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ATIS Evaluation

ATIS EVALUATION FRAMEWORK

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SECTION 1: INTRODUCTION

PURPOSE

Evaluations of federally funded intelligent transportation system (ITS) deployments are required as part of the partnership agreement between the United States Department of Transportation (USDOT) and the local agency receiving the funding. The evaluation component of each agreement is a local self-evaluation funded as part of the overall project budget. These evaluations study how successfully the project met its objectives and what implications the project results might have for future ITS deployments.

This report documents the results of a series of ITS project evaluations performed for the Washington State Department of Transportation (WSDOT). Five Washington state advanced traveler information system (ATIS) projects selected for federal ITS funding in FY 1999 required a local self-evaluation. Four of the projects provide traveler information with similar techniques [highway advisory radio (HAR), variable message signs (VMS), and road weather information systems (RWIS)] in different environments. One project focuses on heavily traveled mountain passes, while a second project focuses on travelers to a ferry terminal. A third project involves a freight corridor between the U.S. and Canada, while another project involves corridors heavily used by recreational travelers. The final project involves the expansion of a traveler information communications backbone with a fiber optic link to a traffic management center (TMC).

As part of this research project, a standardized evaluation approach was developed that can be used to evaluate the effects of state ATIS deployments. The required evaluations of the five ATIS deployments were used as an opportunity to develop and test the standardized ATIS evaluation framework. The combined evaluation development process and project evaluations were designed to meet the following objectives:

- Create a straightforward evaluation process for ATIS projects that can be applied easily and that results in findings that are easily communicated.
- Gather lessons learned and guidelines for developing and operating an ATIS system.
- Explore methods to evaluate system performance and quantify the benefits so that the value of these kinds of investments can be generalized, at least within specific environments.
- Support “mainstreaming” of ITS, i.e., facilitate the process by which ATIS applications can be considered and funded as part of the normal transportation investment process.
- Add to the industry’s understanding of the impact of ATIS investments on transportation systems and users.

This project proposed a methodology for evaluating ATIS projects to address the above objectives. The methodology was then used to assess five ATIS projects in Washington state. On the basis of the results of the five project evaluations, lessons learned and guidelines for planning and operating ATIS systems were developed to provide a better understanding of ways to approach future ATIS projects. In addition, a general approach for quantifying the benefits gained from the projects was explored.

PROJECT OVERVIEW

The methodology developed in this project was tested through the evaluation of the following five WSDOT ATIS projects:

Project	ATIS Components
Ferry Terminal Traveler Information	• VMS • Web (CCTV/Real-Time Status)
SR 101 Traveler Information	• HAR • Web (RWIS/CCTV)
SR2 and SR97 Traveler Information	• HAR • VMS • Web (RWIS/CCTV)
SR 395 Traveler Information	• HAR • Web (RWIS-ESS/Cameras)
Tacoma TMC Enhancement	• Fiber optic link

Edmonds Ferry Terminal

The main objective of the Edmonds-Kingston Ferry project was to install comprehensive traveler information systems to inform ferry system users about delays and congestion on ferry routes. The goal was to improve safety and operations at the ferry terminals and on the highways leading to the holding areas and to enhance customer service by providing information to help customers make more informed traveler decisions. The ATIS elements consisted of two Web cameras on SR 104, a VMS on I-5 northbound, a VMS on SR 104, and a camera pointing at the VMS on SR 104 to display the message to website users and to assist the Traffic Operations Center (TOC) with monitoring the VMS messages.

SR 101

SR 101 on the Olympic peninsula is a corridor heavily used by recreational travelers. The objective of the SR 101 Traveler Information project was to provide travelers with traffic and weather information for the region. This information was designed to provide travel alternatives for travelers facing delays and to help support tourism in the area. The project included new RWIS, cameras, and HAR sites, as well as some retrofitting of existing RWIS and HAR sites.

SR 2 and SR 97

SR 2 and SR 97 include two heavily traveled mountain passes, Stevens Pass and Blewett Pass. The ATIS project installed a roadway information system to communicate weather, road surface conditions, and road closure information to the public and maintenance crews. The systems included cameras, RWIS sites, VMS, HARs, and an extension of power and communications systems. The RWIS information and camera images are provided to the public via an Internet website and linked to the WSDOT home Web page. WSDOT maintenance crews use this information to monitor changing conditions instantly to help them more efficiently manage the roadway surface. HARs were located at sites that enable travelers to receive traction information and to take alternative routes or other actions to avoid being delayed because of a road closure.

SR 395

SR 395 is primarily used by commercial vehicles and the general public traveling between Spokane and the Canadian border. ATIS systems were designed to provide information to these travelers regarding road conditions and weather status and to assist maintenance crews with operations. The project included two mobile HAR facilities, two RWIS-ESS (road weather information system environmental sensor stations), and a camera installation at an existing RWIS location.

Tacoma TMC Enhancement

The WSDOT Olympic Region is in the process of installing fiber optic cable for ATIS equipment along the I-5 corridor. This ITS earmark project installed a link from the I-5 and SR 512 interchange to the Tacoma Traffic Management Center. This link connects the TMC with the City of Tacoma fiber network and will be used to transmit video signals and traffic flow information from I-5 when the corridor project is complete.

EVALUATION APPROACH

The evaluation methodology developed consists of two components: lessons learned and benefit estimation. The lessons learned framework was used to review the development process (planning, design, construction) and operations and maintenance (O&M) for five ATIS projects, with particular emphasis on identifying technical, management, and institutional issues that could affect, or have affected, the successful implementation and operation of each project. This information was collected through interviews with a variety of stakeholders, project managers, and support staff, as well as reviews of project documents. Appendix A describes this methodology.

In addition, a methodology was explored to quantify the estimated benefits of traveler information systems in a way that could be used to support the transportation investment decision-making process. Previous ATIS evaluations in Washington, and ATIS evaluations in general, have not been designed to estimate quantitative benefits, partly because benefits can be extremely difficult to measure directly. As a result, the qualitative aspects of ATIS projects, such as customer acceptance and customer satisfaction, are far more likely to be measured than quantitative aspects such as safety and mobility benefits. This project reviewed previous literature evaluating ATIS and developed a basic methodology for estimating the benefits of ATIS information services. Appendix B describes this methodology research.

REPORT ORGANIZATION

This report documents the project tasks and findings in three categories:

Individual Project Reports

Section 2 – Edmonds ferry terminal traveler information project

Section 3 – SR 101 traveler information project

Section 4 – SR 2 and SR 97 traveler information project

Section 5 – SR 395 traveler information project

Section 6 – Tacoma TMC enhancement

Overall Observations and Conclusions

Section 7 – Technical and institutional lessons learned

Section 8 – Conclusions

Appendices

Appendix A – Methodology for qualitative measures

Appendix B – Methodology for quantitative measures

Sections 2 through 6 describe each of the five ATIS projects evaluated. Section 7 describes overall observations and lessons learned based on the combined evaluations of all five ATIS projects. The Conclusions section describes key results of the project and upcoming follow-up activities. The appendices describe the evaluation methodologies developed in this project.

Each individual project report (Sections 2 through 6) is organized according to the following categories of questions used in the interview process:

- Project background: Overview and objectives of the project
- System features: ATIS features of the project
- System operations and maintenance: Typical applications of the system, and maintenance procedures and experiences
- Public response: Feedback from the public and other agencies
- Project management: Issues during project planning, design, and deployment
- Notable observations: Specific observations or lessons learned that could have applications for future projects. These observations are presented in tabular form, with responses from project participants shown as examples. These observations were evaluated across all projects and summarized in Section 7.

SECTION 2:
EDMONDS FERRY TERMINAL TRAVELER INFORMATION

PROJECT BACKGROUND

Washington State Ferries (WSF) operates the largest ferry system within the United States, connecting the Olympic Peninsula to the I-5 corridor and eastern Washington, and providing access to islands within Puget Sound. WSF supports daily travel for many residents commuting within Puget Sound and is a major component of the tourism industry in the state. Over half the passengers each year are recreational travelers.

The popularity of the ferry systems has caused traffic safety and operations problems in the queues, at the terminals, and along the highways leading up to the holding areas. WSDOT and WSF have used striping and signage modifications to attempt to deal with these problems. However, the modifications were customized to each terminal instead of based on a standard. This lack of consistency in striping and signage made some ferry information confusing to the general public.

As an alternative approach to handling the queues, WSDOT and WSF sought federal ITS earmark funding to implement ITS solutions. The funding would be used to develop more uniform methods of signing, striping, and ITS systems at all ferry terminals in the state. These changes would improve safety and operations and enhance customer service by providing information in a consistent manner to help ferry customers make more informed traveler decisions.

Interviews regarding the project were conducted with the WSDOT project manager, WSF terminal and customer support staff, WSF operations, WSDOT Traffic Systems Management Center (TMSC) operations, and WSDOT maintenance.

A separate evaluation was also conducted by Battelle Memorial Institute to document the benefits of the ITS deployments. Its evaluation focused on the impact of ITS on ferry operation efficiency, safety, and customer satisfaction. Project participants often referred to results from the Battelle study during interviews.

SYSTEM FEATURES

The ATIS elements consisted of two Web cameras on SR 104, a VMS on I-5 northbound and on SR 104, and a camera pointing at the VMS on SR 104 to display the message to website users and to assist the WSF Traffic Operations Center (TOC) with monitoring the VMS messages.

The installed elements of this project differed from the original plans for the ferry terminal. WSDOT and WSF mutually funded the consulting firm CH2M Hill to develop a toolbox of strategies that could be applied to ferry terminals in Washington. The consultant used the Edmonds ferry terminal as a case study for the task. The goal of the study was to determine the problem areas at the terminal and develop strategies to address these issues. The study was not focused specifically on ATIS solutions. CH2M Hill outlined a toolbox of strategies, including both traditional improvements (signing, striping, roadway changes) and "non-traditional" changes (ATIS).

The original scope of the project involved closing down the Pine Street intersection with SR 104 near the ferry dock, improving signage and striping in the area, and removing the curb and gate of the holding lane by the ticket booth. The ATIS component of the design effort was to be the installation of two traffic cameras along SR 104 to provide traffic information on the WSF website and to assist with traffic management of the queues. Project stakeholders including the WSDOT, the Edmonds Parks Department, and the Edmonds City Police identified Pine Street as the main source of traffic management problems related to the ferry queue. Many minor incidents had occurred as a result of vehicles cutting in line and dangerous traffic maneuvers at this intersection. During the design effort, public outreach and coordination with the stakeholders began in order to bring the issue of closing Pine Street before the City Council. The residents on Pine Street were supportive of closing the intersection, since their neighborhood faced many problems with ferry traffic. However, travelers who used the route to access the neighborhood on the other side of the intersection did not want to close Pine Street. The closure would result in additional driving time in their commute. The decision pitted neighborhood versus neighborhood and caused problems with the City Council. The City Council denied WSDOT its request to close the Pine Street intersection.

While dealing with the issues surrounding Pine Street, the design team began to consider additional options in case the initial recommendations by CH2M Hill did not work as planned. When the City Council denied the request for the Pine Street intersection, the project scope changed to focus on ITS improvements. WSDOT looked for additional funding for the terminal improvements and was successful in receiving the ITS earmark. Changes were then made to the design plan to incorporate other ATIS elements. The traveler information system eventually built consisted of the following components:

1. two full-motion video cameras at SR 104/Pine Street
2. VMS at SR 104/102nd Place West
3. a snapshot video camera at SR 104/102nd Place West pointed at the VMS sign to assist with monitoring message status
4. a video camera transmitter at SR 104/Dayton Avenue
5. VMS near south 145th Street Northeast on I-5.

Figure 1 displays a map of the Edmonds area and the locations of the new devices.

SYSTEM OPERATIONS AND MAINTENANCE

The ATIS components are used primarily to provide traveler information for ferry users. The VMSes on SR 104 are primarily used to display ferry delays, wait times over one hour, construction notices, and schedule changes. The VMS on I-5 is used for accident and construction information, particularly when lanes are closed on the interstate. It is only utilized for the ferry system in the event of serious delay. The cameras allow ferry users and WSF operations to view the status of ferry traffic through the WSDOT and WSF website.

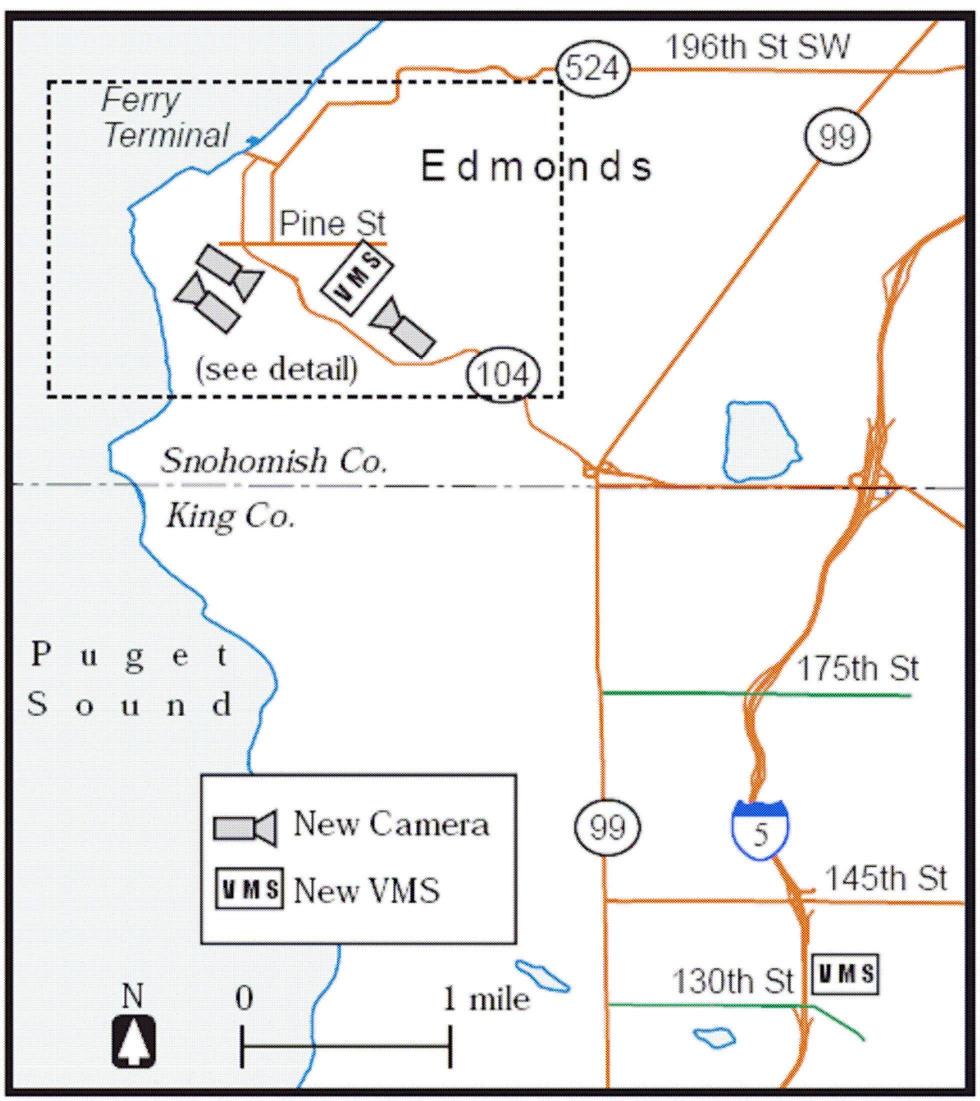

Figure 1. Edmonds ferry project deployment

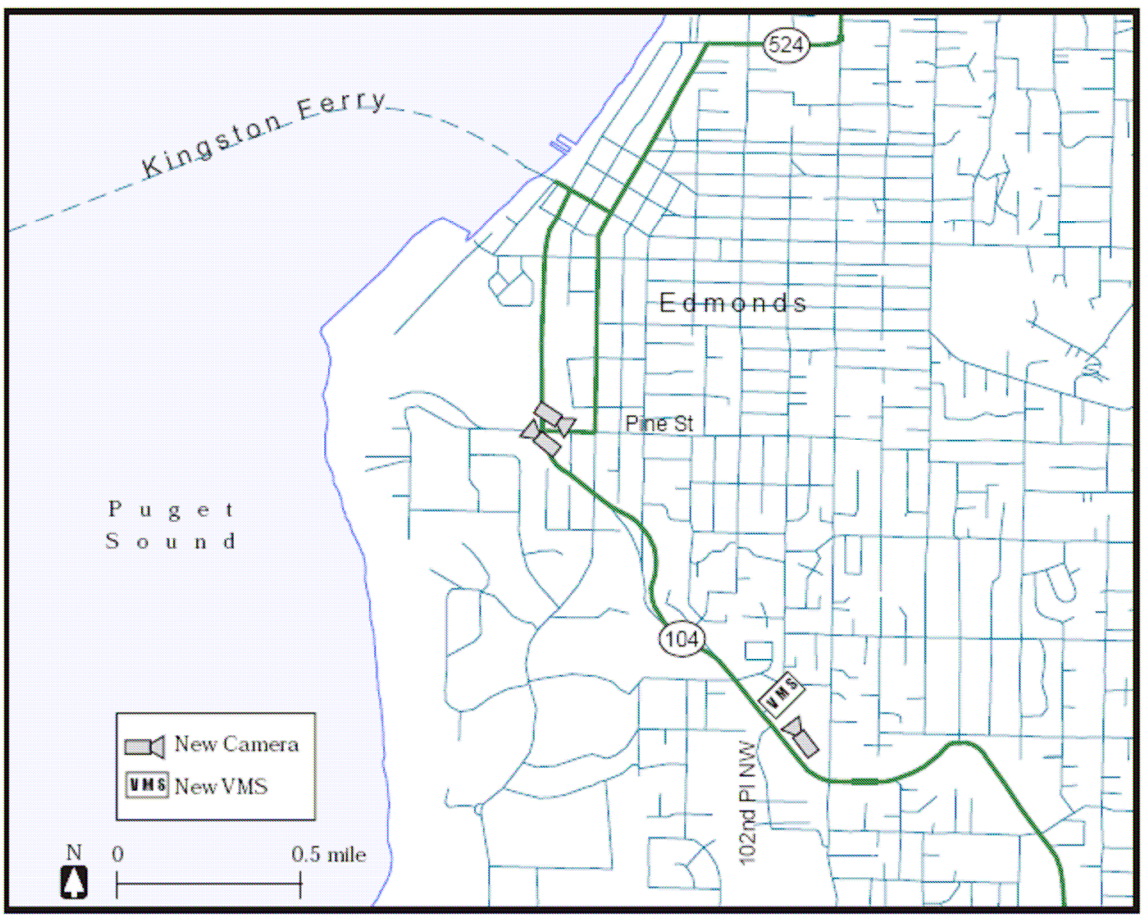

Figure 2. Edmonds ferry project deployment (detail)

Operations

The WSF TOC is responsible for posting messages to the VMS on SR 104. Terminal agents view the cameras and contact the TOC with traffic status. The TOC is also capable of checking the camera images through the WSF website. The cameras at Pine Street and the overpass leading to the terminal are helpful for determining wait time. The TOC uses previous knowledge of the wait times associated with different lengths of queues; if a camera shows a back-up to a certain location, the TOC operator can estimate the wait times on the basis of previous experience. In the past, queue lengths were estimated by employees on their way to work or a patrol officer driving to the back of the queue. The installation of the camera system allows the on-site supervisor and TOC staff to determine wait times. Meanwhile, the TOC also monitors radio communications and vessel movement for information on delays or vessel problems. The operator uses all of the available information to estimate ferry delays and posts a message to the VMS through a dial-up connection.

In the event of serious delay, the TOC can contact the WSDOT Northwest Region TSMC regarding information to be posted to the VMS on I-5. The WSDOT TSMC shares a control room at the Northwest Region with the Radio Dispatch Center. The radio operators are responsible for communicating with maintenance, emergency phones, construction offices, incident response teams, and the State Patrol. When WSF TOC determines that a message is necessary, the operator contacts the Radio Dispatch Center to request a message on the I-5 VMS. If the conditions appear to warrant the message and the VMS is clear, flow operators will post it immediately. If the message includes a specific alternative route, the operator needs clearance from a DOT supervisor. If a message is already on the I-5 VMS, a multiple phase message can be used. The TMSC prioritizes the VMS messages for I-5. WSF will usually call the Radio Dispatch Center when it would like the message terminated. The TSMC relies heavily on WSF input for ferry status information, and its operators rarely monitor the ferry system themselves.

The frequency of use of VMS varies depending on season and time of day. The ferries are the busiest during the summer months, especially on holiday weekends. During the summer, the VMS message can change every 2-3 hours. Sign usage is more sporadic during the rest of the year, occurring mainly on the weekends. Weekday messages mainly give information regarding construction or breakdowns because there is usually little heavy traffic during those periods.

Maintenance

An operations and maintenance (O&M) agreement exists between WSDOT and WSF. WSF had recently completed its TOC and would have needed additional equipment and trained staff in order to provide O&M support for the new ATIS devices. WSDOT already had the expertise and maintenance equipment necessary for the role through the Northwest Region TSMC, and the additional effort and cost for maintenance was marginal for the TSMC. Given these circumstances, WSDOT agreed to provide maintenance for the devices within the terminal area. WSF is still responsible for all labor and maintenance costs and reimburses WSDOT for the work within the terminal area.

The WSDOT ITS maintenance staff and WSF personnel concur that the O&M agreement has been very successful. Terminal Operations usually e-mails ITS maintenance with requests for WSF equipment maintenance. All other ITS devices are monitored on computers in the ITS maintenance office. Depending on the level of urgency of the maintenance required, crews either leave that day or the following morning.

Maintenance problems reported by staff often relate to the central computer used for data collection and transmittal, rather than problems with the VMS or cameras. A contract is in progress to update the system and replace it with a newer computer, but several years will probably be necessary to work through the updates.

When device problems occur, the maintenance staff uses O&M manuals that outline the equipment and specifications at each site. The ITS maintenance staff developed reference manuals for all projects that include maps of the sites, as-built descriptions, and equipment information. These manuals can be referenced when maintenance is performed at a site. Typically, while crew members are at a site fixing a problem, they also conduct a standard preventative maintenance check of the equipment, cabinet, and grounds.

ITS maintenance staff expressed concern regarding the use of consultants for design, construction, and equipment installation. The consultants on a previous ferry project did not consult with WSDOT maintenance for support. This lack of communication created a disconnect between the components of the system designed by consultants and the capabilities of WSDOT for maintenance. These differences were especially apparent when repairs or replacement were necessary, since WSDOT did not have supplies for repair or spare equipment. The consultant's system was also not fully compatible with other WSDOT ITS elements. Although the current project was completed in-house, difficulties arose in technical integration with the consultant design. These problems potentially could have been avoided by coordinating with maintenance during the design process.

SYSTEM USEFULNESS

According to WSF staff, the new systems have met their original objectives by providing better customer service to ferry users and significantly improving terminal operations, particularly with regard to traffic and queue monitoring. Before the new system, dock agents at Edmonds would drive to the end of the queue to observe traffic and then notify the TOC of delays. Since implementation, terminal agents use the cameras to view traffic status. The TOC can also monitor the traffic status directly and make changes to the VMS. This change reduces the burden on terminal agents to monitor the queues.

PUBLIC RESPONSE

Typically, public feedback occurs only when a system is not working properly, as opposed to positive feedback from customers using the system. An independent evaluation conducted by Battelle determined that the public finds the information about delay and schedule changes helpful. In addition, WSF staff reported that the WSF website receives user visits indicating that commuters are checking the cameras before leaving home or work.

PROJECT MANAGEMENT

A number of agencies were involved in the management of the ferry ATIS project. WSDOT operated as the lead agency and had a role in the background study, planning, design, and construction, and it continues to assist with operations and maintenance of the systems. WSF worked with the WSDOT Northwest and Olympic regions to develop a task assignment for the ferry project. WSF and WSDOT mutually funded a task study by independent consultant CH2M Hill to develop a toolbox of strategies for ferry system improvements that could be applied consistently at all locations. The Washington State Patrol (WSP) is under contract with the ferry terminals to patrol the area and monitor safety. WSP subcontracts the task to Edmonds City Police, but the role remains funded by WSF. The City of Edmonds Parks Department, Public Works, and City Police were all involved in talks with the Edmonds City Council regarding adjustments to the road leading to the ferry terminal. The large number of stakeholders required effective communication during the design process; open communication lines continue to provide benefits for operations and maintenance.

NOTABLE OBSERVATIONS

Table 1. Notable observations from the Edmonds Ferry Terminal Traveler Information project

	PROJECT EXAMPLES
MAINTENANCE	
Role of maintenance	▪ Maintenance was required to modify or replace some of the initial equipment to make the devices compatible with existing technology.
Role of maintenance	▪ More communication with maintenance staff might have resulted in a more effective initial system. WSF had to pay WSDOT maintenance to make changes and improvements to the system after initial use.
Maintenance support	▪ Lack of adjustments to the as-built drawings makes it difficult for maintenance to trace out cable runs and find equipment.
Maintenance support	▪ The consultant on a previous project used incompatible equipment and set up the system differently from other WSDOT devices. These differences were especially apparent when repairs, replacement, and integration were necessary.
Maintenance support	▪ ITS maintenance staff's goal is to monitor system performance over time and track changes from the initial diagnostic test, instead of solely conducting preventive maintenance checks while at the site doing maintenance work.
Maintenance support	▪ The shoulder-mounted VMS installed on I-5 is easier and safer to access than an overhead-mounted VMS.
PROJECT MANAGEMENT	
Technology costs	▪ Maintenance was required to make changes and improvements to the ferry ATIS elements to make all components compatible.
Role of operators	▪ The operating process could be more user-friendly. The VMS verification process is cumbersome.
Role of stakeholders	▪ WSDOT and WSF worked with Edmonds City Council regarding the closure of the Pine Street intersection.
Role of partnerships	▪ An O&M agreement exists between WSF and WSDOT. WSDOT maintains WSF-operated ITS devices so that WSF is not required to expend the funds, effort, and time to develop that support capability for itself.
STAFF, TRAINING, AND SUPPORT	
Training support	▪ The daytime or peak period operators are the users who feel most comfortable with the process of determining an event, communicating the situation, and using the system to post messages. This group is not a 24-hour staff, so it would be helpful if the system were easier to use for the other support staff.
Role of vendors	▪ The software vendor does not have support staff working on the weekend, so WSF operations have no vendor contacts available during a weekend system failure.

	PROJECT EXAMPLES
Baseline (existing) infrastructure	▪ Because both WSF and WSDOT already have existing ATIS devices, support for the new devices could be folded into existing operations.
Technology	▪ Some minor software problems occurred when the equipment was first incorporated with the existing system.
CUSTOMER RESPONSE	
Traveler feedback	▪ Typically, public feedback occurs when a system is not working properly, as opposed to positive feedback from customers using the system
Traveler feedback	▪ An independent evaluation conducted by Battelle determined that the public finds the information about delay and schedule changes helpful.
Traveler and staff feedback	▪ The WSF website receives visits from commuters checking the cameras before leaving home or work, according to WSF staff. ▪ Terminal agents and the TOC use the cameras to monitor traffic status.
Staff feedback	▪ WSF employees are advocating the need for additional ATIS devices for the ferry service.

SECTION 3:
SR 101 TRAVELER INFORMATION

PROJECT BACKGROUND

SR 101 circles the Olympic peninsula and is heavily used by recreational travelers. During the summer months, traffic volumes on SR 101 increase by up to 50 percent. These travelers require quality traveler information to help locate and use area services. WSDOT had been in communication with various local representatives (North Olympic Peninsula Visitor and Convention Bureau, city council members, representatives from local chambers of commerce), discussing possibilities for providing traveler and tourism information. The objective of the SR 101 Traveler Information project was to provide travelers with traffic and weather information for the region, as well as alternatives for travelers facing delay. The deployment was meant to help manage traffic, promote tourism in the area and benefit local economies.

Interviews were conducted with the WSDOT project manager, operations staff, and WSDOT maintenance.

SYSTEM FEATURES

The SR 101 project included new RWIS, cameras, and HAR sites, as well as some retrofitting of existing RWIS and HAR sites. The project was conducted in phases in order to maximize the use of the budget.

The first stage of the project was the installation of two new RWIS sites and retrofitting of one existing RWIS site with a camera for remote weather verification. The existing site is on SR101 at milepost 215, west of Port Angeles. The two new sites are on

SR101 at mileposts 256.3 (between Port Angeles and Sequim) and 274.6 (east of Sequim near the junction with SR 20).

The next stage of the project was the development of a website. The original concept was a website for the North Olympic Peninsula containing ATIS information such as camera images, weather and roadway information, and HAR report access. The website would also contain links to tourist information in the region. WSDOT policy required all website information to follow a consistent design, however; so although the tourist website was designed and posted, links were removed from the WSDOT site. The traveler information is still available on the WSDOT traffic and weather pages but without the tourist links.

Deployment continued with the retrofitting of an existing HAR site on SR 104 near the Hood Canal Bridge with two new HAR signs with flashing beacons for traffic on SR 3 at milepost 56.6 and westbound SR 104 at milepost 13.3 heading toward the bridge. This HAR provides information about the status of the bridge and unusual ferry delays. Cameras were also installed on SR 3 at milepost 58.1 and SR104 at milepost 12.2 for detection of long delays due to extended openings of the Hood Canal Bridge. The information from these cameras is used to update the HAR message. A VMS already existed on SR 104, so the camera was placed on the VMS sign.

To manage the extended HAR system, updated HAR software was installed at the Olympic Region management center. The existing management system did not have sufficient staff or capacity for additional HARs; the upgraded system allows for better operation of the existing HARs and the expansion of the HAR network.

The final stage of the project was the installation of three new HAR sites along the SR 101 corridor. These sites are at the intersections of SR 101 with SR 20, SR 112, and SR 113. Each HAR site has two signs on SR 101, one in each direction of travel. The sites also have a third sign on the intersecting state route. All of the signs are approximately two miles away from the route junction to offer information to traffic heading in the direction of the intersection.

Figures 3 and 4 display maps of the SR 101 project area and the locations of ATIS devices.

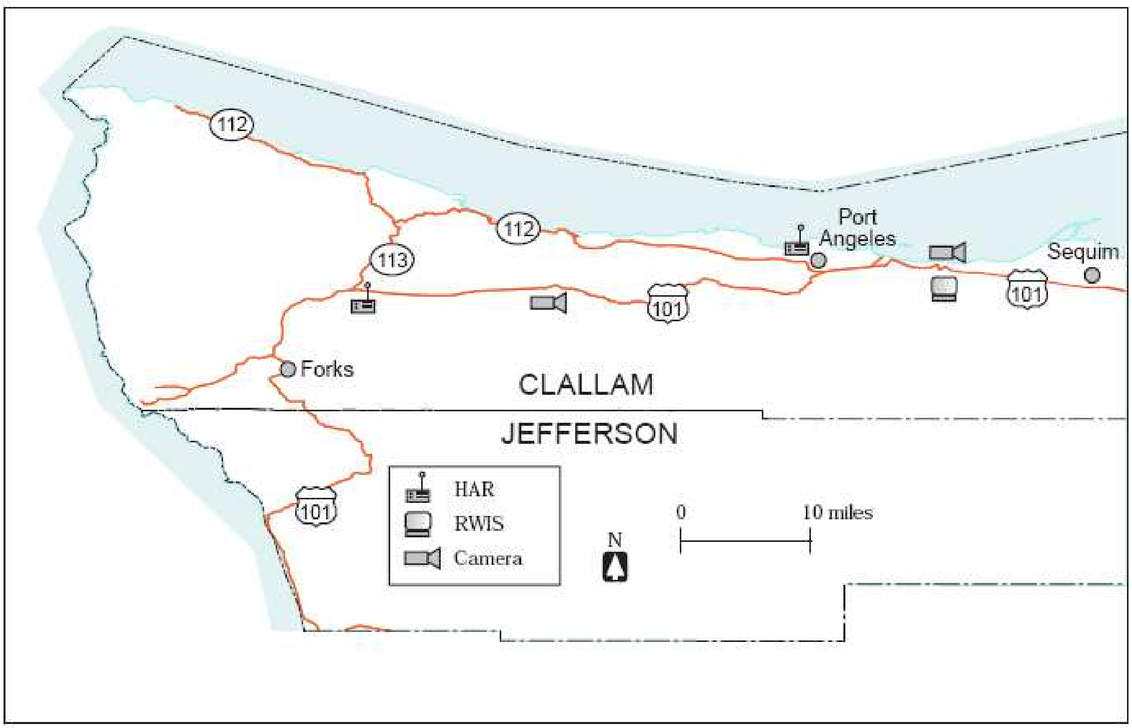

Figure 3. SR 101 project deployment (to the west of Sequim, Washington)

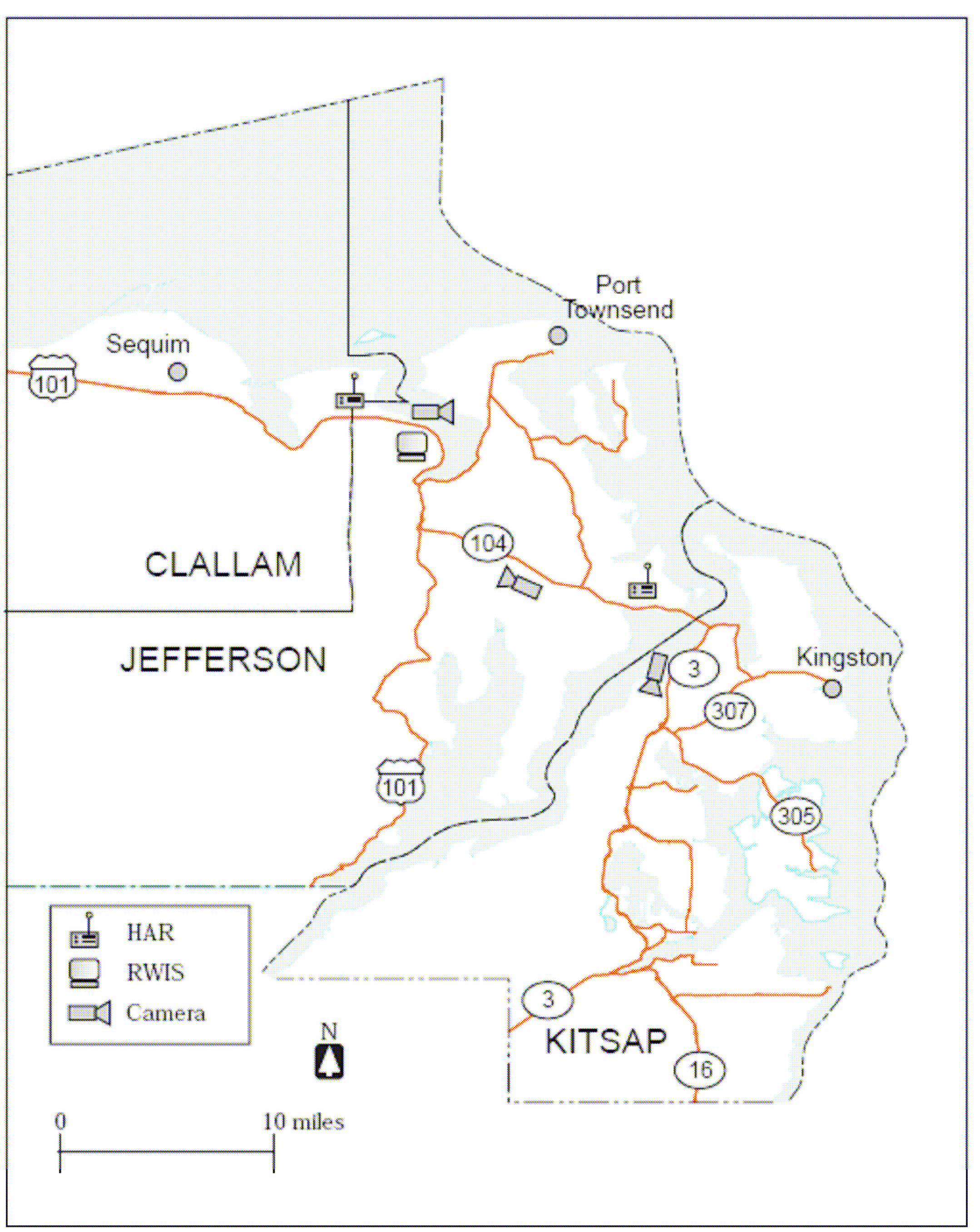

Figure 4. SR 101 project deployment (to the east of Sequim, Washington)

SYSTEM OPERATIONS AND MAINTENANCE

ATIS components on SR 101 are used to provide region-specific traveler information such as weather conditions, incidents on the roadway (accidents, road slides), extended openings of the Hood Canal Bridge, and ferry terminal information.

Operations

The Olympic Region management center in Tacoma is responsible for posting messages to the HARs and VMSes. Input for messages regarding road closures and conditions usually comes from maintenance crews. The Washington State Patrol (WSP) provides information about traffic and accidents. Operators at the management center can also use automatically updated information from RWIS installations and images from the cameras. When maintenance or the WSP contacts the management center, operators determine which messages are appropriate and can often choose from pre-recorded HAR broadcasts. Each message is devised to communicate specifics about the situation, explaining the type of situation and the location (e.g., accident or closure at milepost, road). The turnaround between the time when a HAR request is placed to the time when the message is in service is usually about five-minutes. When a new type of message needs to be posted, the management center may take more time to determine the appropriate generic message to explain conditions or advise caution. The timeframe for postings is dependent on the situation and changes in condition.

Maintenance

WSDOT Olympic Region maintenance covers the management and operations of 600 lane-miles to ensure the safety of the traveling public. ITS maintenance is a separate division. Most maintenance issues with the new SR 101 traveler information system resulted from typical bugs in installing a new system, as well as determining what the system is capable of and how to use the information. It also took some time to train operators how to use the devices. The HAR sites on SR 101 and the junctions with SR 112 and SR 113 were placed in remote locations without much existing infrastructure. This required integration to get the systems up and running and linked to the region's infrastructure, but the integration was relatively seamless.

Soon after implementation, a camera on an RWIS sign went out of service, leaving the RWIS functional but lacking camera verification. The equipment had no back-up support and needed to be sent away for repair; it eventually took three months to fix the device. The Department has now acquired a back-up camera to avoid this problem in the future. Additional back-up equipment would be useful to have.

Maintenance crews rate the HAR and RWIS as at least 90 percent reliable. Occasionally the devices are out of service because of server and connection problems, but these issues are very infrequent. Overall, the planning and design for this project was very specific about equipment selection and specifications. The equipment is considered "maintenance-free," and after the bugs were initially worked, it has only required routine preventative maintenance.

SYSTEM USEFULNESS

HAR systems are typically used to broadcast information about accidents and weather conditions, and to notify travelers of road closures as a result of accidents and slides. The maintenance staff reported that the equipment meets all of the expected requirements and provides information on a consistent basis. The maintenance group would like to see additional HARs in the area. HAR has performed well with no complaints. It is easy to use and does not require much training for operation. The device can be controlled by a cell phone, with a simple phone call to turn the system off. Maintenance staff has not encountered any transmission problems using 800 MHz radio and cell towers. RWIS can be verified by camera images on the Internet to ensure that it is providing accurate information about road conditions.

The maintenance crew has found the equipment very useful for notification about inclement weather and roadway information. SR 112 and SR 113 frequently experience slides during the rainy season that require road closures and maintenance clean-up. Maintenance has a direct Internet link to the weather data from the RWIS at the junctions of SR 101 with these routes. This link provides more detailed information about roadway temperatures and conditions than the public WSDOT website. The cameras provide access to images of the roadway so maintenance can assess conditions and verify RWIS. The maintenance staff uses this information to forecast road problems and determine when anti-icing is necessary in the winter. This procedure saves the time of driving the 30 miles to the location to check conditions. Deicing liquids are widely used throughout WSDOT, making it useful to know the status of the road to develop a schedule for deicing procedures.

The maintenance staff requests HAR broadcasts to notify travelers of slide locations and road conditions. Because there are few alternative routes in the region, HAR is very useful for warning travelers about conditions to help with travel decisions. The information also saves time for the maintenance office because it has reduced the number of phone calls from travelers requesting roadway information and explanations of back-ups. The maintenance office would like more of this equipment to be installed and more widely dispersed throughout the region.

PUBLIC RESPONSE

WSDOT has received positive feedback about the ATIS from the general public, the Olympic peninsula community, and commercial vehicle operators. The Department has received e-mails with positive comments about being able to view road and weather conditions via the Web. Motorists occasionally stop on the roadway and thank WSDOT workers for the new systems. They often refer to specific times when they were able to change their route because of HAR information and arrive at their destination on time. The maintenance office also receives phone calls from people who have been sent to the website by other travelers and want to know where to find the information. Maintenance staff believes the public has grown to rely on the information from this equipment; if there are problems on the roadway and no information is posted, maintenance or the WSP receives calls requesting that messages be broadcast.

The Olympic peninsula stakeholders were initially very excited about the project, particularly the tourism website. Some people were disappointed when the website was not implemented as planned, but they understood WSDOT policy. The stakeholders are pleased that a statewide website with traveler information exists, and tourist information is still available through an Olympic Peninsula tourism website not affiliated with WSDOT. According to some project participants, the regional tourism page probably would not have been implemented without the influence of this project.

Trucking companies have also given WSDOT positive feedback about the system. The commercial vehicle operators use the weather and road condition information to schedule the dispatch of vehicles and determine when to load chains for dangerous road conditions.

PROJECT MANAGEMENT

Both the project managers and the maintenance crew emphasized the need for communication with the Maintenance Office during all phases of the project, including planning, design, construction, and operations. Maintenance crews are familiar with the rural area's roadway and weather conditions and can provide input that a design group 60 miles away from the site does not necessarily know. Initially, the Maintenance Office was informed that the project was occurring, but the design team determined the locations for the equipment. The maintenance crews would have preferred to have had some of the equipment at other locations.

In addition, secluded locations were chosen so that the system would not be noticeable to the public and to hopefully discourage vandalism. These locations required extra equipment for power and communication. Maintenance crews had to travel to remote locations to fix problems. The fences around the devices did not provide protection because vandals could cut through the fence in the secluded area without being noticed. Last summer, the solar panels for three HARs were stolen, with a replacement cost of $15,000 per location.

The project was completed within the original budget, but that required sacrificing the project timeline. The RWIS, HAR, cameras, and flashing signs were installed in stages, which allowed for maximizing the budget. Another source of schedule change was the precision taken in choosing equipment vendors so that the systems could be integrated seamlessly with the existing infrastructure. The time necessary to find a successful vendor for HAR slowed project progress.

NOTABLE OBSERVATIONS

Table 2. Notable observations from the SR 101 Traveler Information project

	PROJECT EXAMPLES
MAINTENANCE	
Role of maintenance	▪ The project manager advocates involving maintenance in all phases of the project, including design, construction, and operation. He believes that communication between maintenance and project management is one of the main facets of project success.
Role of maintenance	▪ Maintenance is familiar with the rural area's roadway and weather conditions and can provide input that a design group 60 miles away from the site does not necessarily know. If asked, maintenance crews would have put two of the three RWIS in different locations.
Maintenance support	▪ The information provided saves time for the Maintenance Office because it has reduced the number of phone calls from travelers requesting roadway information and explanations of back-ups. ▪ The Maintenance Office uses the cameras on the RWIS to view road conditions at the sites. This procedure saves the time of traveling to the location to determine conditions. RWIS also provides road temperatures to aid in determining when to apply chemicals for deicing.
Benefits to maintenance	▪ The Maintenance Office was initially unclear about the capabilities of RWIS but now utilizes the information regularly.
RURAL DEPLOYMENT	
Implementation costs	▪ The sites were built in remote areas without any power. These locations required extra equipment for power and communication. They needed to be equipped with solar panels and batteries.
Implementation costs	▪ Secluded locations were chosen so that the systems would not be as noticeable to the public and would hopefully discourage vandalism. The fences around the devices did not provide protection because vandals could cut through the fence in the secluded areas without being noticed.
Rural benefits	▪ SR 112 and SR 113 frequently experience mudslides during the rainy season. ▪ Throughout the winter and spring there are usually a lot of accidents. The State Patrol uses the devices to advise traveler caution.
Rural benefits	▪ The maintenance staff uses the weather page and the RWIS information to forecast road problems and determine when it should apply deicing chemicals.
PROJECT MANAGEMENT	
Implementation costs	▪ The HAR sites on SR 101 and the junctions with SR 112 and SR 113 were placed in remote locations without much existing infrastructure. This set-up required integration to get the systems running and plugged into the region infrastructure.
Vendor considerations	▪ A source of schedule change was needed to choose equipment vendors so that the systems could be integrated seamlessly with the existing infrastructure. It took time to find a successful vendor for HAR, which slowed down the project progress. ▪ The vendor of the RWIS equipment made a successful bid for the project, but WSDOT did not look closely enough at the fine print. WSDOT requires a licensed electrician to install all equipment and the vendor did not have anyone licensed available. It cost extra money to get a licensed electrician to do the installation. The contract was revised to avoid future similar problems with installation.

	PROJECT EXAMPLES
Implementation costs	▪ The project was completed according to the original budget, but in order to match the budget, the timeline was sacrificed. The RWIS, HAR, cameras, and flashing signs were installed in stages. The stages allowed for maximizing the budget.
Role of stakeholders	▪ Getting input from regional public agencies was very helpful for the project. It was difficult to organize the meetings with the large group of stakeholders and the variety of ideas. Often, WSDOT needs conflicted with community needs. Overall, though, the stakeholders were able to work through issues, and everyone was very cooperative with the planning.
STAFF, TRAINING, AND SUPPORT	
Training support	▪ A camera at an RWIS site became inoperative, leaving the RWIS functional but lacking camera verification. The equipment had no back-up support and was sent away for repair. It took the vendor 2-3 months to fix it.
Technology	▪ Most technical issues resulted from typical bugs in installing a new system and determining what the system is capable of and how to use the information.
CUSTOMER RESPONSE	
Traveler feedback	▪ The Olympic Peninsula community provided feedback indicating excitement about the availability of traveler information. The Department receives e-mails with positive comments about being able to view road and weather conditions. ▪ Motorists stop on the roadway and thank WSDOT workers for the new systems. They often refer to specific times when they were able to change their route because of HAR information and arrive to their destination on-time. ▪ Maintenance claims the public has grown to rely on the equipment. If there are problems on the roadway and no information is posted, the public calls maintenance or Highway Patrol to tell it to broadcast messages.
Traveler and staff feedback	▪ The cameras provide access to images of the roadway so that maintenance can assess conditions and verify RWIS. ▪ The maintenance office receives phone calls from people who have been sent to the website by other travelers and want to know where to find the information.
Staff feedback	▪ The maintenance office wants more of this equipment and for it to be more widely dispersed throughout the region. ▪ The Department would like to see additional HAR in the area. It is easy to use and does not require much training for operation. ▪ There are not enough devices to provide all of the useful information. The Department has made requests for new HAR and RWIS. Five new RWIS are slated for installation in the Olympic Region.

SECTION 4:
SR 2 AND SR 97 TRAVELER INFORMATION

PROJECT BACKGROUND

SR 2 and SR 97 include two heavily traveled mountain passes, Stevens Pass and Blewett Pass. These passes connect north central Washington to Western Washington and are particularly significant during the winter months when high snowfall and avalanche closures affect other pass locations. Interstate freight and local tourism on the routes are dependent on accurate traveler information.

The objective of this project was to augment and improve traveler information systems to communicate weather, road surface condition, and road closure information to the public and maintenance crews.

Interviews were conducted with the WSDOT project managers and O&M staff.

SYSTEM FEATURES

The systems included cameras, RWIS sites, VMS, HAR, and an extension of power and communications systems.

SR 97 – Blewett Pass

Funding allowed for a camera to be installed at the Blewett Pass summit, along with power and communications capabilities. A generator was installed to provide power at the remote site, and the communications network was enhanced. In addition to the valuable camera image, the improved communications enabled access to data from the existing RWIS at the summit. An additional RWIS was also installed on the south side of the summit. A VMS and HAR were installed on the south side of Blewett Pass near the

SR 97 junction with SR 970. These devices are used primarily for route selection information. A VMS was also installed on the north side of Blewett Pass, primarily to provide chain-up information for travelers heading toward the summit.

SR 2 - Stevens Pass

The Stevens Pass implementation primarily utilized HAR technology. One HAR was installed on the east side of Stevens Pass near the Leavenworth maintenance shed. Another HAR was placed at the summit of Stevens Pass, in partnership with the Stevens Ski Area. WSDOT was responsible for installation. A camera had already been in service at the summit. A fiber optic and microwave connection to the existing Stevens Pass camera was set up to improve the speed of Stevens Pass picture and RWIS updates to the Internet. The fiber cable also provides a local connection to the HAR radio. Before the new connection, each individual component required a long distance phone call for updates. The cable allows for future expansion of ITS projects in the area. A portable HAR was also purchased and has been used in the winter at the Winchester Rest Area on I-90. This HAR primarily provides information to westbound travelers on I-90 regarding the conditions, restrictions, and closures on Snoqualmie Pass and Stevens Pass.

Figure 5 displays a map of the SR 2 and SR 97 project area and the locations of the ATIS devices.

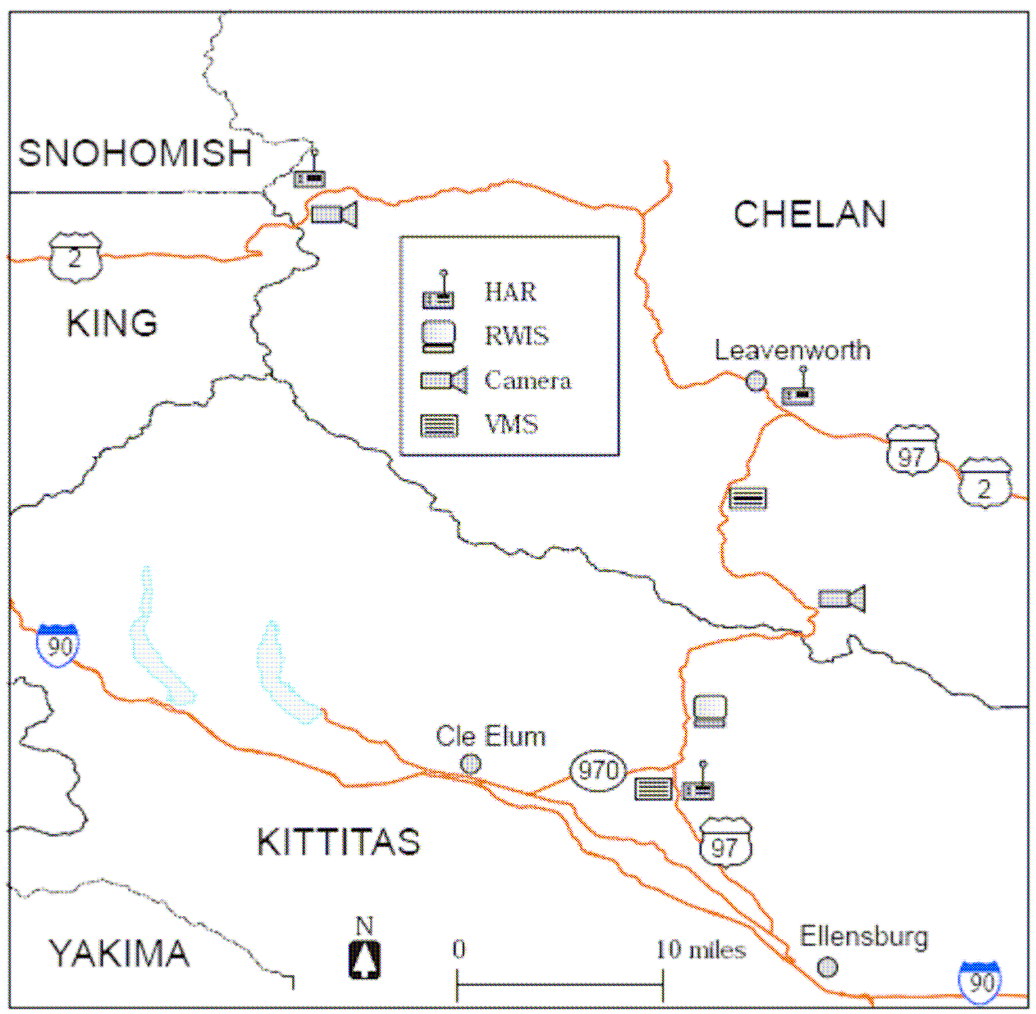

Figure 5. SR 2 and SR 97 project deployment

SYSTEM OPERATIONS AND MAINTENANCE

The VMS and HAR on Stevens and Blewett passes are typically used to provide chain requirements and roadway information. O&M effort has increased with the installation of the new equipment. The new systems were integrated with the existing system, although there was not much ITS equipment (three VMS and one HAR) before this project.

Operations

The ATIS devices are used primarily in the winter to inform travelers of road conditions and chain requirements. Maintenance and snowplow crews work with the WSP to determine whether chains should be required, as well as any other restrictions. The crews in the field pass on status reports and chain recommendations to the operators at the radio room in Wenatchee. From November to March, the radio room operates 24 hours a day, 7 days a week. During the winter, the VMS and HAR messages are updated at least every four hours. During the summer, the radio room in Wenatchee is open from 8:00 to 5:00 weekdays and the TMC in Yakima controls operations at night. The systems are used less frequently during the summer months. If no construction or accident information is required, the systems are left blank unless a specific incident such as a wildfire warning or Amber Alert emergency occurs. During the summer the traffic engineer must approve messages regarding public safety information and fire warnings from the Forest Service.

Accident and road closure information is posted immediately. The crew uses pre-recorded messages and makes changes based on the location of the incident. The media and Public Information Officer are notified to send out a highway alert. This process takes about 10-20 minutes. Messages are usually posted with a timeframe for termination. If the WSP is conducting a truck chain inspection, the message will have a start date and end date. With chain information, the posting is left until conditions change. Accident information updates are required every two hours or as soon as the TMC gets new information.

Interviewees repeatedly stressed the frustration of using a dial-up connection to change the messages. The systems utilizes the oldest software in the state, according to staff. It is very time consuming and requires a lot of work from the operator, especially during the winter season when signs can require 10 changes in a day. The dial-up is slow, and the computer occasionally locks up with a "Communications Error." Operators say that multiple calls are often required to get reach a device. After three tries, the operator will call the maintenance crews and ask them to change the devices manually with laptops at the site. The operating software is not user-friendly and the method of communication is often unsuccessful. Each HAR and VMS must be connected to separately through a dial-up connection. Operators would prefer an integrated software system that would allow them to post messages to more than one device at a time.

The operations center currently works out of the Maintenance Office, but it is being renovated with video cameras and new equipment and will become a TMC.

Maintenance

Maintenance crews have no complaints regarding their role in O&M. If an operator cannot connect to the site remotely from the computer, maintenance crews in the field go to the site and connect to the device directly. Maintenance has made no complaints regarding location access, but this role is time-consuming and could be resolved by an improved communication system.

One equipment issue could have future ramifications for maintenance crews. Some of the signs were purchased from a company that is now leaving that line of business, so it may be difficult to get replacement parts for the equipment. New equipment will have to be from a different vendor and may require different software.

Maintenance suggests that the project team heavily research the vendors before selection, although the field has become competitive, and businesses are often unsuccessful.

SYSTEM USEFULNESS

The systems are very helpful for both travelers and maintenance crews. Viewing conditions on the Web pre-trip can help travelers make informed decisions. The systems can also notify travelers of scheduled avalanche control and allows them to change their trip times if necessary. This information can lead help prevent travelers from becoming irate. In addition, information about road conditions and chain requirements facilitates safe winter travel on the passes.

Maintenance appreciates the time savings gained by use of ATIS. Staff members, from the regional superintendent to the techs in the field, have Internet access and use RWIS and the latest forecast to help determine priority routes for winter plowing. Maintenance would like more cameras with RWIS to help make equipment deployment decisions. The increased safety created by chain information provided by HAR and VMS allows maintenance to spend more time plowing instead of dealing with incidents. Another benefit to maintenance crews was provided by the communications system enhancement at Blewett Pass; the changes improved crew radio communications as well as device access.

Changes to the VMS signs also benefited the maintenance crews. The old VMSes were flip signs. During stormy weather, maintenance crews would need up to an hour to get across the pass to change the sign. This time-consuming task would take the crew away from plowing or other activities. The new VMS allows messages to be called in through the radio, and the crew is only required to travel to the site when communication errors occur.

PUBLIC RESPONSE

Public response suggests that the drivers are using the information and appreciate the systems. The Department has received e-mails from the public expressing favorable opinions about the cameras and website. People are happy with the concept of the system, but want the devices to work 100 percent of the time. Drivers complain when any part of the equipment is down.

Some WSDOT staff feel that some travelers might expect too much of the system. It is difficult to provide perfect information on VMSes and HAR. Information such as “Expected reopening at 2:00” or “Pass now open” can become outdated quickly because of weather changes. Some drivers might also have unreasonable expectations about the ability of WSDOT to react to changing conditions. Drivers complain that information on a sign 20 miles from the pass is not accurate when they reach the summit and encounter different conditions. This feedback can be frustrating for system operators, but they continue to provide the most accurate possible information.

PROJECT MANAGEMENT

The project team decided it was more important to minimize the cost of the project, even if this decision meant extending the project schedule.

NOTABLE OBSERVATIONS

Table 3. Notable observations from the SR 2 and SR 97 Traveler Information project

	PROJECT EXAMPLES
MAINTENANCE	
Benefits to maintenance	▪ The techs in the field have Internet access and are using the RWIS information to help determine where to go for snow plowing. ▪ During stormy weather, it would take maintenance crews up to an hour to get across the pass to manually change the original flip VMS signs. This time-consuming task would take the crew away from plowing tasks. Now the messages can be called in through the radio, and the crew does not have to travel to the site.
Benefits to maintenance	▪ As the staff has become more familiar with the capabilities of the system, the use of the Web cameras has increased.
RURAL DEPLOYMENT	
Rural benefits	▪ VMS and HAR are typically used to provide travelers with roadway information and notify them of chain requirements.
Rural benefits	▪ When the communications on Blewett Pass were updated for the new systems, the changes also improved the crew radio communications.
PROJECT MANAGEMENT	
Implementation costs	▪ The project team decided it was more important to minimize the cost of the project, even if this decision meant extending the project schedule.
Role of operators	▪ The systems utilize what staff believe is the oldest software in the state, with a dial-up computer modem. It is very time consuming and requires a lot of work from the operator. Each sign and HAR needs to be dialed individually through the modem. ▪ Operators would prefer an integrated software system similar to the Olympic region system used for the SR 101 project. A computer can send a message to a specific HAR or manage multiple devices with a single step.

	PROJECT EXAMPLES
Role of stakeholders	▪ Requests from the city of Leavenworth pointed to a need for additional traveler information and helped instigate the project. ▪ Environmental issues arose regarding the VMS on the north side of Blewett Pass. The original project plan was to replace the existing flip sign at the same location. This location was too close to a creek, so the location was changed.
STAFF, TRAINING, AND SUPPORT	
Staffing considerations	▪ The new devices create an added workload for the single radio operator. A new ITS technician was hired to help with communications support. The Yakima TMC is available for support when needed for emergency back-up. As the region gets more devices it will be necessary to hire additional computer staffing.
Training support	▪ During part of the year, the devices require only one operator. But from November to March, the operator works with 5 additional radio operators to deal with the increased winter demands. This staff needs to be trained.
Role of vendors	▪ The vendor is leaving this business, and this will affect the ability to get replacement parts for existing equipment. New equipment will have to be from a different vendor and may require different software. The Department will have to ensure that the devices have the necessary technical support.
Baseline (existing) infrastructure	▪ The region had relatively few ATIS before this project. The new systems required training to familiarize staff with system operation and capabilities.
Technology	▪ The system encountered some radio communications problems and poor signals to the signs. The HAR needed to be tweaked a couple of times, but these technical difficulties were expected.
CUSTOMER RESPONSE	
Traveler feedback	▪ Radio operators have not received any public feedback. There is little recognition to the operators for the work required to manually operate the system, since it is difficult to determine whether travelers are using the information. However, they do receive positive feedback from the maintenance crew.
Traveler feedback	▪ Drivers often complain when any part of the equipment is down.
Traveler and staff feedback	▪ Maintenance crews use the cameras, RWIS and the latest forecast to determine priority routes for plowing. ▪ The Department has received e-mails from the public expressing favorable opinions about the cameras and website.
Staff feedback	▪ Maintenance would like more cameras with RWIS to help make equipment deployment decisions. ▪ Two new VMSes are being placed in the area. The operations center currently works out of the maintenance office but is being renovated with video cameras and new equipment and will become a TMC.

SECTION 5:
SR 395 TRAVELER INFORMATION

PROJECT BACKGROUND

SR 395 is a highway of local, statewide, and national significance connecting Washington to British Columbia and Oregon. Commercial vehicles, local commuters, and recreational travelers between Spokane and the Canadian border travel through the corridor. Commercial trucking is especially dependent on the highway to move products, and the industry generates important economic benefits for the region.

The objective of the SR 395 ATIS project was to provide information to commercial vehicle operators (CVOs) and the general public regarding road conditions and weather status to help travelers make informed decisions and efficient route selections. The systems would also improve the efficiency of maintenance operations.

A separate evaluation, contracted by the USDOT Joint Programs Office, was conducted by Battelle Memorial Institute to document the benefits of the ITS deployments. The report focused on the impact of ITS on the efficiency, safety, and traveler decision making of CVOs, general travelers, and maintenance crews. The evaluation also assessed overall system performance.

The project manager contacted for this project was satisfied with the Battelle evaluation and its conclusions. The project manager frequently referenced the Battelle report in communications with TRAC. Because much of the evaluation activities planned for this project were already performed by the Battelle project, most of the information in the following project description (section 5) was extracted from the

Battelle study and reorganized to match the format used in the evaluations performed for the other ATIS projects discussed in this report.

SYSTEM FEATURES

ATIS devices were deployed to gather and disseminate roadway and weather information. The HAR typically notifies travelers of conditions on Sherman Pass, including road closures, dangerous driving conditions, and incidents (e.g., mudslides), border crossing status, road construction, traction requirements, and vehicle restrictions. One mobile HAR facility was installed at the junction of SR 20 and SR 21, near Republic, on the west side of the pass. A second mobile HAR was installed at the junction of SR 25 and SR 395, near Kettle Falls, on the east side of the pass. The project also deployed two new road weather information system environmental sensor stations (RWIS-ESS) with closed-circuit cameras. One RWIS and camera were placed at Sherman Pass on SR 20. The other RWIS and camera was installed at Laurier, where SR 395 crosses the Canadian border. In addition, a camera was added to an existing RWIS at Loon Lake.

Figure 6 displays the SR 395 project area and the locations of ATIS deployments.

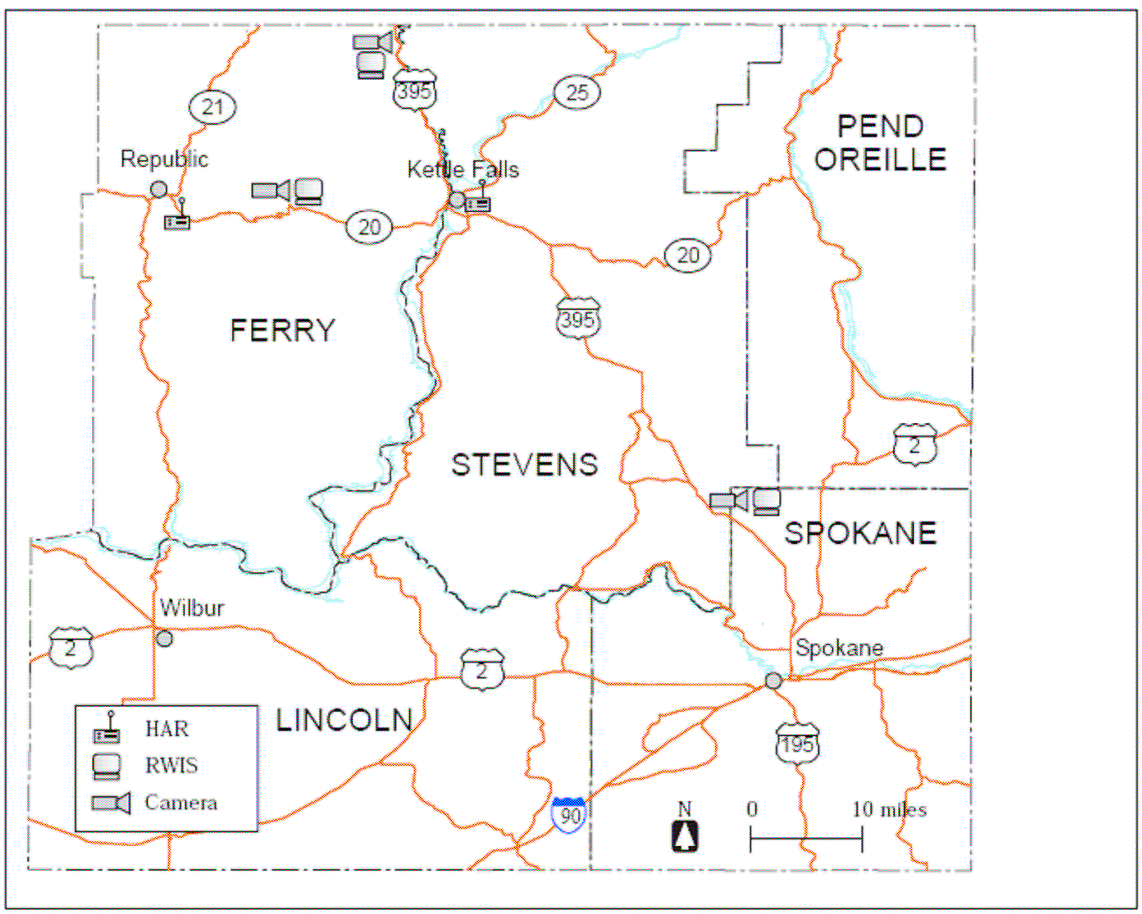

Figure 6. SR 395 project deployment

SYSTEM OPERATIONS AND MAINTENANCE

Operations

The RWIS and cameras function automatically. The RWIS collects pavement temperatures, surface conditions, solution freeze point, sub-grade temperature, wind speed and direction, precipitation type and intensity, visibility, air temperature, relative humidity, and atmospheric pressure. This information is automatically sent to maintenance crews and the TMC, as well as updated on the WSDOT website. The camera images are also automatically refreshed on the website.

The mobile HARs require more staff involvement in their operation. Field crews report pass conditions to the Spokane TMC. In addition, WSP calls in hazardous road conditions, requests for sand and plow trucks, and road closings to the TMC. The TMC operators also monitor the data from the RWIS and cameras. The operators are responsible for posting messages to the HARs. The mobile HARs are operated remotely with a solar powered cellular phone. A script is used to update current conditions on the HARs every four hours, if warranted. In the fall of 2003 the TMC began operating 24 hours a day, seven days per week. The Spokane operators are also responsible for updating the Eastern Region Lowland Road Report toll-free number and relaying the pass conditions to the Central Washington TMC in Wenatchee.

Maintenance

During the initial period of operation, the three RWIS sites have performed with no known system failures or outages at Loon Lake or Laurier, and one outage at Sherman Pass when a pavement sensor cable was cut by a snowplow. Maintenance crews expressed complaints about accessing RWIS information. The task can be time consuming for busy maintenance personnel. The computer and Internet access speed are slow at the Republic shed, and access is very inconsistent. Satellite Internet connectivity was installed but did not alleviate access problems because of poor dish orientation and a complex path between the shed and the WSDOT server. Storms often interfered with the connection. The dial-up connection allowed access to all of the RWIS data, whereas the satellite connection gave the sheds access to the public WSDOT site with just a portion of the information. These problems created frustration among maintenance personnel. Numerous maintenance problems have hampered the HARs. The HARs were designed to be used periodically only in severe conditions. Instead, the devices were used continuously. Because the HARs were designed with solar power, continuous use and cloud cover prevented the solar panels from charging the unit. The power supply issue caused the flashers to not operate, so travelers were not aware when messages were on the radio. Permanent power was required and installed at both sites and now the systems are working properly. In addition to the power problems, the cell and pager communications in the area were unreliable, requiring several attempts by operators to change the messages. Maintenance may install a hard-wire phone connection to remedy this problem.

SYSTEM USEFULNESS

The ATIS equipment is located in areas that have encountered winter road condition problems in the past and areas that serve as indicators of weather systems that could affect the region. This placement makes the information particularly useful to maintenance crews and travelers. The remote, mountainous, rural areas made it difficult to efficiently gather information about weather and road conditions. The new system makes the information available to travelers and CVOs for better preparedness. Additionally, the information assists maintenance crews in restoring the roads to satisfactory level-of-service conditions as soon as possible. RWIS pavement information, cameras, and weather forecasts help in determining the necessity of distributing trucks and to which locations, as well as in determining when to apply anti-icing chemicals.

PUBLIC RESPONSE

This project represented the first time that travel information of substantial value was made available in this region. The Battelle evaluation gathered responses from the general public, CVOs, and operations and maintenance crews regarding the new ITS capabilities.

Battelle created an Internet survey for the WSDOT website to gather public opinions about the traveler information. The majority of respondents found the traveler information to be very useful. The survey showed that travelers felt better prepared, safer, and more comfortable for their travels. They also said that the site is well organized and easy to use. Travelers felt that the variability of weather throughout the pass requires more cameras to view more locations. Other public suggestions included altering the position of the cameras to relieve obstructed views, adding lighting at camera sites to allow nighttime viewing, and increasing the reliability of the cameras to prevent extended downtime.

The Battelle evaluation also collected feedback from CVOs. CVOs use website and HAR information to prepare for conditions on their routes. The companies can alert customers of possible delays, pack the vehicles with serviceable tire chains, and be prepared to reduce speeds as necessary. Fifty-one percent of Battelle's interviewed CVOs found HAR information useful. They said that the ITS information sources were used as supplements to the traditional sources such as CB radios, AM/FM radio, and cell phones, as opposed to replacing these sources. The CVOs commented that being more prepared helped them deal with the stress of driving under hazardous weather conditions.

Some CVOs suggested that the addition of a computer and Internet connections at weigh stations would be helpful for checking travel information en-route.

A number of interviewed CVOs were unaware of the WSDOT website and camera images but expressed interest in using the services. This issue points to the need for promoting ITS services to the public. The WSP also said that the new information is valuable to the WSP and to travelers but requires an increase in public awareness. The WSP said that the number of public calls inquiring about conditions did not decrease with the information available on the Internet, suggesting the benefit of publicizing the information services.

PROJECT MANAGEMENT

The project team faced permitting requirements that pushed the project behind schedule. At the initial earmark meeting in the fall of 1999, WSDOT targeted the fall of 2001 as the date for the systems to be installed and operational. The equipment became operational in the fall of 2002, about one year behind schedule.

A permit from the U.S. Forest Service was necessary for the Sherman Pass site, causing delays in the project schedule and design changes. Effective interagency coordination between WSDOT and the U.S. Forest Service was necessary to move forward with the RWIS plans. WSDOT was required to comply with the U.S. Forest Service design guidelines. Communication with the USFS resulted in a design that was acceptable to the Forest Service but not optimal for system performance. The design constraints required the RWIS to be placed in heavy timber to be more discreet, which reduced the system’s potential effectiveness. The resulting location problems include distance from the road surface, inability to pan more of the road segment, susceptibility to vandalism and falling limbs during storms, and increased difficulty to service.

Battelle reported that the local project team felt that additional ITS capabilities throughout the region would increase benefits at relatively modest costs. The systems have increased interaction between groups such as the field maintenance personnel and the TMC staff. Maintenance crews use the information to improve efficiency, and general travelers and CVOs feel safer and better prepared for road conditions.

NOTABLE OBSERVATIONS

Table 4. Notable observations from the SR 395 Traveler Information project

	PROJECT EXAMPLES
MAINTENANCE	
Role of maintenance	▪ Maintenance crews have requested lighting at the sites, since about half of the maintenance operations are conducted at night.
Benefits to maintenance	▪ Precipitation forecast on the Internet is used to decide whether to apply anti-icing chemicals. RWIS data and camera images are used to determine the necessity to distribute trucks and to select locations.
RURAL DEPLOYMENT	
Implementation costs	▪ Because of lack of power supply at the sites, the HARs were designed to use solar power. Continuous use and cloud cover prevented the solar panels from charging the unit. Permanent power was required and installed at both sites. ▪ The long distances between the maintenance sheds and the support staff in Spokane caused delays in computer support.
Rural benefits	▪ The equipment was located in areas with winter road condition problems in the past and areas that serve as indicators of weather systems that could affect the region.
Rural benefits	▪ The remote, mountainous, rural areas made it difficult to efficiently gather information about weather and road conditions. The new system assists maintenance crews in restoring the roads to satisfactory conditions as soon as possible.
PROJECT MANAGEMENT	
Role of stakeholders	▪ A permit from the U.S. Forest Service was necessary for the Sherman Pass site.
STAFF, TRAINING, AND SUPPORT	
Technology	▪ Some communications breakdowns occurred between the TMC and field maintenance during the early stages of implementation, but these problems were remedied with more experience with the systems.
CUSTOMER RESPONSE	
Traveler feedback	▪ The Battelle survey found a lack of public awareness of the new systems, particularly the information on the Web.
Traveler feedback	▪ The Colville WSDOT facility reported a decrease in phone inquiries as a result of informing callers that information is available over the Web. ▪ CVOs use the website and HAR information to prepare for conditions on their routes, allowing them to alert customers of possible delays, ensure inclusion of serviceable tire chains, and know that it may be necessary to reduce speeds.
Traveler and staff feedback	▪ RWIS data and camera images are used to determine the distribution of trucks. ▪ The Battelle Internet survey gathered public opinions regarding the new ITS capabilities. The majority of respondents found the traveler information to be very useful. The survey showed that travelers felt better prepared, safer, more comfortable for their travels.
Staff feedback	▪ Because the weather varies significantly throughout the pass, the system needs more cameras so the traveler can see the weather in more locations. ▪ Maintenance is supportive of the system and could utilize more devices.

SECTION 6:
TACOMA TMC ENHANCEMENT

PROJECT BACKGROUND

The City of Tacoma, in cooperation with the Tacoma Fire Department, had already built a fiber network within the city limits, but there was no existing connection to the Tacoma Traffic Management Center (TMC). The TMC is located 4 miles from I-5 and 10 miles from downtown Tacoma, in Pierce County but not within the Tacoma city limits. This location meant that the City of Tacoma had no interest in or authority to install fiber to the TMC. The existing ATIS sent camera images through the Tacoma fiber network to the fire department hub at the fire station on 12^{th} and Cushman, the highest point in the City of Tacoma. A microwave dish then converted the fiber images to radio to send via microwave to the TMC.

The objective of this ITS earmark was to improve ATIS communication by linking the existing City of Tacoma fiber network with the TMC. The first phase of the project linked the TMC to the fiber network. The second phase, to be completed with a separate ITS earmark, will install fiber optic cable for the ATIS equipment along the I-5 corridor, from the I-5/SR 512 interchange to 49^{th} Street. A local evaluation will be conducted by TRAC on phase two after the project has been completed.

Interviews were conducted with the WSDOT project manager and operations at the Tacoma TMC.

SYSTEM FEATURES

The fiber optic project installed a 24-count single mode fiber optic cable from the I-5/SR 512 interchange to the TMC on SR 512. The I-5/SR 512 interchange was the closest camera site to the TMC. The interchange could then operate as a communications hub, with data from other devices running through the hub to the TMC. Approximately 4 miles of fiber and conduit were installed and used to convert an existing CCTV camera from microwave to fiber. VMS control software was installed at the TMC to enable operators to control VMS and CCTV from one terminal. Video end equipment was also installed at the TMC. Video end equipment was installed at the City of Tacoma Fire Station, as well as a fiber optic link to the existing City of Tacoma fiber network. This link allows the fire station and the TMC to share information.

Figure 7 displays the location of the Tacoma TMC and the fiber optic cable.

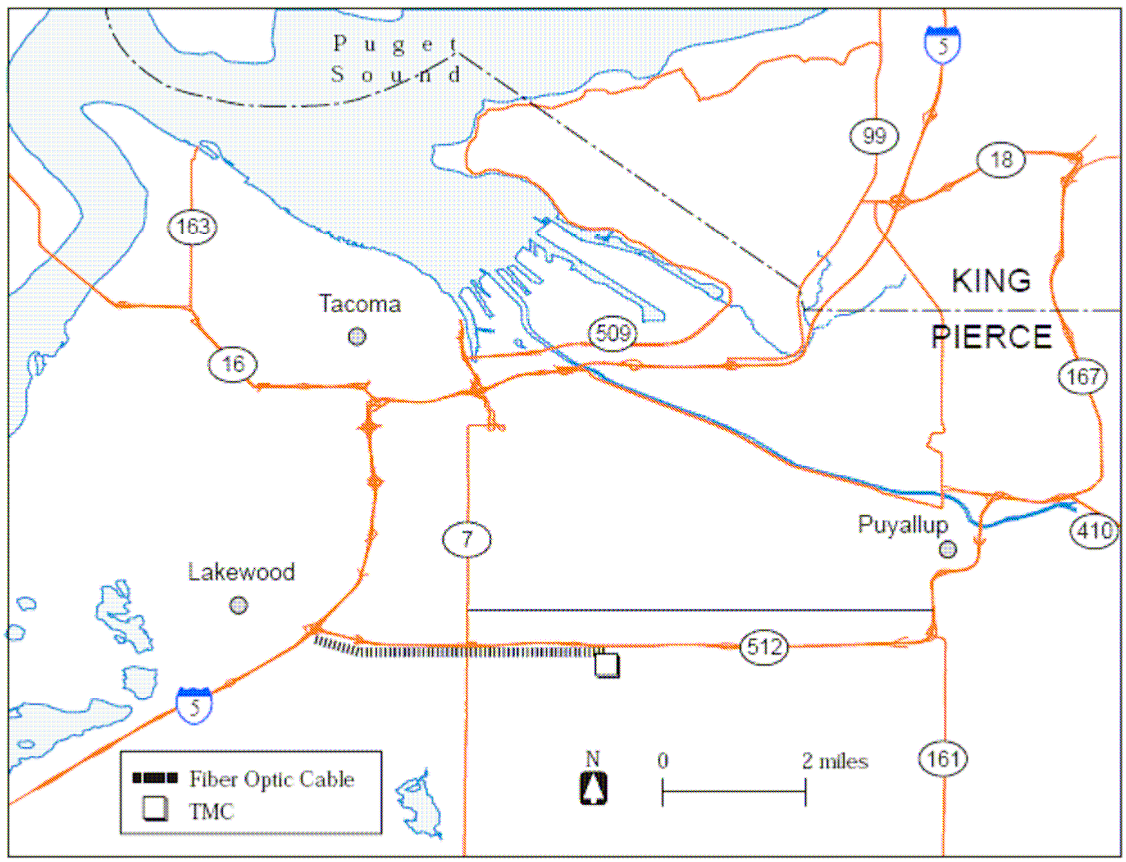

Figure 7. Tacoma TMC project deployment

SYSTEM OPERATIONS AND MAINTENANCE

The fiber is similar to a telephone line. Once it is installed, it requires no operation. The end equipment sends the information through the fiber. It has been problem-free so far. A contractor installed the system, and the process went smoothly.

Operations

The fiber is a conduit with end equipment that converts light to a usable image for a video monitor. Control directions for the camera pan, tilt, zoom can be sent back through the fiber to the device. The fiber transfers information significantly faster than microwave. The operators at the TMC are pleased because of the better operability of the equipment.

Maintenance

Maintenance on the fiber link is rarely required. Microwave always had problems with wind, rain, obstruction from other objects, and being knocked out of line. Since WSDOT's initial partnership with the fire department in 1996 or 1997, there has not been a single fiber failure. One concern with fiber is the chance that somebody will accidentally (or intentionally) cut the wire, particularly in construction sites. These cuts are not easy to repair. The fiber has a lifetime warranty with the manufacturer if problems occur.

SYSTEM USEFULNESS

The fiber link has many advantages over the old microwave system. The fiber provides a direct link to the cameras, allowing all images to be seen at the TMC and displayed on the WSDOT website at one time. The existing analog microwave system only allowed the TMC to receive three of nine images at one time, but the fiber can handle more bandwidth and carry all the cameras. Snow, wind, and rain interfered with the microwave connection, but those problems do not occur with fiber. Fiber optics produces higher quality of images and can also be used to link HAR and VMS. This feature will save money on the monthly expense for T-1 and POP lines to connect to the devices. The microwave connection is gone now except where necessary for physical barriers such as bridges and rivers, that fiber cannot cross.

Connecting the TMC to the City of Tacoma fiber network creates the ability to transmit video signals, traffic flow information, and other ITS data to any agency located in the vicinity (Tacoma Fire Department, Pierce Transit, Pierce County Sheriff). Future projects can be added to the network with virtually no cost for communication.

PUBLIC RESPONSE

There has not been any response from the public, but WSDOT usually does not hear anything from people unless there are problems. The fire department, which partnered with WSDOT on this project, has been very happy with its half of the partnership because it now has a complete communications system. Other local groups have not yet seen the advantages of the network segment installed from the interchange to the TMC. When phase 2 is completed, and the entire network is in operation, WSDOT expects more feedback.

PROJECT MANAGEMENT

Cooperation between public agencies was crucial to the success of this project. WSDOT chose to work with the fire department because of the history of the city of Tacoma and its relationship with the fire department. When electricity first became available, the Tacoma Fire Department was given authority over the utilities. This responsibility was written into the Tacoma City Charter. Since then, the fire department does not have to ask permission to put facilities on existing utilities (poles, trenches). Other city agencies (public works, sewage, accounting, health) deal with a shared joint fiber system.

The relationship with the fire department began many years prior to this project. In 1997, the Tacoma Fire Department had responsibilities at Tacoma Industrial Airport and needed alarms at the airport to be sent to the communications center. In order for this to happen, the fire department needed broadband across the Tacoma Narrows Bridge. WSDOT was also trying to get communications across the bridge. The bridge engineers did not want additional equipment on the bridge. The existing equipment was franchised to telephone companies. Usually this franchise includes cable-threading options for WSDOT, but the contracts for the bridge did not. The fire department had existing copper in copper trays across the bridge. They decided to pull the copper out of the trays and replace it with fiber. The bridge engineers approved of this method as long as the diameter of the trays remained the same. The fire department was willing to share the fiber with WSDOT. WSDOT had the money to buy the fiber and install it, and the fire department had the technical capability to install it. WSDOT bought the fiber, and they worked together to pull it across the bridge. This project initiated the partnership.

Around that time, some new ITS devices were installed in the region and connected to the TMC by microwave. WSDOT partnered with the fire department to develop utilities agreements and begin to put fiber on the city streets adjacent to the freeway. These installations were the first steps in building a fiber network. This network connected the fire department to the pictures and video information on I-5. The information was delivered directly to their communications center to aid with incident management. The fire department was the first to respond to freeway incidents, sending medical aid and fire trucks. The details of the partnership benefited both agencies. WSDOT purchased the fiber, and the fire department installed it and maintained it. Each agency received 15 of the 30 fibers for use. WSDOT benefits from having its cameras on a fiber network. The fire department benefited from enhanced capabilities between its stations and headquarters.

Although the partnership began years ago, WSDOT still did not have direct access to the city network. The addition of the link from I-5 to the TMC connects the

TMC to the fiber network. After phase 2 of the project, the TMC will be able to access all ATIS devices along the I-5 corridor through fiber communications.

The project stakeholders strongly encourage vigorously pursuing partnerships with other agencies. Partnerships expand the network while dividing the costs between multiple agencies. Many other state and local agencies use fiber but do not communicate with each other. Because many agencies have the resources available, they could be working together and expanding networks.

The Traffic Office expressed reservations about the internal method of design and construction. The project began with an initial concept from the Traffic Office; the designers then designed the project. It was put out to bid for a contractor and then turned over to the Project Office. The Project Office was then in control of the project until completion. At the very end of construction, an electrical inspector from the Traffic Office conducted an electronics check to review splices and test performance measures. This technically capable inspector was the only contact outside of the Project Office. The Traffic Office was only involved through the rumor chain and questions of, "When will the project be done?" The system performance check was removed from the designers and users, even though the designers and users would be responsible in the end.

Another issue discussed by the project manager was the need to ensure that the design has the capacity to handle future changes or additions. The original design called for 24-count fiber. The other federal project, from Gravelly Road to 48th Street, has required additional fiber, so the original was replaced with 196-count fiber. The designers also regret using only one conduit. It is difficult to pull additional cable through the conduit because of pulling friction and tension. The addition of multiple conduits or an interduct would have allowed for future expansion.

NOTABLE OBSERVATIONS

Table 4. Notable observations from the Tacoma TMC Enhancement project

	PROJECT EXAMPLES
MAINTENANCE	
Role of Maintenance	▪ Some maintenance issues have resulted from initial design elements. Some suggested that the project should have pulled more fiber, installed an interduct or two conduits, and more pull boxes. Consultation with maintenance during design may have prevented some of these issues.
PROJECT MANAGEMENT	
Implementation costs	▪ The project timeline varied on the basis of the other elements of the project. The connection to the ATIS on I-5 is still in progress and will be completed with Phase 2.
Implementation costs	▪ The Tacoma fiber project is being conducted in 2 phases. This report evaluates Phase 1. ▪ The second part of the project involving the fiber along I-5 from Gravelly Lake to 48th Street was done separately because the funding was not available all at once on the state side.
Role of operators	▪ System operators were not consulted between the initial concept for the design and a final electronics inspection before operations. The system performance check was removed from the designers and users, those who are responsible in the end.
Role of stakeholders	▪ The project required effective communications, particularly between WSDOT and the Tacoma Fire Department. Communications with Pierce Transit and the City of Tacoma also took place.
Role of partnerships	▪ Details of the partnership between the Tacoma Fire Department and WSDOT: • DOT gets its cameras on fiber • Fire Department gets enhanced capabilities between the stations and headquarters • WSDOT bought the fiber, Fire Department installed it and maintains it • The fiber consists of 30 fibers; each gets 15 for use
CUSTOMER RESPONSE	

	PROJECT EXAMPLES
Traveler and staff feedback	▪ There hasn't been any response from the public, but WSDOT usually doesn't hear anything unless there are problems. ▪ Most have not yet seen the advantages of the piece from the interchange to the TMC. When Phase 2 is complete, they expect more feedback.
Staff feedback	▪ The project participants are very supportive of the use of fiber for system communications. The fiber is significantly faster than microwave. Since WSDOT's initial partnership with the fire department in 1996 or 1997, there has not been a single fiber failure. Microwave always had problems with wind, rain, obstruction from other objects, and being knocked out of line.

SECTION 7: OBSERVATIONS AND LESSONS LEARNED

The following discussion describes observations gleaned from interviews conducted for the five ATIS projects in this evaluation effort. During the interview process, there were a number of instances when a perspective expressed by a respondent regarding one project was later echoed by another respondent in relation to a different project. The frequency with which such shared observations occurred was in part a reflection of the applications, technologies, and supporting agency structure that most of these projects had in common. However, because those attributes are frequently encountered in many other ATIS projects, the shared responses that were accumulated can have broader value as a "lesson learned" or a topic worthy of consideration for future ATIS projects and other field technology implementations. Even in those cases where an observation was made for only one project, it was often possible to recognize the broader potential applicability of the observation to other projects with similar characteristics.

Some of the observations in this discussion are descriptive, noting patterns that seemed to arise in several projects. Other observations represent issues, both resolved and unresolved, that arose during planning or deployment that are potentially useful to consider before ATIS projects are developed. Finally, some observations are more prescriptive, suggesting guidelines for future project planning.

In most cases, these observations were shared among two or more of the five projects, although some were unique to a particular project circumstance. While some of the observations could be considered common-sense considerations, such observations can sometimes be easy to overlook and are useful to reiterate, particularly when those topics were considered noteworthy enough to mention by one or more project participants.

Table 6 summarizes the observations and lessons learned and the corresponding projects that provided related information. The observations are grouped into the following categories:

- Maintenance
- Rural deployment
- Project management and agency coordination
- Staffing, training, and support
- Customer response.

Following the table, each observation or lesson learned is then discussed.

Table 6. Lessons learned by project

LESSONS LEARNED	Ferry Terminal	SR 101	SR 2 and SR 97	SR 395	Tacoma Fiber
MAINTENANCE					
Maintenance group participation helps ensure system compatibility	X	X			
Maintenance group participation contributes to successful implementation	X	X	X		X
Contract information should be updated to reflect as-built conditions	X				
Projects with consultant participation should consider maintenance participation as well	X				
Proactive, preventive maintenance can reduce support expenses	X				
Design choices should factor in maintenance cost and safety considerations	X			X	
ATIS information enables maintenance organizations to perform their tasks more efficiently and effectively		X	X	X	
The process of discovering the full potential of ATIS devices can be a gradual one		X	X		
RURAL DEPLOYMENT					
Rural ATIS applications often involve remote locations that can result in additional deployment and maintenance needs		X	X	X	
Rural ATIS devices can be more susceptible to vandalism and theft issues because of their remote locations		X			
Rural ATIS applications have critical safety implications		X	X	X	
ATIS information facilitates enhanced rural maintenance capabilities		X	X	X	
PROJECT MANAGEMENT					
Integration with existing ITS technology elements can affect schedule and cost	X	X			X
The vendor selection process can affect scheduling, implementation, and support		X			
Incremental implementation can produce both benefits and tradeoffs		X	X		X
The perspectives of system operators should be considered during project development	X		X		X
Effective stakeholder communications help facilitate resolution of jurisdictional issues	X	X	X	X	X
Leveraging shared resources can produce benefits in a more cost-effective manner					X
Matching one partner's needs to another partner's complementary capabilities can enhance cost-effectiveness	X				

STAFF, TRAINING, AND SUPPORT					
Staffing plans should take into consideration any additional workload anticipated by the use of new devices			X		
Staff training programs should consider not only initial staff at the time of deployment, but future staff as well	X		X		
Vendor accessibility can affect system operations	X	X	X		
Staffing, training, and support requirements are affected by prior baseline conditions	X		X		
It is not unlikely to encounter a period of tuning and bug fixes	X	X	X	X	
CUSTOMER RESPONSE					
In general, traveler feedback to DOT staff was not high	X		X	X	X
While feedback was not extensive, there was a sense that travelers were using the new information and were supportive of its availability	X	X	X	X	
Camera views provide valuable information to travelers and DOT staff alike	X	X	X	X	
There was general DOT staff support for additional ATIS devices	X	X	X	X	X

MAINTENANCE

A significant theme that emerged among comments from project staff revolved around the significance of maintenance-related considerations in ATIS project development and operations, and the contributions of maintenance toward project success. The maintenance-related observations are grouped into the following categories: 1) treating maintenance staff as a project client, 2) supporting project maintenance, and 3) project benefits for maintenance staff.

Maintenance Staff as the Client

A review of the five projects in this effort illustrated the value of DOT maintenance group input to an ATIS project. As one project staff member noted, the inputs of the maintenance group for his project were considered important throughout project planning, design, implementation, operations and maintenance; the maintenance staff was considered a key client of the project. Comments about the role of maintenance were common among most of the projects evaluated and usually focused on general issues such as the appropriate role of maintenance in the project development process, rather than unusual technical issues.

- **Maintenance group participation helps facilitate system compatibility.** Early involvement by the DOT maintenance staff in the proposal development, system design, and technology selection stages was cited by participants of several projects as important to help ensure compatibility of new devices with existing equipment. In the cases reviewed, new devices and their supporting infrastructure were implemented as a supplement to existing devices and infrastructure; it was therefore important to verify that the full planned functionality of the new devices would still be achieved once they were integrated into the existing system. The maintenance staff was cited as being in the best position to review technical device and network specifications and evaluate compatibility. A compatibility check also has implications for reducing both initial installation expenses and ongoing support expenses. A technical review can help reduce the possibility that incompatibilities will be discovered following installation of new equipment, that could require additional time and expense to diagnose and remedy. Furthermore, if the design uses new devices that are compatible with or based on existing devices, the maintenance staff will be more likely to already have support for the new devices in place in the form of working experience with the devices, testing equipment and procedures, and compatible spare parts. Maintenance participation should also be considered following a project postponement. If a project bid process is prepared, postponed, then re-bid, an updated maintenance review should be considered to reflect any new equipment since the original bid review. This can help verify that the bid is current with new technology developments and compatible with updated DOT maintenance practices and equipment guidelines.

- **Maintenance group participation contributes to successful implementation.** The value of early involvement by the DOT maintenance staff in choices related to implementation was also mentioned. Specifically, the selection of sites for data collection sensors and information transmitters or displays can be critical to project success. Because of the nature of their work, maintenance groups have experience with the pattern and variability of local weather and road conditions. They are often in the best position to provide specific information on problem areas that should be considered in sensor and transmitter/display placement and to suggest potential sites that make the most sense in terms of data collection (for sensors) and information access (for information transmittal devices such as VMS or HAR). Maintenance staff can also provide assistance on technical operating issues related to placement, such as power access for new devices, communications access and performance or signal coverage limitations, or environmental restrictions related to construction.

Supporting the Maintenance Staff

As with many field technology implementation projects, an ATIS system deployment is inevitably accompanied by some level of maintenance. The cost of ongoing maintenance and support is influenced by technology selection and installation decisions, as well as by the availability of support staff and funding. While there are technical considerations associated with maintaining typical ITS equipment such as RWIS, HAR, VMS, and camera systems, the following maintenance staff comments tend to focus on ways to support the overall maintenance process. These are issues of the type that are arguably common in many other field installations of technology.

- **Contract information should be updated to reflect as-built conditions.** Several comments were made about the need to update contract design documentation to reflect subsequent changes that occurred during implementation. The lack of up-to-date as-built design documentation has clear support implications; if design documents do not match actual conditions, additional time and expense could be required to review and document the actual design before support and maintenance options are performed; as a result, associated expenses can be higher than expected. Furthermore, while project staff might have a detailed working knowledge of the design of the system, it is not sufficient to rely upon the collective knowledge of staff regarding any modifications to original design plans. As projects are completed, staff are often reassigned, and memories about specifics fade over time. Therefore, institutional memory is not a substitute for written records of design changes.

- **Projects with consultant participation should consider maintenance participation as well.** In one project, maintenance staff noted that design and implementation of a previous project in the area were performed by an outside consultant. Subsequently, performance problems required support by WSDOT maintenance. Because the devices and installation processes used by the consultant varied from the standard WSDOT equipment and approach, and design drawings were not fully updated, additional time and expense were required to diagnose and solve the problem. In addition, the consultant-designed systems created problems when the new systems are integrated. Therefore, there is a financial incentive to work with DOT maintenance groups to enable them to cost-effectively support devices designed or installed by others.
- **Proactive, preventive maintenance can reduce support expenses.** Several project representatives mentioned the goal of proactive versus reactive maintenance as a cost-effective way to minimize support expenses. However, there was an acknowledgement that funds for maintenance as a whole were often insufficient, and therefore preventive work was often not possible. Nevertheless, maintenance crews sometimes perform some preventive activities as part of

required support work (e.g., during repairs or diagnostic work) when time permits, as a way of maximizing the use of scarce resources.

- **Design choices should factor in maintenance costs and safety considerations.** Device design and placement choices should consider support costs and worker safety whenever possible. One example noted is the use of shoulder-mounted versus overhead-mounted VMSes. There are costs associated with the support of overhead-mounted VMSes because of the lane closures and traffic control required to ensure worker safety on the overhead structures. (Traffic control is required by the state's Department of Labor and Industries to ensure worker safety during maintenance procedures.) This additional effort is not required with a VMS that is mounted on a support structure located on the shoulder. This translates into reduced costs in time, money, and safety risk for the shoulder-mounted system. While the choices are not always clear-cut, these factors can be acknowledged and taken into consideration during the planning and design process.

Benefits to Maintenance

While the traveling public is often thought of as the primary consumer of the information collected and disseminated by advanced traveler information systems, a review of the ATIS efforts in this project also demonstrated the value of ATIS information to DOT maintenance operations and crews. In that sense, maintenance organizations were not only project clients but also recipients of project benefits. While these benefits initially enhanced the effectiveness and operations of DOT maintenance staff, these "in-house" benefits ultimately manifest themselves in better road services for the public, such as more timely and effective roadway maintenance and traveler information.

- **ATIS information enables maintenance organizations to perform their tasks more efficiently and effectively.** Advanced traveler information offers a potentially significant in-house maintenance benefit to transportation and other agencies. This is especially the case where information sources are limited and road conditions are critical to safety, such as with rural applications. Several benefits were noted by project staff:
    - <u>Remote access to variable message signs</u>. Replacement of manually updated message signs with signs that can be remotely updated enables maintenance crews to spend more of their time monitoring and improving road conditions, and less time traveling to signs and manually changing them.
    - <u>Improved communications.</u> Improved networks and supporting infrastructure put in place to support communications to ATIS devices can sometimes be used to facilitate improved crew communications as well.
    - <u>Improved forecasting and prioritizing</u>. Remote access to road condition data (e.g., RWIS sensors) enables crews to more efficiently forecast future weather and road conditions, make snowplowing decisions, and prioritize maintenance tasks and routes.
    - <u>Remote verification</u>. Camera views enable personnel to remotely verify road and weather information, as well as to confirm that message transmissions to VMSes were successfully received.

- Faster response. Information from ATIS devices allows crews to respond more quickly to changing road conditions, thereby reducing the impact of backups and other inconveniences for travelers.

- **The process of discovering the full potential of ATIS devices can be a gradual one.** Some participants noted that there was a gradual process of discovering the broader range of potential applications of new ATIS devices. As the staff gained experience using a device, its utility for supporting new activities became more apparent. (Note that this was a learning curve for determining how the devices can help organizations, as opposed to the initial process of learning how to operate the device.) This was particularly noticed by maintenance staff, who over time were able to develop ways to use road condition monitoring systems such as RWIS and cameras to support their planning for maintenance activities.

RURAL DEPLOYMENT

Three of the five projects in this effort involved predominantly rural deployment. Issues associated with ATIS implementation in a rural environment emerged as a frequent theme in comments by project staff.

- **Rural ATIS applications often involve remote locations that can result in additional deployment and maintenance needs**. Rural ATIS device installation can involve locations that are not only remote relative to central maintenance facilities and regional management centers, but also some distance from necessary power and communications systems. Terrain can affect communications transmission and coverage, making device placement, technology choices, and operational testing particularly important. These factors can also result in more difficulties with future maintenance access.

- **Rural ATIS devices can be more susceptible to vandalism and theft issues because of their remote locations**. While vandalism and theft are not unique to devices in rural locations, remote sites can pose additional concerns. One option mentioned was to deliberately place devices in secluded areas that are not readily visible and, therefore, are less likely to be a target of vandalism or theft. However, as noted above, this can introduce additional inconvenience and cost to extend power and communications access, as well as affect maintenance access. Furthermore, one project reported that the seclusion of a device's site actually facilitated vandalism in a sense, by making any intrusive activity less noticeable. Another option to discourage vandalism is to locate devices near occupied locations such as maintenance sheds, when possible. (This would also have the benefit of providing easier access for maintenance.)
- **Rural ATIS applications have critical safety implications.** Traveler information for remote regions can involve issues that have a direct and often time-critical impact on traveler safety, such as severe weather conditions in potentially hazardous terrain. In those cases, the ATIS notification process must have high reliability, accuracy, and timeliness. This is all the more important for remote regions with few information access options. For these reasons, the maintenance organization's involvement in rural ATIS planning decisions can be critical, as they are familiar with the specific issues and opportunities. This involvement can be enhanced by ongoing dialogue between regional management

centers and maintenance offices to establish a clear delineation of responsibilities and roles.

- **ATIS information facilitates enhanced rural maintenance capabilities.** The benefits of ATIS listed previously for maintenance groups are also applicable in rural applications. These include remote access and updating of VMSes, enhanced power and communications networks, and visual verification of device status and weather/road conditions via cameras. Direct access to road conditions enables road maintenance crews to more quickly forecast conditions and manage their response. In addition, road condition sensors can provide information to maintenance groups that is more specific than the typical data distributed on the Web to travelers, enabling monitoring of specific weather effects such as ice build-up on the road. A well-designed communications network upgrade to support new devices can also enhance communications with existing devices, as well as facilitate general crew communications.

PROJECT MANAGEMENT AND AGENCY COORDINATION

Staff from all five ATIS projects mentioned a range of issues that arose during the project design, planning, and construction phases of their projects. These issues were generally not unique to advanced traveler information system projects, but they represented the types of management and agency coordination matters that could be encountered in any project involving technology implementation and/or government agency participation. These topics can be grouped into two areas: 1) overall project management issues, and 2) agency coordination issues and opportunities.

Project Management Issues

Project management issues were noted on several occasions as affecting schedule, cost or effectiveness.

- **Integration with existing ITS technology elements can affect schedule and cost.** None of the five ATIS projects evaluated were installed in a vacuum. In each case, the traveler information capabilities being implemented were supplements to existing ATIS systems. The nature of those existing systems varied considerably, though, from established networks of devices in an urban setting to smaller collections of devices in rural areas. Nevertheless, regardless of the complexity of the baseline system, all five project designs required consideration of existing devices in terms of a) the location, capabilities, and expansion options of pre-existing infrastructure (e.g., communications networks, power), b) the location, capabilities, and expansion options of existing ATIS devices, c) interaction between new and existing devices in terms of complementary functions and technical requirements, and d) support requirements. In most cases, the net result of these considerations was an investment of time and money that sometimes resulted in schedule delays or extra expenses. The nature of the investment varied by project. In one case, a consultant was used for installation of ATIS devices and associated networking. However, the DOT's ITS maintenance staff noted that the consultant used camera equipment, cabling, and installation procedures that varied from the standard components and approach used by DOT; this, combined with outdated technical plans, made maintenance difficult. After communications difficulties arose, the

DOT staff repaired or replaced components to improve performance and assure compatibility with Department ITS maintenance equipment and practices.

- **The vendor selection process can affect scheduling, implementation, and support.** In three projects, vendor selection issues affected scheduling or implementation of the project, as well as subsequent support. These cases involved additional time taken for vendor selection and equipment procurement, or subsequent modification of original vendor equipment to address performance issues. The result was a schedule delay and/or additional expense. In one case, the project schedule was delayed so that additional time could be taken to select software and equipment vendors whose products would integrate with existing equipment. In the end, these investments contributed to ease of support, data transfer and sharing capabilities, reduced long-term expenses, and greater future expandability. Project staff recommended that additional time be allotted for evaluation, deployment, and testing for future projects that involve software.
- **Incremental implementation can produce both benefits and tradeoffs.** Three of the projects were implemented in a phased process because of scheduled funding availability. While incremental implementation to reflect incremental funding is not uncommon, good overall design can take the phased implementation into account. Possible incremental design objectives include overall cost or cost savings, timing of functionality to coincide with upcoming related needs, or meeting immediate safety needs. In some cases, tradeoffs were required, e.g., trading off schedule adherence in favor of maximizing eventual project functionality, while staying within the original budget.

- **The perspectives of system operators should be considered during project development.** The participation of maintenance staff in the project development process was mentioned previously as a potential contributor to successful system implementation because it enables ease of future support and maintenance to be taken into account during planning and design. Similarly, the participation of system operators in the project development process can help ensure that ease of use and convenient functionality for both hardware and software are considered when ATIS projects are designed. Feedback from the eventual users of the system enables functional limitations and other design shortcomings to be identified and addressed before implementation. In one project, staff noted that the planning, design and implementation process did not include continuous contact between the original system designers and the project implementation process. As a result, the original designers and the eventual users did not participate in the system performance check until project completion. In one rural project, several observations were related to operational issues of the ATIS systems after their deployment, focusing on their functionality and convenience for system operators. Interviews from that project noted the differences in ease of user-friendliness between their software (which they stated was the oldest among state systems) and that of other regional systems. Issues mentioned included difficulties with manual initiation of dial-up communications, including communications errors, and the need to manage each device separately. This is in contrast to another regional system in the state that allows the operator to select multiple systems, enter a message, and initiate communications without requiring the operator to manually manage each step of the process.

Agency Coordination Issues and Opportunities

Coordination issues within and between agencies were noted on several occasions as affecting schedule, cost, and effectiveness.

- **Effective stakeholder communications help facilitate resolution of jurisdictional issues.** In all five ATIS projects, communication between or within agencies was a factor in implementation. The nature of these lines of communication had an effect on project cost, schedule, and functionality. In some cases, communication was in the form of required coordination, such as the siting permit required from the U.S. Forest Service for RWIS and camera placement along SR 395 at Sherman Pass. This permit, and associated restrictions on placement and visibility, eventually affected the utility of both the RWIS temperature sensor and the camera. For other projects, agency communications took the form of public partnerships to facilitate coordination with stakeholders and public outreach. A notable example of this among the five projects was the Edmonds ferry terminal enhancement project, in which a number of state and local government entities participated in planning, design and implementation of the project. In this instance, a key original design element (a proposed street closure) required approval via the local political process. Though the design element was ultimately not implemented because of local opposition, it was not for lack of an organized partnership. Project staff considered the local partnership and lines of communication essential not only for successful management of a project component that required political decision-making, but for the overall project as well. Ultimately, the partnering effort helped increase the level of support for the Edmonds project and facilitated other aspects of the project, including consultant research, traffic control, and maintenance. Such partnerships can be difficult to manage, however. One project required collaboration with several public and private entities related to local governments, business, and tourism groups. Project staff mentioned this as a difficult task, but one that was performed in a cooperative atmosphere with a positive result.

- **Leveraging shared resources can produce benefits in a more cost-effective manner.** Another notable collaboration was the partnership between WSDOT and the Tacoma Fire Department to install communications fiber. In this instance, pooled resources from the two groups enabled them to share communications conduit and serve the data transfer needs of both organizations in a more cost-effective manner than they might have done individually. In fact, the project staff also explored additional partnerships with a local transit agency and the City of Tacoma to share expenses as well as the resulting data. This project was a recent example of collaboration between the WSDOT and the Tacoma Fire Department that originally arose out of a mutual interest in developing efficient communications networks and accessing traffic images. The WSDOT-Tacoma Fire Department partnership is an example in which both groups' data needs and resources were leveraged for the mutual benefit of the participants. Participants in that project suggested that in the future, more aggressive efforts should be made to develop partnerships at both state and local levels, noting that there was the potential to more fully utilize and share available resources. One example noted was the potential coordination of previously isolated efforts among government agencies to build individual communications networks, where pooling resources could produce the same or greater communications benefits more cost effectively.

- **Matching one partner's needs to another partner's complementary capabilities can enhance cost-effectiveness.** The Edmonds ferry project features an inter-agency Operations and Maintenance (O&M) agreement between the WSDOT and WSF. In this partnership, WSF-operated ITS devices such as cameras and associated networks are maintained by WSDOT maintenance staff. WSF can therefore utilize existing WSDOT support capabilities and not be required to expend the funds, effort, and time to develop that support capability for themselves. A contract number was established to enable WSDOT staff time to be charged to a WSF budget. This enabled support to be provided in-house by staff experienced in the WSF devices. (According to the project participants, this arrangement has operated successfully thus far; however, note that while the language of the agreement was prepared, the resulting document has not been formally approved. This has led to concerns about ongoing support in the event of changes in staff or future expansion.)

STAFF, TRAINING AND SUPPORT

The equipment deployed in ATIS projects has varying levels of staffing and training requirements. The hardware and software associated with such projects also require varying levels of support. The following staffing, training, and system support issues were described by project participants:

Staffing and Training Issues

- **Staffing plans should take into consideration any additional workload anticipated by the use of new devices.** While ATIS devices can reduce some staff activities by automating data collection and device updating procedures, other activities can expand. Staffing for all components of the device operation process should be reviewed when new ATIS devices are being planned; this includes device operations staff, hardware and software support staff, and staff that manage field communications with maintenance and public safety agencies. For example, some participants noted increases in Internet usage and general communications (both person-to-person and person-to-device) following implementation. This required the hiring of additional technical personnel to handle both the communications themselves (e.g., radio and computer operators) and maintenance support for communications devices and networks. Note also that changing staff needs can arise from inherent changes in staffing requirements (e.g., a shift from manual device updating by maintenance staff to remote device updating by operators) and/or from increased demand for traveler information services produced by the new ATIS devices.

- **Staff training programs should consider not only initial staff at the time of deployment, but future staff as well.** While vendors might offer training after first installing equipment, there is also a need to consider future training needs as staff turnover occurs, additional staff are hired, or device use expands (e.g., initial weekday peak period use expands to become a responsibility of weekend or night crews). This is often managed on an informal basis but can also be performed with vendor support.

System Support Issues

- **Vendor accessibility can affect system operations.** Operations and maintenance can be affected by changes in vendor access. One example noted by a project participant was a vendor that subsequently left that line of business, requiring a new vendor for subsequent devices. This has an effect not only on vendor support for existing hardware but on the long-term availability of parts, as well as on the availability of technical staff familiar with the devices. This can be a problem in a competitive business environment, which can help spur new technology developments and reduce costs but can also lead to potential disruptions in vendor support if market consolidation occurs. While a customer may not be able to completely avoid this situation, an analysis of the state of the marketplace may be prudent when vendors are evaluated. Furthermore, the timeliness of access to vendor support services for operator hardware and software is also important for system success, especially when traffic operations or traveler safety is affected by equipment reliability. In one case, a lack of support was cited as a cause of delayed operations and additional expense when vendor support was not available on weekends.

- **Staffing, training, and support requirements are affected by prior baseline conditions.** Note that most of the comments received regarding staffing and training were associated with one of the rural ATIS projects, in which the new systems implemented represented a significant upgrade in traveler information capabilities. In those situations, there was a significant increase in technology deployment from the baseline system (and therefore a growth in associated staff and support needs). This is in contrast to the support and staffing changes associated with an upgrade to an urban system in which the baseline situation might already offer significant levels of staffing and support.
- **It is not unusual to encounter a period of tuning and bug fixes.** All the ATIS projects featured some period of initial tuning or bug fixes; extra schedule time during deployment might be required as a result.

CUSTOMER RESPONSE

Customer response can be difficult to evaluate, particularly for traveler information distributed in the field, where opportunities to immediately gauge reactions to information are not as available as they might be with a website (e.g., via online survey responses or website visitor counts). Nevertheless, several respondents mentioned reports of traveler responses in person, by telephone, or by e-mail. While some customer reactions were in response to specific information that was presented, other reactions were in response to the absence of information because of equipment or other difficulties.

The nature of the "customer" encompasses more than individual travelers or DOT staff. Project staff mentioned a variety of consumers of traveler information, including individual travelers, DOT maintenance staff, local municipalities, public safety agencies, traffic engineers, and commercial vehicle operations.

- **In general, traveler feedback to DOT staff was not high.** Traveler response to en route trip information was often limited to a) criticism when information was not accessible because of equipment problems, or 2) criticism of conflicting information or lack of updating between different devices (e.g., information at one VMS was outdated relative to another device). ATIS device operators noted a lack of feedback or traveler reactions to their efforts, although in-house response, e.g., from maintenance crews, was received. Reports from one ATIS project noted that many individual and commercial travelers contacted in a survey were not aware of new traveler information services, particularly those on the Web. This suggests that efforts to expand awareness of new ATIS services after deployment could be beneficial.
- **While feedback was not extensive, there was a sense that travelers were using the new information and were supportive of its availability.** Several project staff persons mentioned that travelers appeared to be becoming more dependent on the information available from ATIS devices. Their belief stemmed in part from the criticisms received when information was not updated in a more timely manner, rather than compliments received when useful information was displayed. Some staff also mentioned a reduction in the number of calls to maintenance and other DOT offices as more information about traffic delays,

upcoming DOT activities such as avalanche control, and weather conditions became available from ATIS devices and the DOT website.

- **Camera views provide valuable information to travelers and DOT staff alike.** Remote camera viewing was cited by nearly every project as very useful, particularly as a means of fast verification of device status or sensor output, as well as estimation of road conditions. This included verification that VMS messages have been updated, qualitative verification of RWIS sensor data, and estimation of traffic conditions including queue lengths. The ability to use visual information to quickly make human judgments about road conditions, particularly when sensors were insufficient or inconclusive, was considered very beneficial.
- **There was general DOT staff support for additional ATIS devices.** There was broad staff support across most of the projects for additional ATIS devices at the appropriate locations. Rural areas were specifically mentioned for additional geographic device coverage.

SECTION 8: CONCLUSION

The five ATIS project evaluations produced a number of observations and potential guidelines for consideration in future ATIS projects. These observations or lessons learned were clustered into several common themes in the areas of maintenance, rural projects, project management, staffing, training, support, and customer response. Among the most notable observations were those involving the role of maintenance in ATIS development and deployment, and considerations when rural ATIS applications are developed. For example, the potential importance of maintenance staff contributions toward the success of an ATIS project development and deployment process was a common theme. The benefits that ATIS services provide to maintenance group operations were also often mentioned. Responses from the three rural projects were often in agreement regarding the issues and benefits associated with rural ATIS applications. Overall, there was general support among WSDOT staff for the view that ATIS services significantly enhance the DOT staff's ability to perform tasks related to maintenance, congestion monitoring, and road and weather condition monitoring. There was also general support for installation of additional ATIS devices in the future.

The interview-based methodology was effective in producing useful information about ATIS benefits and issues, and doing so in a cost-effective manner. Given this initial application, this method appears to be a useful approach for evaluating projects with typical ATIS system characteristics. A review of the similarities of system features between the initial set of five evaluations and the upcoming set of additional evaluations suggests that the interview-based method can be employed for future ATIS projects in a similar manner, and with similar effectiveness.

Research into methods of quantifying traveler information benefits revealed the difficulties of achieving that objective. Past efforts nationwide have documented the challenge of estimating the value of particular traveler responses to information, as well as the practical difficulties of associated data collection. The alternative method explored in this project attempted to bypass those issues to some extent by focusing on the inherent value of traveler information to the traveler, rather than the value of the traveler's reaction to that information. However, this method still requires the estimation of the inherent value of information. Research is ongoing on that subject, and the literature suggests that this approach may have merit as a way to estimate at least a subset of ATIS benefits in a quantitative manner.

In the next phase of this project, an additional 19 required ATIS evaluations will be performed with the interview-based method. These additional evaluations will also provide an opportunity to further test and expand the evaluation method. In addition, the observations from the first set of evaluations will be compared with those from the second set to identify any changes in the way ATIS deployment issues are managed.

APPENDIX A:
QUALITATIVE METHODOLOGY

The project evaluations were performed with a methodology whose principal tool involves extensive use of structured interviews for data collection. The interview tool offers a low-cost method of collecting useful data from individuals directly involved with the project's evolution. Experience with this approach showed that when it is properly used, this method can produce substantive results in the form of useful insights into the project development and operations process.

The interviews were structured by using a script that was designed to address a range of project development issues. The general script included the following seven topics:

Project background: The respondent describes his/her role in the project, the primary issues that prompted the project, and the overall project objectives. Project partners and their roles are determined, as well as overall project cost information.

System features: The respondent is asked to describe the types of functionality that were to be developed in the project, along with associated physical components (ITS hardware and software, and other systems). Any changes made to the original plan/design are discussed, along with the reasons for those changes.

System operations: This topic includes three subtopics. First, system usage is described in terms of the decision-making flow, level of use, and level of support required. System usage is discussed in terms of frequency of use and typical applications. Level of integration with existing ITS systems is also described. Second, technical performance issues are discussed in terms of the individual components, overall functionality, maintenance issues, and agency coordination or staffing. Third, overall level of satisfaction with technical performance is discussed in terms of equipment reliability and usefulness, ease of operator use, and the quality of information transmitted. A comparison is made between completed functions and original specifications.

System usefulness: System usefulness is compared to the original project objectives. Changes in traveler behavior or traffic patterns (expected or unexpected) are discussed. Other changes in terms of internal WSDOT or inter-agency benefits are described.

Public response: Feedback from the public, public agencies or government entities, or private groups is discussed.

Project management: Technical or management issues that arose during planning, design, and construction are discussed, along with their effects (if any) on project functionality, budget, or schedule.

Lessons learned: Suggested changes in future projects of this type are discussed in the areas of functionality, technology, management, or O&M logistics.

While the overall structure of the script was kept constant across all interviews to facilitate meaningful comparisons, individual scripts were flexible, so that the interviewer could respond to unique aspects of that interview. Examples include the addition of questions that reflected the respondent's unique role or perspective on the project, or follow-up questions that explored new topics that arose during the respondent's answer to a scripted question.

As the script contents suggest, the evaluations performed by the project researchers using this approach have shown the value of exploring a wide range of technical and non-technical aspects beyond just the operational functionality. In the evaluations using this method, analyses of institutional, project management, and other non-technical issues were often as critical to a full understanding of project effectiveness and success as an evaluation of the technical operations of the system. The exploration of the planning, design, construction, and maintenance elements of the project development process can also make valuable contributions to an evaluation. In addition, aspects of the project process related to interactions with the public and other agencies can be critical factors in the eventual success of these projects. These types of factors can provide valuable insights into issues that affected the ultimate effectiveness of the project, and can be the kinds of factors that provide the most valuable lessons learned for future projects of that type. Therefore, this method addresses not only technical and operational aspects of each traveler information project but the process by which the system was implemented and supported.

In addition to the interview with script guidance, project notes and documents were also reviewed, primarily for background information. In addition, several future ATIS project evaluations will feature Web-based information. Web-site-based ATIS projects provide a direct means of observing traveler interaction with the information being delivered and offer an additional opportunity to monitor levels of traveler usage and user satisfaction, via such tools as automated Web visit counters and online surveys. Other potential tools for evaluating traveler perceptions include in-person or mailback surveys, or field measurements. In the next phase of this research project, such tools will be evaluated for their usefulness and practicality for individual projects.

A sample of the script follows. Note that this is a general form of the script; the exact questions would be modified depending on the specific project characteristics and respondent background.

Introduction

***Brief introduction:**
*Just as background, the information that we're gathering is part of an evaluation of five ATIS-related ITS earmark projects around the state, of which the **___** traveler information project is one. We have two objectives: **One** is to develop an understanding of ATIS issues for all project stages, including planning, design, implementation, O&M, and agency or institutional issues, and try to develop guidelines and lessons learned that would be useful for future ATIS-related projects. **Second**, we're reviewing the results of all these ATIS-related ITS earmark projects around the state, with the goal of developing a standardized method of evaluating the benefits of traveler information in a way that might also provide useful inputs to the state priority programming and funding processes.

We would like to get your perspective on the development and operations of the ATIS enhancements for the **___**.

Do you have any questions for us before we get started?

A. Project background
B. System features
C. System operations
D. System usefulness
E. Public response
F. Project management
G. Lessons learned

A. Project Background: (Why was the project developed?)

First, could you describe your position, and nature of your involvement in the development of this traveler information system?

What were the **primary issues** that originally prompted the development of this project, and what were the **primary objectives** that the system was designed to achieve?

a.
b.
c.

Were there any other participants in this project besides WSDOT (public and private sector, e.g., WSDOT, city, chamber of commerce, other state agencies, contractors):

What were their roles in the project (build, operate, maintain, advise, etc.)

Approximate cost breakdown (design, construction, O&M)

B. System Features: (What was the original plan, and what was eventually built?)

Planned:

Next, we want to just review the system features that were originally planned, and which were built:

In the original concept for this project, what were the primary system functions and physical components (ITS hardware and software, and other components):

a.
b.
c.

<u>Built:</u>

What system components were eventually built:

a.
b.
c.

(During the design and construction process, were any of the principal system components modified, removed, or added compared to the original design? Or did the basic design remain unchanged?)

C. System Operating Process: (How, and how well, does the system function)

SKIP IF NO INFO:

First, we have some questions about how the system is typically used, e.g.,
(Alternatively: Could you describe how the system was designed to be used, e.g.,)

What is the decision making process for posting/updating info via VMS or HAR:
- To start: what is the nature of the monitoring process
  - (sequence of events that leads to posting info)
  - what personnel are involved, your role
  - what types of situations or data tend to initiate the process of sending traveler info (VMS and HAR)
  - how frequently does monitoring take place (periodic or constant)
- What is the decision-making flow; who makes the call on posting

threshold for determining that you should send VMS/HAR traveler info (length of delay, type of events, queues)
how long does decision-making process usually take
what type of information is posted (queues, wait time, schedule change advisories) Other, e.g., incidents?

How frequently is the system used?
When is the system typically used (year-round, highly seasonal variations)?
Do variations affect system staffing?

What types of posted data are or can be routinely archived (message content, time stamps, system status/down time)?
Are the VMS and HAR messages usually logged?

Describe the level of O&M effort required to support the system.
(Who has responsibilities, level of staffing req'd)

How are the new systems integrated with existing ITS infrastructure or information sources, e.g., existing ATIS devices, WSDOT Regional office, etc.?

Has system use changed over time since the initial deployment, e.g., in terms of

Usage:
Frequency of use
Types of information given to travelers
Process:
Type of data that you monitor
Level of staff effort for O&M

Were there any unexpected technical performance results, either good or bad, in terms of:

Technical

a. The functionality of the system
b. Technical performance of the hardware components

O&M

c. O&M issues

Coordination and staffing

d. Coordination between agency partners
e. Unexpected staffing requirements or other staffing issues

Do you interact with other local agencies?

Overall, what is your <u>level of satisfaction with technical system performance</u>, in terms of

Equipment:
reliability
Infrastructure locations (usefulness to traveler, as well as maintenance access)
Ease of use for the operator (WSDOT, etc.):
Information flow (e.g., does the system/process, from detection to posting of info, facilitate a timely response)
Quality of the traveler information:
Message accuracy (sufficient sources to make a decision)
Message timeliness (e.g., does the system facilitate timely response)

Does the completed project meet the original technical specifications?

Are there any notable strengths, weaknesses or limitations of the resulting system (either the technology and the organizational interactions)?

D. System Usefulness and Project Objectives: (Does the system meet its **transportation** objectives?)

To what extent has the system met its original objectives (from question 1)

a. transportation
b. organizational
c. other

Changes in traveler behavior, either measurable long-term, or individual examples
Have there been any noticeable changes in traveler behavior or traffic patterns since the system was implemented? If so, what kind? (e.g., reduced demand during congestion, shift in demand to alternate routes, changes in tourism levels)

Were there any unexpected transportation effects, either good or bad:

a. transportation
b. organizational
c. other

Usefulness within WSDOT? Vs. public benefit?

E. Response from the Public and Others: (What is the response to the project?)

What type of feedback, if any, have you received regarding the performance or usefulness of the system:

a. From the public
b. From other public agencies
c. Any other groups

Have there been any specific lessons learned, or changes made, as a result of this feedback?

F. Project Management: (How successful was the project implementation process?)

During the planning, design, and construction phases, were there any unexpected technical or project management issues or events, either good or bad, related to

a. Technical implementation
b. Relationships with the contractor
c. Coordination between agency partners

Did any of those issues eventually affect

a. Project scope (functions, devices)
b. Project budget
c. Schedule

If so, how?

Was the project completed according to the original schedule and budget?
(Estimated and actual completion dates)

If not, what were the principal sources of schedule and budget changes?

G. Lessons Learned:

<u>This project</u>

In hindsight, is there anything you would have done differently for your project, or suggestions you would recommend for future projects of this type, in terms of:

(ITEMIZE)

a. System functionality that was implemented
b. System technology or vendor choices that were made
c. Project management or agency coordination
d. O&M logistics or division of responsibilities
e. Anything else?

<u>Other projects</u>

Are there any suggestions you would offer to an agency considering a similar type and scale of ATIS project in the future:

f. System functionality
g. System technology or vendor choices
h. Project management or agency coordination
i. O&M logistics
j. Anything else?

Any other general comments about the project?

For follow-up questions, is there anyone else that you would recommend we talk with about the project?

APPENDIX B:
QUANTITATIVE METHODOLOGY

INTRODUCTION

The purpose of the ATIS evaluations discussed in this report is to support future investment decisions to expand the implementation of ATIS. The results in this report are based primarily on qualitative data from interviews. A qualitative evaluation can provide insights into the technical and institutional issues that arise during the various stages of system development; determine the measures or strategies taken by project partners to address and resolve those issues; and identify lessons learned that can be applied to benefit the deployment of future ITS.

In addition to qualitative assessments, researchers have considered the feasibility of quantitative evaluations. Quantitative data can provide benefits for investment decision-makers and are particularly useful for priority programming because the quantitative value of projects is one of the criteria WSDOT decision makers use to prioritize mobility improvements. However, quantitative performance estimates can be difficult to develop because of the unpredictability of traveler behavior and ATIS use. Below is a summary of the issues related to quantifying ATIS benefits and a description of various options for conducting a quantitative evaluation.

BACKGROUND

Quantitative methods often focus on the benefits accrued from changes in the behavior of individual travelers as a result of the information provided by the ATIS during times of adverse conditions or potentially adverse conditions. These changes are generally assumed to include the following:

- change in route
- change in time of the trip
- avoidance of the trip
- change in destination
- increased preparedness for adverse conditions.

However, determining traveler behavior is difficult. It is complicated to measure people's reactions to traveler information, particularly because these reactions often vary from trip to trip. The traveler's reaction to the information is often a function of one or more of the following factors:

- the availability and familiarity of alternative routes
- the type of trip
- the length of the trip
- the importance of arriving on-time
- the source of the information
- level of anxiety.

In many cases, people do not change their travel plans at all but are better prepared for the conditions because of knowledge gained from the ATIS.

In order to analyze traveler behavior in response to information, a number of traveler assumptions must first be considered. Table B-1 outlines some assumptions of ATIS and the data required to verify those assumptions.

Table B-1. Travel time savings assumptions and data requirements

ATIS Assumption	Data Required
Benefits will vary with the volume of travelers.	• Traffic counts, vehicle miles traveled, vehicle hours traveled
Traveler exposure to the information will only occur if the ATIS is working properly.	• Percentage of time ATIS hardware and software are working as planned
Not all travelers with access to ATIS information will see/hear/understand it.	• Percentage of travelers who see/hear and understand the ATIS messages.
Different corridors can have a different mix of types of travelers.	• Percentage of each traveler type.
Travel behavior changes vary by type of traveler.	• Behavior changes by type of traveler.
There is a frequency and duration with which conditions that generate benefits occur.	• Frequency of adverse or potentially adverse conditions.

Although data such as vehicle volumes are collected frequently, the other assumptions require specific data that are difficult to assess. The variability in traveler behavior is significant.

A traveler survey might be conducted to determine trends in traveler decision-making in response to ATIS deployments and reduce the bias of assumptions about traveler behavior. Such a survey might include questions about access to information, responses to various messages, and the amount of time saved if an alternative route is chosen. However, traveler decisions tend to be dependent on many factors specific to the individual trip, which makes it difficult to ask about a driver's typical response to ATIS. In addition, the amount of time saved by taking an alternative route varies considerably with different trips and congestion.

If an estimate for travel time saved could be determined from traveler behavior, the quantitative methodologies would also require a value of time. Previous research has shown that people value time differently depending on their purpose for travel and the conditions under which travel occurs (USDOT 1996). One approach that is commonly utilized determines the value of travel time on the basis of average salary. Work trips are assigned a higher value than personal trips. Choosing a value for time involves a number of additional assumptions about the traveler and more data collection on the types of trips taken.

In addition to the challenges of establishing patterns in traveler behavior in response to ATIS, the amount of non-recurring delay is also difficult to determine. ATIS is typically utilized to mitigate non-recurring delay. However, the amount of non-recurring delay can vary extensively from rural to urban ATIS locations. The frequency of incidents and traffic volumes varies significantly in an urban setting, while the use of rural ATIS is usually dependent on weather conditions, a force that is always unpredictable.

Because of the uncertainties in traveler behavior, value of time, and recurring and non-recurring delay, previous attempts at quantitative methodologies have produced, at best, general approximations of ATIS benefits.

QUANTITATIVE METHODOLOGIES

Evaluation efforts have attempted to estimate the quantitative benefits of ATIS. The following is a summary of previous quantitative methods that have focused on traveler response to ATIS.

Mitretek Systems Simulation

One method used to estimate the benefits of traveler information is computer simulation. These simulations are particularly effective in measuring travel-time savings under different conditions. A study by Mitretek utilizing a simulation model called PRUEVIN modeled the impact of ATIS applications in the I-5 corridor of Seattle (Wunderlich et al. 1999). The project analyzed a combination of traffic flow, historical weather, and incident data using the transportation planning model and simulation to identify the impacts of ATIS under a variety of scenarios. The model produced quantified benefits in average delay, throughput, travel time variation, and vehicle-miles traveled. Although simulations are effective for calculating travel-time savings, they are expensive to develop and very project-specific.

Volpe Center Approach

A project conducted by Doug Lee at the Volpe Center categorized travelers by their behavioral reactions to ATIS and determined the value of time savings on the basis of these reactions (Lee 1999). The study focused particularly on the Seattle WSDOT website. Lee argued that in order for traveler information to provide benefits, the information must be easily accessible by travelers, relevant to their trip, and used to alter travel behavior. The analysis was based on hypothetical values for growth in website usage, estimated market segmentation, anticipated willingness to pay, and travel-time savings. Although the study provided a spreadsheet approach for calculating ATIS benefits, the model relied heavily on assumptions of traveler behavior. Lee acknowledged the difficulty of determining how travelers alter their behavior in response to information and how much the information is worth, to themselves or to the transportation system. This lack of measured data makes it challenging to derive a precise conclusion with this analytical methodology.

SCRITS

The Science Applications International Corporation developed the spreadsheet tool SCRITS (SCReening for ITS) for the Federal Highway Administration (FHWA) to be used in sketch-planning analysis of ITS user benefits (SAIC 1999). Although SCRITS is relatively simple and straightforward, it also relies on many assumptions about the impacts of ITS applications. Most of the SCRITS worksheets require baseline data from other sources. User input values, such as the frequency the system is used, the percentage of drivers who access the information, and the amount of time saved by each driver, are difficult to determine. The broad range in these assumptions requires additional sensitivity analysis.

IDAS

Cambridge Systematics was selected by the FHWA to develop the ITS Deployment Analysis System (IDAS), a post-processor to a travel demand model. In IDAS, all ATIS benefits are based on traveler responses such as route changes, mode shift, and temporal diversion. The results are expressed as changes in vehicle miles traveled, travel time, and throughput. Safety and air quality benefits are calculated on the basis of user-defined relationships to these three outputs. IDAS was used to evaluate ARTIMIS, a traffic management and traveler information system in the greater Cincinnati and Northern Kentucky region (http://idas.camsys.com). The ARTIMIS project had the necessary before-and-after regional travel demand model. The analysts were also able to use results from local evaluations as inputs for system-wide impact values, such as the percentage of vehicles that saved time and the estimated time savings. Although the IDAS analysis was successful for ARTIMIS and other ITS evaluations, it can only be used as a post-processor for projects with travel demand models (CSI 1997).

Summary

The methods described above demonstrate some of the difficulties of determining a quantitative value of ATIS. Analysis requires assumptions and estimates about traveler behavior that typically vary with the traveler, location, device, and particular situation.

VALUE OF CERTAINTY

This project explored an alternative method that does not require assumptions regarding traveler behavior in response to information. The methodology assumes that additional knowledge about a trip has inherent value, regardless of whether or how the traveler responds. The minimum value of the ATIS deployments can be considered the value of the information provided by the system. The value of traveler information results from a reduction in uncertainty and the ability to make informed traveler decisions. Information reduces uncertainty, which leads to improved decisions and more effective actions.

Literature Review

A literature review was conducted to determine how others have valuated information and the certainty of knowing of what to expect. Many studies have used a willingness-to-pay methodology to determine travelers' value of information. The method involves asking travelers how much they would be willing to pay to receive the information.

A study conducted by London Transport focused on the Countdown system for buses, which provides real-time passenger information at bus stops (Smith et al. 1994). Real-time information at bus stops reduces the anxiety of waiting and allows passengers to choose to not wait or to find a diversionary activity during the wait. A survey was conducted to determine passengers' value of the system. Passengers were willing to pay an average of 26 pence (approximately $0.45) for the information and the associated improved certainty about their wait times. The study used a number of tests to validate this result. Passengers were asked to put a value on in-vehicle travel time, which they set at 160 pence per hour. This value was close to the 165 pence per hour that London Transport Buses used in service planning. Passengers were also asked about their willingness to pay through increased bus fare. This question led more directly to the need to pay, so the value was expected to be lower. Instead, the average response exceeded 20 pence per trip, which helped confirm the value of 26 pence.

The Department of Transport also conducted a study of the use and opinions of traveler information and willingness to pay for the information in the form of a phone call or Short Message Service (SMS) message (Parker and Glaysher 2002). Only a quarter of the participants were willing to pay for personal alerts before a journey, and about a third were willing to pay for information during a journey. The suggested values ranged from 10 pence to 1 pound (approximately $0.19 to $1.90) per information item. The average reply was a valuation of 40 to 50 pence ($0.75 to $1.00).

A 1998 San Francisco Bay Area study interviewed 1000 respondents through a computer-aided telephone survey about their willingness to pay for ATIS (Wolinetz 2001). The hypothetical ATIS provided notification of unexpected congestion, estimated time of delay, and alternative route planning around congestion. Seventy-three percent of respondents were willing to pay for this information. The value was determined by questioning, “Are you willing to pay $1.00?” and decreasing the amount in $0.25 increments to $0.25 per call if the answer was negative. The respondent value averaged $0.74 per call.

Another study in the Bay Area focused on users of a traveler advisory telephone system (Khattak and Prokopy 2003). Respondents were asked about a hypothetical per-call service charge. At least some users were willing to pay $0.25 per call. The study also found that average usage would increase with customized traveler information.

Polydoropoulou et al. (1997) conducted a study of SmarTraveler, a Boston area ATIS that provides real-time, location-specific traveler information via telephone. The study attempted to determine how often travelers would use the system given different service charge scenarios. The study determined that for $0.10 per call, the service would be used between two to three times per week.

A commuter needs study performed in Sydney, Australia, by Kim and Vandebona (1999) considered driver attitudes toward traffic information. Those respondents who were willing to pay for the service preferred a per-call charge to a monthly flat-rate charge. Table B-2 summarizes the values for willingness to pay determined from the literature review.

TableB-2. Values of information

Source	**Valuation**
London Transport phone or message service *Parker and Glaysher 2002*	$0.75 - $1.00
San Francisco phone service *Wolinetz 2001*	$0.74
London Transport Countdown for buses *Smith et al. 1994*	$0.45
Bay area traveler advisory *Khattak and Prokopy 2003*	$0.25
Australia phone service *Kim and Vandebona 1999*	$0.25
Boston SmarTraveler *Polydoropoulou et al. 1997*	$0.10

Value of Certainty Methodology

The proposed value of certainty methodology employs several steps.

1. Determination of initial costs and yearly operation and maintenance costs

The initial cost of a traveler information system includes the cost of the hardware, project design, and installation. These values can be collected from the project manager or from project budget information. Annual costs include operations charges, such as phone lines and electricity, and maintenance fees for check-ups and equipment repair.

2. Estimation of the number of people who access the information

The number of people who access the information varies among the types of technology. For example, the number of people who see a variable message sign (VMS) may be the same as the number of people who see a highway advisory radio (HAR) sign, but HAR users are also required to tune into a station, an extra step that not all travelers may take. A percentage of the average annual daily traffic (AADT) on the roadway can be used to estimate the number of people who access the information. The number of people who access camera images on a website is also variable. These values can be determined by using website counters.

Because this methodology focuses on the value of certainty, it evaluates the accessing of the information, rather than the utilization of the information. The peace of mind gained from any piece of traveler information has a value, whether the traveler changes routes or simply feels more prepared for the trip. Even an unused device has value. If a traveler on a mountain pass sees a blank VMS or non-flashing HAR, there is comfort in knowing that there are no traveler advisories for the road ahead. Therefore, the number of people who access the information can be simplified to the number of people who see a message (or absence of message) on a website, VMS, or HAR.

3. Determination of a base value of information

The range of values determined by the literature review can be utilized to valuate traveler information systems because it accounts for the possibility of information being used to reduce anxiety about traveling conditions as opposed to focusing solely on traveler diversion to alternative routes. Using a willingness-to-pay method provides a conservative valuation of traveler information. People often do not approve of payment for services and will under-price the value of this information.

4. Calculation of benefits

The calculation for the value of certainty takes into account the above assumptions. It determines benefits on the basis of a range of values for information and the percentage of drivers who access the information. This benefits calculation can be compared to the initial cost and annual operating and maintenance costs.

Value of Certainty Example

An example of the value of certainty method is outlined below for the VMS on SR 104, which was part of the Edmonds Ferry Terminal project.

1. **Determination of initial costs and yearly operating and maintenance costs**

The following initial and yearly costs were determined from the project work plan, Operations and Maintenance Agreement, and input from operations staff:

Project Element	Background	Cost
VMS	VMS sign and installation	$60,000
Project design, construction engineering, and contingencies	Approximately 15-20% of installation subtotal	$10,000
Operations	Phone line	$600
	Electrical power	$500
Maintenance	Assuming 2 trips to sign per year	$1,000
	TOTAL	**$72,100**

2. Estimation of the number of people who access the information

The WSDOT *2003 Annual Traffic Report* (WSDOT 2003) lists the AADT for SR 104 at the VMS as 10,000. The VMS provides information to traffic traveling west to the Edmonds ferry terminal, but it is assumed that not all travelers notice the sign or register the meaning of the message. Therefore, the AADT passing the VMS can be estimated as 5,000**.** A range of percentages of travelers who view the VMS (20 to 80 percent) can be tested.

3. Determination of a base value of information

A range of values based on the literature review can be specified as possible valuations of information and the certainty that accompanies it. A range of values from $0.01 to $0.50 will be tested. Although some of the valuations in the literature review were higher, using a lower range will provide a conservative estimate of benefits.

4. Calculation of benefits

The benefits of the VMS for the range of values of information and percentage of travelers who view the sign must be calculated. Figure B-1 illustrates the methodology results by considering the amount of time necessary for the VMS to recoup its initial costs.

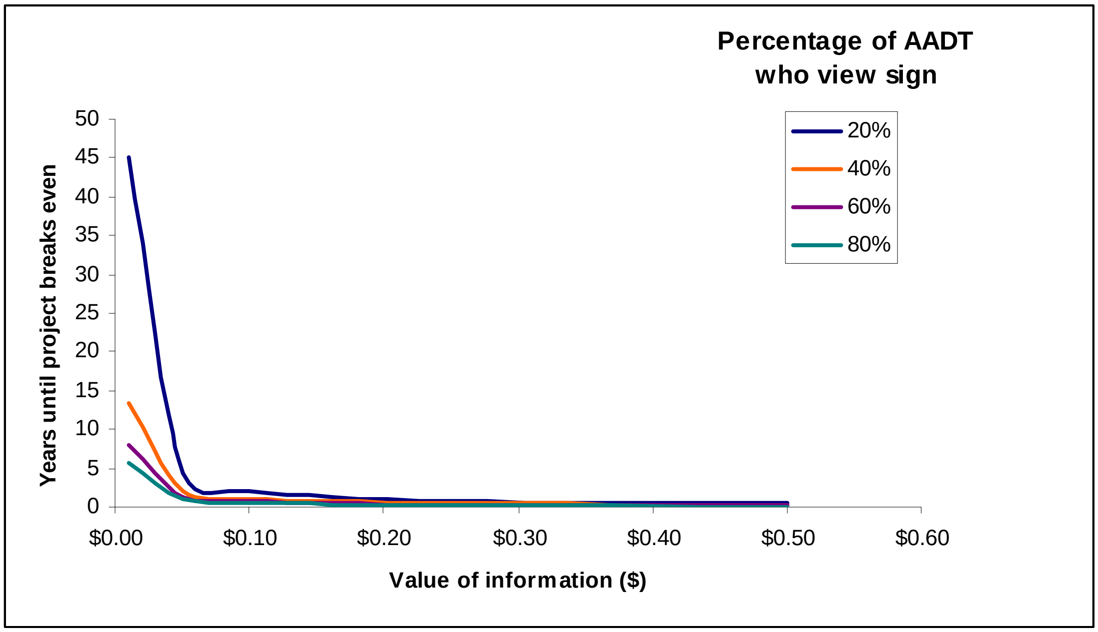

Figure B-1. VMS benefit forecast: years until project benefits equal project costs

When the value of information is set at $0.01, project costs may be regained in between 6 to 45 years, depending on the percentage of travelers who see the sign. At this value of information, it is difficult to argue that the VMS benefits outweigh the costs. However, with an information value of $0.05, project costs may be regained in between 0.9 to 4.3 years. This timeframe is more feasible in the context of mobility programming decisions. The benefits of the VMS on SR 104 outweigh the costs if the value of information is assumed to be $0.05 or higher. For example, with the value of information set at $0.05 and the viewing of the sign set at 60 percent, after 1.33 years, the VMS has a value of $54,750 per year. Table B-3 outlines the benefits of the VMS on SR 104 using the value of certainty methodology.

Table B-3. Value of certainty benefit calculations

Value of information	Percentage of travelers who see VMS	Years until project breaks even	Benefits per year after initial cost is recovered
$0.01	20	45.16	$3,650
	40	13.46	$7,300
	60	7.91	$10,950
	80	5.60	$14,600
$0.05	20	4.33	$18,250
	40	2.03	$36,500
	60	1.33	$54,750
	80	0.99	$73,000
$0.10	20	2.03	$36,500
	40	0.99	$73,000
	60	0.65	$109,500
	80	0.49	$146,000
$0.25	20	0.79	$91,250
	40	0.39	$182,500
	60	0.26	$273,750
	80	0.19	$365,000
$0.50	20	0.39	$182,500
	40	0.19	$365,000
	60	0.13	$547,500
	80	0.10	$730,000

<u>Summary</u>

The value of certainty methodology assumes that a driver finds peace of mind in knowing about traveler conditions. The advantage of this methodology is that it avoids the difficulty of determining typical traveler response to ATIS information. The methodology simply values knowledge of the information. In the example of the methodology, if the action of receiving information from the VMS can be valued at $0.05 or more, the traveler information system will result in significant benefits.

Although the methodology provides an option for avoiding assumptions about traveler behavior, it still requires other assumptions. The calculations are based on the assumption that there is inherent value to information, regardless of whether the traveler responds. The percentage of travelers who see the information (or absence of information) must be estimated. In addition, the methodology estimates a minimum quantitative value for the information. If these assumptions can be validated and values can be determined, the value of certainty methodology can provide a straightforward, economical approach to approximating the benefits of ATIS.

CONCLUSIONS

Regardless of the chosen methodology, determining a quantitative value for ATIS projects is a complex process. Every method has positive and negative aspects. Analysis requires assumptions and estimates about traveler behavior, and it requires values of time and information that typically vary greatly according to the particular situation. It is difficult to determine how information converts into traveler decisions. In addition, it is complicated to develop an evaluation method that accurately measures the benefits of individual ATIS deployments yet remains broad enough to apply to a spectrum of projects and objectives and allow for ATIS investment comparisons.

When the assumptions can be validated, quantitative evaluations can provide valuable benefits for priority programming decisions. It is important to note that many of the methodologies summarized in this report focused on user benefits only, not the benefits that resulted from operations such as improved maintenance efficiency. As seen in the qualitative evaluation, these operating and maintenance benefits often constitute a large part of the benefits of ATIS implementations. Qualitative analyses are always available to encompass all aspects of ATIS projects.

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