies that are part of the Vancouver Area Smart Trek (VAST) consortium of agencies that are sharing and integrating information to provide comprehensive traveler information in the Vancouver, Washington/ Portland, Oregon, metropolitan area.

System Usage and Benefits

The information from the Region's freeway management system is used by Region traffic operations and maintenance personnel, the WSP, the freight industry, and the general public.

Camera images from the CCTV cameras on the Region's highways are available on the WSDOT website. The Region provides a comprehensive congestion map that displays real-time congestion information from the area's freeways.

Cost, Operations and Maintenance

The total cost for this work was slightly less than \$1.5 million.

The Southwest Region Traffic Operations office operates the system from its Vancouver TMC. The Region's ITS Maintenance office maintains and repairs the field devices and communications equipment. Two ITS engineers/technical specialists oversee the system. Two ITS/Electronic Technicians maintain the field and communications equipment. The TMC is staffed 24/7.

No additional funding or personnel were provided to handle the operations or maintenance of this system.

Architecture and Standards

The following Washington State ITS Architecture market packages are represented in this project:

- Network Surveillance (ATMS01)
- Regional Traffic Control (ATMS07)
- Traffic Incident Management System (ATMS08)
- Wide-Area Alert (EM06)
- Disaster Response and Recovery (EM08)
- Disaster Traveler Information (EM10).

In addition, the VAST program's ITS Architecture was completed in 2000 and was used to plan this project.

The following NTCIP standards were used on this project:

- NTCIP 1203 – Communications to VMS
- NTCIP 1204 – Communications to Environmental Sensor Stations (ESS).

Lessons Learned

1. This project went approximately 5 percent over budget. Additional state funding was provided to cover this overrun. The original cost estimate was based on filling gaps in the existing fiber system. However, the actual costs of fiber installation can vary a great deal, depending on both surface and underground conditions. Given the size and complexity of this project, getting within 5 percent of the estimated cost was very good. When large fiber communications projects are proposed, it is a good idea to allow a large amount for contingencies or to provide a source of additional funding to cover cost overruns.

3.13: Wenatchee Advanced Traffic Management System, ITS-2004(051)

Background

The City of Wenatchee is located at the confluence of the Wenatchee and Columbia rivers near the eastern foothills of the Cascade Mountains. It is the largest city in Chelan County and is the county seat. The population of the urban area is approximately 54,000 (2000 census figures).

It is a major transportation hub and is the headquarters of WSDOT's North Central Region. The city's location, at the decision point for two routes through the

Cascade Mountains, SR 2 and SR 97/I-90, makes it a critical place to provide motorists with information on road and weather conditions.

The North Central Region had already deployed CCTV cameras, HAR stations, and RWIS stations. However, there was no “control room” in the Region headquarters building where all of the information could be monitored and easily accessed. The building contained only the Region “radio room,” from which radio operators monitored maintenance and construction communications, dispatched state maintenance and incident response forces, and operated some of the traveler information field devices. Therefore, there was a need to install camera monitors and other ITS control equipment so that TMC operators could gather and provide more accurate and timely information to the public.

Project Description

The primary objective of the project was to install ITS field equipment where there were some gaps in the system and to construct a TMC to integrate the ITS monitoring and control systems. The Region had a small TMC that consisted mainly of a radio room to handle Region communications with maintenance and construction forces. A computer workstation in the TMC, which was used for all of the radio room functions, was also used to view CCTV camera images.

Project funding was used for the following:

- an RWIS station and CCTV camera at Loup Loup
- half of the cost of an RWIS station and CCTV camera at Winton
- a HAR station at Wenatchee
- three CCTV cameras at the north end of Wenatchee
- equipment for the TMC, as well as its installation.

Region funds were used to expand the radio room. The original project called for the installation of two HAR stations. However, planners determined that the single HAR station at Wenatchee provided adequate coverage, so the second one was not installed.

Prior to the installation of the HAR server and client software as part of this project, each HAR station was independently controlled over a standard telephone. The new system provides centralized control of the Region's HAR stations and allows one message to be sent to multiple HAR stations with a single command.

The project installed several workstations, servers, MPEG4 decoders, network devices, and telephony devices that allow integrated monitoring and operation of the field devices. Below are descriptions of these components and how they are operated (see Figure 10):

- On one wall, all of the streaming video can be displayed and manipulated (pan, tilt, zoom control from a single interface). Images captured as still photos are also displayed (by area). The system displays a rotating series of images, moving to a new one every few seconds to allow the TMC operators to get a sense of conditions throughout the region.
- MPEG4 video from cameras across the region is transmitted by using TCP/IP via Ethernet and radio communications to the TMC. As an additional benefit, the video is provided to the Washington State Patrol to enhance public safety.
- Still images are captured and delivered over phone lines or various communications networks to one of two servers. The images are then uploaded to the WSDOT Internet site for public view and delivered to the TMC for operator use. The images can be seen at <http://www.wsdot.wa.gov/regions/northcentral/camera.cfm>
- RWIS data are also delivered to a server at the TMC by phone or other network communications. From there they are collected and uploaded to the Web for public and WSDOT use.
- HAR control is now unified, as discussed previously. Messages can be sent to all HAR stations at once or scheduled to go out at a later time. Messages can be stored and reused as needed. HAR beacons are controlled with the same interface.



Figure 10. Wenatchee Advanced Traffic Management System

- Though not funded as part of this project, a single workstation controls all of the VMSs and variable speed limit (VSL) signs in the Region. (The North Central Region operates a variable speed limit system for SR 2 over Stevens Pass.) Separate software applications are needed to operate the VMSs and VSLs.
- Because control of the Region's field devices is shared with the South Central Region, the South Central Region's TMC in Union Gap is able to control the HAR stations, VMS, and VSL signs.

System Usage and Benefits

TMC operators from both North Central Region and South Central Region use the system. Outside of normal working hours, the system is monitored and controlled by operators at the WSDOT South Central Region TMC, which is open 24/7. The system saves the TMC operators a great deal of time by integrating and simplifying the process

of recording and transmitting HAR messages. Every ITS field device in the region can be controlled from three computers in the TMC.

WSDOT staff and the public use the information from the system. Camera images, road conditions, and weather information are readily available on the WSDOT website. HAR and VMS messages alert motorists of road and weather conditions and allow them to choose the best route through the mountains. The Washington State Patrol has the ability to view the camera images and can control those cameras that have pan, tilt and zoom capability to better monitor road conditions and manage incident response.

Use of both the operating systems and the gathered information is almost constant by both WSDOT staff and the public. The public has given favorable feedback about the camera images available from the WSDOT website, particularly about the camera at Loup Loup, which is a popular winter recreation area.

The TMC is also large enough, and suitably equipped, to be used as an emergency management center in the event of a disaster. Because the Region radio room is part of the TMC, managers can monitor statewide communications and Region CCTV, road, and weather conditions from one place.

Cost, Operations and Maintenance

The cost of the project was approximately \$460,000. Additional time and about \$30,000 in additional funding were required for modifications to enable the use of wireless communications to the HAR beacons. At the same time that this project was taking place, a statewide project was being conducted to install HAR software that would interconnect all of the region HAR servers to a statewide HAR server. This allows statewide messages, such as Amber Alerts and disaster-related messages, to be broadcast. It also allows HAR messages to be broadcast on the WSDOT website. One of the features of the new software allows wireless communications for beacon activation.

Region staff involved with maintaining this system include a communications technician and an IT technician. No additional staff or funding was provided to operate or maintain these systems.

Preventative maintenance on the CCTV cameras is done twice a year, which takes about one day per year. Problems have been encountered keeping the RWIS stations in operation, including problems with the equipment in the field and with communications.

Architecture and Standards

The following Washington State ITS Architecture market packages are represented in this project:

- Network Surveillance (ATMS01)
- Traffic Information Dissemination (ATMS 06)
- Regional Traffic Control (ATMS07)
- Traffic Incident Management System (ATMS08)
- Speed Monitoring (ATMS19)
- Road Weather Data Collection (MC03)
- Weather Information Processing and Distribution (MC04)
- Broadcast Traveler Information (ATIS1)
- Emergency Call-Taking and Dispatch (EM01)
- Wide-Area Alert (EM06)
- Disaster Response and Recovery (EM08)
- Disaster Traveler Information (EM10).

The following NTCIP standards were used on this project:

- NTCIP 1203 – Communications to VMS
- NTCIP 1204 – Communications to Environmental Sensor Stations (ESS).

Lessons Learned

1. An ITS communications network is the key piece of infrastructure that is necessary to achieve surveillance, data collection, traveler information, and almost all other traffic operations and management functions that are necessary to provide safe and efficient travel conditions. Flexibility and redundancy are crucial, particularly in a mostly rural environment, like the North Central Region, where large distances must be spanned and weather conditions are harsh.
2. Assembling a team of talented folks who have worked together, understand the problem and project objectives, and are committed to the successful completion of the project will deliver good results almost every time.
3. Several technical lessons learned include the following:
 - Make sure that the PC that is driving the video screens has the processing speed and the video card(s) capable of doing the job.
 - Keep HAR transmitters completely separated from other electronic devices or shield them. The communication equipment for one of the HAR stations was located near the HAR transmitter, and this caused video interference at times.

3.14: Regional Traffic Signal Interconnect, ITS-2004(057)

Background

The WSDOT operates many traffic signals in unincorporated areas of the state. This is particularly true in the case of the traffic signals at freeway ramp terminal intersections. Typically these ramp terminal signals have not been treated as part of the freeway ramp metering system. In most cases they have been interconnected and coordinated with only the arterial traffic signals on either side. While it is not currently possible to actually operate the ramp metering and arterial traffic signal systems in a coordinated manner, connecting these systems can provide the communications infrastructure necessary for coordinated operations in the future.

Project Description

The goal of this project was to connect arterial traffic signal systems near freeway ramps to a central signal system. This would provide the communications infrastructure for future coordinated operations.

This project installed communications infrastructure from certain freeway ramp metering signals (listed below) to ramp terminal traffic signals and other signals on the connecting arterials. Fiber optic communications cable and Ethernet communications protocols were used for the connections. The traffic signals were connected to the WSDOT i2TMS™ traffic signal control software supplied by Siemens. The traffic signal control hardware and software for these signals reside at the WSDOT Northwest Region TMC in Shoreline. The project interconnected traffic signals on the following state highways (see Figure 11):

- SR 96 – five traffic signals. Also installed were
 - new 2070 signal controllers
 - three CCTV cameras
 - connection for eight existing traffic signals on SR 527 to the WSDOT i2TMS™ central software at the Northwest Region TMC.

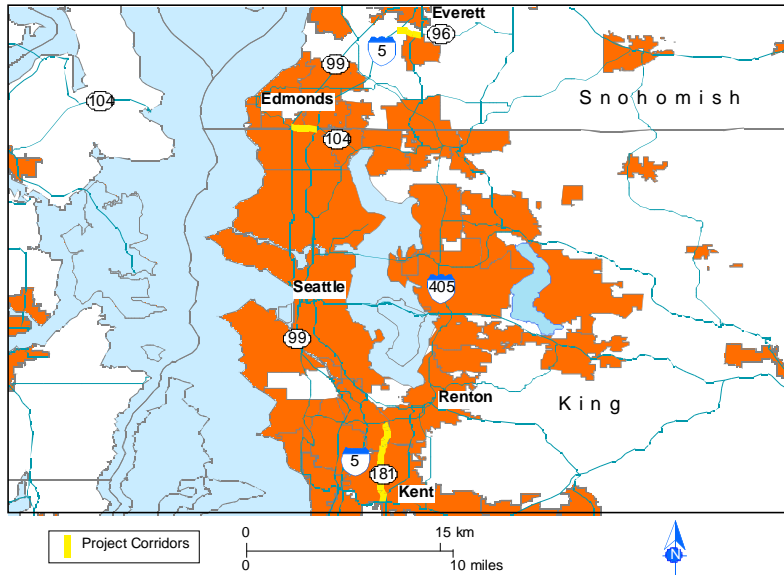


Figure 11. Regional Traffic Signal Interconnect

- SR 104 – six traffic signals. Also installed were
 - new 2070 signal controllers
 - five CCTV cameras
 - a fiber connection to WSDOT’s maintenance facility on SR 104
 - connection to the traffic signal at the intersection of SR 104 and SR 99.
- SR 181 – five traffic signals. Also installed were
 - new traffic signal cabinets and 2070 signal controllers
 - five CCTV cameras
 - a center-to-center communications connection to the City of Tukwila’s TMC.

In all of these cases, the traffic signals at the ramp terminal, and therefore, all of the other traffic signals on the crossing arterials that are connected to those signals, are connected to the fiber optic cable that provides communications to the freeway management system central computer located at the NW Region TMC.

This project originally proposed to interconnect the following signal systems as part of Phase 1:

- SR 96 from I-5 to SR 527
- SR 104 from SR 99 to I-5
- SR 516 from SR 99 to I-5.

The work on SR 516 was dropped because the installation of fiber optic communications cable along I-5 to the SR 516 interchange was delayed. That fiber was installed after this project had been completed. The project to interconnect the signals on SR 516, which was deleted from this ITS earmark project, is funded in a future state project. The work to connect the signals on SR 181 was, therefore, added to this project.

System Usage and Benefits

Connecting the ramp terminal traffic signals to the freeway management system communications network enables remote access to these signals from the TMC. Signal operations activities, such as reviewing or changing traffic signal timing plans, can be performed at the TMC, where the monitoring and operation of the freeway ramp metering system also take place. Vehicle monitoring (with the CCTV cameras) and vehicle detection (from the loop detectors) at arterial signals will be used to fine-tune the ramp meter control system and vice versa. Queues at both the ramp terminal traffic signals and the ramp meters can be monitored, and control software can be adjusted to keep the queues from affecting the operation of the other systems. Any local agency connected to arterial traffic signals that are, in turn, connected to these WSDOT traffic signals can obtain real-time freeway data through the communications network.

These connections between arterial and freeway systems and between local and WSDOT systems are the first step in a long process to enable data to be shared and the eventual joint operation of traffic signal networks.

The CCTV video images from the cameras that were installed as part of this project are also available to the public on the WSDOT website.

Cost, Operations and Maintenance

WSDOT's NW Region signal operations engineers use the system on a daily basis to check operational status. The Region's Signal Maintenance technicians maintain the system. No additional funding or staff was provided to operate or maintain the system. The maintenance required to keep the fiber optic interconnection in operation is much less than what was required to keep the previous twisted-pair, copper wire in operation.

The total costs for each part of the project were as follows:

- SR 96: \$91,000
- SR 104: \$90,000
- SR 181: \$92,000.

Architecture and Standards

The Puget Sound Regional ITS Architecture was prepared in June 2001 and updated in August 2006. The project complied with the goals of the architecture by enabling data sharing and, eventually, regional traffic control.

The following ITS architecture market packages are represented in this project:

- Network Surveillance (ATMS01)
- Surface Street Control (ATMS03)
- Freeway Control (ATMS04)
- Regional Traffic Control (ATMS07).

NTCIP standards were used in the purchase of the traffic signal controllers and for communications with the CCTV cameras.

Lessons Learned

1. Communications cabinets can never be too large. Try to anticipate future needs and, if funding permits, spend extra to accommodate future expansion. This is true for the cabinets at communications hubs, traffic signal controller cabinets, communications conduit, fiber optic cable, and many other components.
2. Communications infrastructure is the key to enabling regional operations. The first step toward a regional traffic operations program is to enable the sharing of

information about the status of the various connected systems. This means both data and video. Once the communications links have been established, then operations managers can use this information to make better decisions regarding both freeway and arterial operations. Eventually, systems can be added and operations protocols developed that will make these operational adjustments automatically. This project and others, such as the Traffic Busters project, that are developing a regional communications network and connecting the agencies in the central Puget Sound to it, are crucial to enabling a new, regional way of managing traffic.

3.15: 511 Travel Information, Phase 3, ITS-2004(058)

Background

The United States Department of Transportation (USDOT) petitioned the Federal Communications Commission (FCC) for an N11 nationwide phone number for traveler information in April 1999. The FCC approved the use of 511 in July 2000. The FCC order approving 511 allowed five years for implementation, after which the use of 511 would be reviewed. If the 511 service was not widely implemented, the number could be removed from use for the delivery of traveler information and assigned for some other nationwide function. In response to this deadline, the Federal Highway Administration (FHWA) announced a grant program to support and encourage the implementation of 511.

Previous to the implementation of 511, WSDOT operated several telephone hotlines to provide traveler information. These were

- Washington State Ferry System (137,000 calls per month)
 - 800-84FERRY
 - 888-808-7977
 - 206-464-6400 (WSF).
- WSDOT roadway traveler information (250,000 calls per month)
 - 800-695-7623 (ROAD)
 - 206-368-4499 (DOT-HIWY)

- 800-419-9085 (Hood Canal Bridge).

Total calls per month: 387,000

When this project started, nine cellular phone companies and 27 landline phone companies operated in Washington State. Each of these would need to re-program their switching software to re-route calls to the new 511 number.

Project Description

The implementation of 511 in Washington State was completed in phases. Because none of the transit agencies or other jurisdictions was ready to implement a 511 system, WSDOT took the lead and applied for the federal grant that was available for deployment in Washington State. Because the existing travel information hotlines would remain in operation, a bare-bones system of 48 ports was planned. This system could handle 48 simultaneous incoming phone calls. The system was designed to be voice-responsive only (no touch-tone features) because it was thought that a large portion of users would access the system from cellular phones while driving. A voice-responsive system would eliminate the need for the users to push buttons, thereby reducing distractions and potential safety hazards. This system became operational in September 2002, with access limited to two telephone companies. Many companies were unable or unwilling to quickly reprogram their switches to accommodate this new number. One company even filed suit challenging the legality of the designation of 511. This suit was later dropped. No redundancy was built into the system.

The initial demand calculations prepared during the design phase indicated that 48 ports would not be sufficient to handle the call volume when the other hotlines were discontinued. Seventy-five ports would be required to handle the anticipated call volume if the calls lasted only 1 minute. If the calls lasted for 2 minutes, 139 ports would be required.

In May 2003 the number of ports was increased to 96, with 80 of these for 511 and the remainder for WSF and the HERO system (a system that allows drivers to notify

WSDOT of high occupancy vehicle lane violators). Combining the highway and ferry information systems resulted in some cost savings. The peak load on the highway information system occurs during the winter months, when mountain pass information is in high demand. The peak time for ferry system information occurs during the summer as a result of tourist demand. So the system was designed to shift demand to vacant ports as needed. A minimal number of ports was reserved for ferry information to provide a timely response to ferry customers even during periods of peak demand for highway information. The deployment of two servers, with 48 ports each, provided system redundancy. By this time, almost all phone companies provided access to 511.

In response to customer complaints about the voice-responsive system, touch-tone capability was added in November 2004. A direct connection to Oregon's 511 system also began operation at this time.

A major upgrade was completed in January 2006. The work done at that time constitutes the Phase 3 project evaluated here. The work that was proposed for Phase 3 included the following:

- increase the number of ports to a minimum of 144
- conduct a survey and usability tests to determine customer attitudes
- add Amber Alert capability
- provide direct connections to eight transit agencies
- provide users with the ability to customize the system to make information retrieval faster.

Below is a description of what was actually accomplished.

The number of ports was increased to 192. The existing system computers, which were four years old, were replaced, and one of these new computers was deployed at WSF headquarters to provide off-site redundancy. The speech recognition software was upgraded. The rate that data were refreshed was changed for callers using voice-

recognition from an average of every 7 minutes to less than 2 minutes. Caller identification was added to identify repeat callers and offer them the option of receiving the information that they had requested previously. Amber Alert and temporary alert capabilities were also added so that messages could be delivered to callers from across the state. The direct connections to the eight transit agencies were not implemented. Only one direct connection, the one to the WSF, was made. The transit agencies lacked funding to modify their systems to handle the expected increase in calls, so the other connections were not made. WSDOT did prepare an application for STP/CMAQ funding to aid the transit agencies in implementing these connections, but the project did not score well in the competitive process and was not funded.

In June 2006, the refresh rate for callers using the touch-tone system was upgraded to be the same as that for users of the voice-recognition system.

System Usage and Benefits

The system is available to anyone with a telephone, either land line or cellular, to dial 511 and obtain travel information. The system receives its heaviest use during the winter from people seeking information on road conditions in the Cascade Mountain passes. Usage is also high in the summer months as tourists seek information on the ferry schedules and routes. Commuters use the system to obtain information on congestion and incidents on their daily commute routes. The system also provides current and forecast weather information and transit phone numbers.

The system works as follows:

The main dialog prompts callers for the information they are seeking. Callers can speak their response at any time, interrupting the prompts and option lists. This allows users experienced with the system to get to the desired information quickly. Callers are asked to select from the following:

- ferry information (direct link to WSF telephone lines)

- mountain passes (road restrictions and current weather conditions)
- current traffic (congestion, HOV congestion, construction work)
- other (weather, express lane status, public transit telephone numbers, passenger rail telephone numbers, airline telephone numbers, and traveler information telephone numbers for adjacent states and provinces).

Callers can use 511 to obtain weather information for any city in the state. They can say “weather,” then specify the city when prompted. They will hear the current and forecast weather conditions.

The call volume of the system ranges from 40,000 calls per month in the summer to over 450,000 calls per month in the winter. Total calls for 2006, which had the highest call volume since the start of the system, were almost 1.85 million calls. The total calls for 2007, which is the last full year with complete data, were almost 1.58 million. The system experienced its 7 millionth call in August 2008.

In 2005, a consultant conducted an interactive voice response (IVR) survey to obtain customer feedback on the 511 system. From early February to late March of that year, 511 callers were prompted to take a brief survey. A total of 649 callers participated in the survey during this period. Two-thirds of the participants were from western Washington and the remainder were from eastern Washington.

Participants in this survey were also asked if they would participate in more in-depth usability testing of both the voice-activated and touch-tone 511 systems. Seven participants were recruited for this testing, and six actually participated. Their characteristics were as follows:

- Gender: 4 males, 2 females
- Residential area: 2 rural, 2 suburban, 2 urban
- Counties: 3 King, 1 Snohomish, 1 Skagit, 1 Okanagon
- Ages: 1 (35-39), 1 (40-44), 2 (50-54), 1 (60-64), 1 (70-74)
- Frequency of using 511 system: 4 at least every 2 weeks, 1 weekly, 1 daily

- Type of phone used for calling 511: all used a cell phone
- Use of mountain passes in the winter months: 5 yes, 1 no.

The key findings of this testing are listed below. More detailed information is available in *WSDOT 511 IVR Survey and Usability Testing Results*, PRR, Inc., May 2005, which may be obtained from Eldon Jacobson (jacobe@wsdot.wa.gov).

- **Information from 511 is used to change travel plans.** Usability testing participants reported using the 511 system to determine which routes to take, mountain passes to use, and times to travel. Twenty-one percent of survey respondents reported changing their plans on the basis of the information they received during their last 511 call.
- **Users are generally satisfied with the 511 system.** Usability testing participants said it was a great system that just needed some tweaking. Sixty-eight percent of survey respondents indicated that they were *satisfied* or *very satisfied* with the 511 system.
- **Users are generally satisfied with 511 features.** Usability testing participants appreciated the traffic conditions, roadway incidents, and mountain pass information. Seventy-five percent or more of the survey respondents were satisfied with most of the features of the 511 system.
- **The voice recognition feature needs improvement.** This was the biggest frustration for usability testing participants, who experienced, during the testing, problem with the system understanding their voice commands. Of those survey respondents who were dissatisfied with the 511 system, 26 percent indicated that it was because the voice recognition feature did not work adequately. Forty-five percent of all survey respondents were satisfied with the voice recognition system.
- **More information is needed about other parts of the state.** Thirty-six percent of survey respondents thought that information was missing in the current 511 system. When asked specifically what kind of information was missing, they most commonly said information about geographic coverage.
- **Respondents are very likely to use the 511 system again.** Almost all the survey respondents (87 percent) agreed that they would be *likely* or *very likely* to use the 511 system again. All of the usability testing participants reported being very likely to use the system again, and in fact planned to use some of the new features they learned about during the testing.

Architecture and Standards

The following Washington State ITS Architecture market packages are represented in this project:

- Traffic Information Dissemination (ATMS05)
- Weather Information Processing and Distribution (MC04)
- Transit Traveler Information (APTS8)
- Broadcast Traveler Information (ATIS1)
- Interactive Traveler Information (ATIS2)
- Wide-Area Alert (EM06)
- Disaster Traveler Information (EM10).

Lessons Learned

1. Before the implementation of 511, WSDOT had a great deal of experience with telephone hotline information systems. As mentioned previously, several roadway information lines and ferry system information lines were available, all of which experienced high call volumes. These systems used humans to make the recordings and provided information with touch-tone menus. Many WSDOT personnel had “ownership” of these existing hotlines and were reluctant to see the new system replace these and make them obsolete. As a result, there was a tendency for WSDOT to focus on the complaints about and problems with 511. At times it appeared that their intent was to make 511 fail and return to the previous telephone hotline systems. Very little public information support was provided to introduce the system to users. Even after a survey and usability testing indicated that customers had generally favorable attitudes toward 511, the attitude of WSDOT management toward 511 remained mostly hostile.

Implementing a system like 511 was bound to be a difficult process. This was a particularly difficult transition because it involved new technologies, such as voice recognition software and computer generated voice, that many people dislike and that were likely to have problems at the start. The group responsible for implementing 511, WSDOT’s Advanced Technology Branch (ATB), knew that it would take several phases for 511 to become successful. Because funding was not available initially for WSDOT to purchase the top of the line voice recognition and computer generated voice systems, the ATB decided to implement the best system that it could afford and solicit funding for upgrades. That was why an implementation plan that kept the existing hotlines in operation for a trial period was chosen. Experience with callers using cell phones in cars

led to the conclusion that a touch-tone operation was needed (see 2, below) and most customer complaints disappeared when that option was implemented.

2. Voice-only technology doesn't work with cell phones all of the time because of background noise. Cell phone microphones are designed to pick up a large radius of sound because the microphone is not placed directly in front of the user's mouth. This means that background noises are also picked up. It is hard for voice-recognition software to separate the voice from the background. Having touch-tone capability prevents a great deal of user frustration.
3. WSDOT chose to purchase or lease the equipment to implement 511. Many other states chose to lease the service from a consultant as part of a pooled fund study. States using the Condition Acquisition and Reporting System (CARS) were able to pay a monthly fee, based on call volume, to participate in a consultant-developed 511 system. WSDOT is part of the CARS pooled fund study and uses CARS to deliver information to its 511 system, but WSDOT chose to build the software interface and own the hardware that handles 511 calls. This approach resulted in a large initial purchase cost for 511 but relatively low monthly charges. The total 511 implementation cost was approximately \$1.4 million, and the cost to operate and maintain the system for the 07-09 biennium was \$724,000. While the implementation costs for the other 511 approach are not available, a management review of the two approaches conducted several years ago determined that there was not much difference in life cycle costs, based on current call volumes, between the two approaches. As systems improved and call volumes increased, several of the states that implemented the pay for service approach were considering purchasing their own equipment.
4. As of September 2007, 511 systems were operational in 29 states, and eight more states were expected to implement systems in 2008. The 511 system was expected to be accessible by 65 percent of the U.S. population by 2008. There is no doubt that an easy to remember, national number for traveler information is a good idea. WSDOT chose to be in the forefront of the effort to implement 511. It is unfortunate that it did so, however, without the full commitment of the agency to make the transition to the new technology as easy possible for the users. While WSDOT was not one of the first to implement 511, it was one of the first to implement a statewide system and to provide near-real-time congestion updates for Seattle area freeways over the phone. Instead of publicizing this significant achievement and helping its customers make the transition to the new system, WSDOT took almost a year, after the initial deployment of the system, to install signs and provide information to the media on 511.

APPENDIX A: INTERVIEW/QUESTIONNAIRE TEMPLATE

A. Project Background

- a. Describe your position
- b. How were you involved with this project?
- c. What were the primary issues that prompted the development of this project?
- d. What were the primary objectives of this project?
- e. Were there other participants in this project besides WSDOT?
 - i. What were their roles in the project?
- f. What was the approximate cost of the project?
- g. Do you have any information on operating, maintenance or life-cycle costs?

B. System Features

- a. What existed before?
 - i. If something existed, how was it incorporated into the new system?
- b. What was originally planned to be built?
- c. What was actually built?

C. System Operations

- a. How is the system used?
- b. Who uses it?
- c. How often is it used?
- d. Who operates and maintains the system?
- e. What levels of staff support and funding are required for O&M?

D. System Usefulness

- a. Does the system meet its original objectives?
- b. Are all parties satisfied with the system?
- c. What are the strengths and weaknesses of the system?
 - i. Was anything done to improve the weaknesses?

E. Public Response

- a. Does the public have access to system?
 - i. If so, are data available on usage?
- b. Have there been any comments from the public concerning the project?

F. Project Management

- a. Have there been any project management issues that affected the scope, budget or schedule?
 - i. If so, what are they?
- b. Was the project completed on time and within budget?
 - i. If not, why not?
- c. Were any ITS standards used on the project?
- d. Was the ITS architecture used in the planning, development or deployment of the project?

G. Lessons Learned

- a. Is there anything you would have done differently on this project?
- b. Are there any suggestions for those considering future projects of this type?
- c. Is there anyone else that we should interview about this project?

APPENDIX B: PREVIOUS EVALUATIONS OF THE WSDOT ROAD AND WEATHER INFORMATION SYSTEMS PROGRAM

Boon, C.B., and Cluett, C. March 2002. *Road Weather Information Systems: Enabling Proactive Maintenance Practices in Washington State*. Washington State Department of Transportation. WA-RD 529.1

Cluett, C., Kitchener, F., Frevert, B., and Conger, S. November 2003. *Evaluation of Rural ITS Information Systems along U.S. 395, Spokane, Washington*. U.S. Department of Transportation ITS Joint Programs Office, Report 13955.

Senn, L., and Boselly, E. *ARROWS Evaluation*. February 2005. Washington State Department of Transportation. WA-RD 608.1

APPENDIX C: FEATURE SETS*

1.1 Feature Sets: The following is a list of features that have been developed and approved by the personnel from the traffic management centers of the six WSDOT regions. The feature sets are categorized in the following areas:

- Messaging
- Scheduler
- Status
- Logs
- Maps
- Beacons
- Security, Site and System
- Software
- Hardware

Each of these is explained below.

1.1.1 Messaging

1.1.1.1 Features such as stop, pause, playback, delete, import, append, cut, paste, copy, convert, rewind and fast-forward.

In message preparation, the operator should be able to use soft controls that are similar to those on any standard cassette recorder.

1.1.1.2 Text to speech software, concatenated synthesis. Use of text to speech would allow consistent audio to be delivered to each HAR. Due to unique Native American location names in Washington State, the speech engine shall pronounce these names correctly. Hyphenation, misspelling or any distortion of the actual spelling of the names will not be allowed. New names added to the library shall be available to each operator.

* Note that this is an edited version of the original that was provided to vendors.

1.1.1.3 Automatic message assembly and activation by various sensory inputs (third party generated text files). This function, used in conjunction with text to speech software, would allow messages to be automatically sent to the appropriate HAR. The placement of the message at the appropriate HAR should be automatic, with or without operator assistance. In all instances, the operator shall be allowed override capabilities.

1.1.1.4 Uniform library based on repetitive incidents. The library database shall be structured for ease of message preparation and editing. The library shall be manipulated from sources such as a relational database or any other means to provide consistency. The library will allow for the addition of new messages and the editing or deletion of any message.

1.1.1.5 Multiple message combining. Allows different events to be grouped together. The system shall allow the combination of messages of different content that can be sent to an associated HAR.

1.1.1.6 Message multicasting. Allows broadcast of the same message over multiple selected HARs (Amber Alerts). The system should be able to send the same message to a selected number of HARs simultaneously. The addition or deletion of a HAR from the selection shall be possible.

1.1.2 Scheduler

1.1.2.1 Automatic station ID. As required by the FCC, all HARs will be identified by their call sign at half-hour intervals beginning at the top of the hour. This identification message should be generated by a device at the HAR or by a system function. It should not interfere with the message broadcast. A voice ID should be an option.

1.1.2.2 Extended calendar for advance scheduling. The system shall include an intuitive calendar that is the system calendar at each workstation which allows the scheduling of a date and time for messages to be broadcast.

1.1.3 Status

1.1.3.1 Current message being broadcast. The system shall have the capability of showing the current message being broadcast on the selected HAR.

1.1.3.2 Real-time HAR operational status. The condition of the HAR should be able to be assessed by some method. Operational checks would be performed to determine such things as transmitted or reflected power, condition of the charging source, whether the cabinet door is open, etc.

1.1.3.3 Deactivation of any HAR when not in use and seamless reactivation. Individual HARs should be capable of being turned off by the TMC operator. In the event of a loss of audio, creating a dead carrier, the deactivation of the HAR should be automatic when the transmitter is on for over 30 minutes to adhere to FCC regulations.

1.1.3.4 Actual broadcast message monitoring in TMC. The TMC should be capable of monitoring the actual message being broadcast.

1.1.4 Logs

1.1.4.1 Historical archiving of messages, operational events, user access, etc. The system should allow pertinent information to be saved for further use. Such record keeping should allow for the verification of the message transmitted by a particular HAR at some specified time. Additional information such as user access and whether the log was turned on or off, should also be available.

1.1.4.2 Historical archiving of technical status of individual HARs.

The system should archive any additional functions that would provide a history of the HAR performance or any recorded failures.

1.1.5 Maps

1.1.5.1 Region map showing HAR and beacon locations. Each of the six regions should have a scalable map showing the locations of each HAR and their associated beacons.

1.1.5.2 Mouse-over showing text box of exact HAR station and beacon location and status. Each workstation in the system should be capable of showing the status of a particular HAR by simply running the mouse over the location on the screen.

1.1.5.3 Click-on for HAR station control, programming and scheduling. Each workstation in the system should, when the mouse is clicked on a particular site, bring up a menu to use for programming and other functions.

1.1.5.4 Regional interactions and monitoring of other regions.

The system should provide for interaction with other regions as well as a centralized WSDOT point to be determined. This will allow data sharing. This interaction shall not be disruptive when used for informational purposes. The ability to control one region's HARs from another shall be available. This will allow flexibility when using the HARs during an emergency.

1.1.6 Beacons

1.1.6.1 Beacons should be able to be controlled independently, as a group, or tagged to a schedule or message. Flexibility in beacon activation should be available.

1.1.6.2 Transmitting operational status. The system should be able to monitor certain functions of a beacon, such as the loss of power, malfunction of lights, etc.

1.1.7 Security, Site and System

1.1.7.1 Site security monitoring and reporting of unauthorized intrusion. The system should have a feature that can send alarms to the TMC in the event of an unauthorized entry.

1.1.7.2 Password access for operational and technical control, level dependent. System shall provide level dependent access.

1.1.7.3 Encryption requirements if IP protocol used. Vendors shall provide detailed information, if available, on how to provide proper protection of the system from outside access.

1.1.8 Software

1.1.8.1 Operates in standard Microsoft Windows environment.
The system shall operate using Microsoft Windows 2000 and Microsoft Windows XP

1.1.8.2 User defined screen configurations. The system should allow individual operators to configure screens for things such as color, size, etc., according to personal preferences.