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Evaluation of Rural ITS Information Systems along U.S. 395, Spokane, Washington

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EXECUTIVE SUMMARY

As part of the Intelligent Transportation Systems (ITS) Integration Program as authorized in the Transportation Equity Act for the 21st Century (TEA-21), the U.S. Federal Highway Administration (FHWA) funded the Washington State Department of Transportation (WSDOT) to install various ITS technologies in the mostly rural and mountainous region north of Spokane, Washington to the Canadian border. These system components are intended to facilitate collecting and communicating information to commercial vehicle operators, public motorists, and maintenance crews concerning current weather conditions, road surface conditions, border crossings, floods, slide areas, and other information necessary to assist roadway users in making informed travel decisions. Enhanced traveler information can increase safety, improve the efficiency of commercial vehicle operations, benefit road maintenance activities, and provide the general traveler with an increased level of knowledge and comfort regarding the conditions that they may encounter.

U.S. 395 north of Spokane, Washington is a rural, mostly two-lane highway that carries a mix of traffic including commercial vehicles, local and general business commuters, and recreational motorists throughout the year. Commercial traffic in the U.S. 395 corridor is of particular economic importance to the region, carrying significant north-south truck traffic. U.S. 395 is a major north-south trunk-line highway to Canada with traffic flows to and from SR 21, SR 20, and SR 25. U.S. 395 provides the only direct truck access to mainline rail terminals in Spokane. This network of roads serves significant tourism demand with camping, skiing, water recreation, and other summer and winter outdoor activities readily available in the area.

The Problem

The availability of traveler information regarding accidents, construction activities, road weather conditions, and flooding events has been limited in this region. Prior to the ITS earmark project there was limited availability of traveler information outside the immediate Spokane area. The concept underlying this project is that with better rural road condition information, commercial and public travelers will be able to make better decisions regarding their trip timing, route selection, and preparedness leading to a more efficient and safer transportation system. In addition, road maintenance crews and system operators will be able to more efficiently manage the transportation facilities for which they are responsible. The central problem is that it is very difficult in such remote, mountainous, rural areas to efficiently gather accurate information about weather and road conditions and to make good information available to travelers, especially during times of inclement weather. The road maintenance teams can greatly benefit from improved information that helps them provide better services more efficiently and cost-effectively, and can bring road surfaces to level-of-service conditions sooner under winter weather conditions. Using ITS to improve winter road maintenance and provide enhanced traveler information helps travelers be better prepared for driving conditions and enhances their travel safety. In a recent policy forum sponsored by the FHWA and the American Meteorological Society, three types of weather mitigation strategies employed by highway operations and maintenance personnel were highlighted. These are *advisory* information, the ability to *control* traffic flow under prevailing conditions, and opportunities for *treatment* of road surfaces to clear snow and ice.[1] The benefits of these road weather management strategies include improved safety, mobility and productivity. Each of these elements is addressed in this evaluation.

ITS Project Equipment

The system included the installation and operation of ITS information and communication technologies, and their integration into a regional ITS that will assist in the collection and dissemination of critical road and weather information to travelers and WSDOT operators in the U.S. 395 corridor. Specifically, two Road Weather Information System Environmental Sensor Stations (RWIS-ESS) and two mobile Highway Advisory Radio systems (HARs, complete with signage) were installed at key locations in the project corridor. Closed Circuit Television (CCTV) cameras were included in the two new RWIS-ESS installations and one was added to an existing RWIS station in the study area. The locations for the RWIS-ESS included Loon Lake and Laurier on U.S. 395, and atop Sherman Pass on SR 20. The observations made by the sensors include pavement temperature, surface condition, solution freeze point, sub-grade temperature, wind speed and direction, precipitation type and intensity, visibility, air temperature, relative humidity, and atmospheric pressure.

The total cost for the construction and installation of all these system components, including WSDOT oversight, contingencies, and miscellaneous post-installation system repairs and upgrades, was estimated to be $446,807.

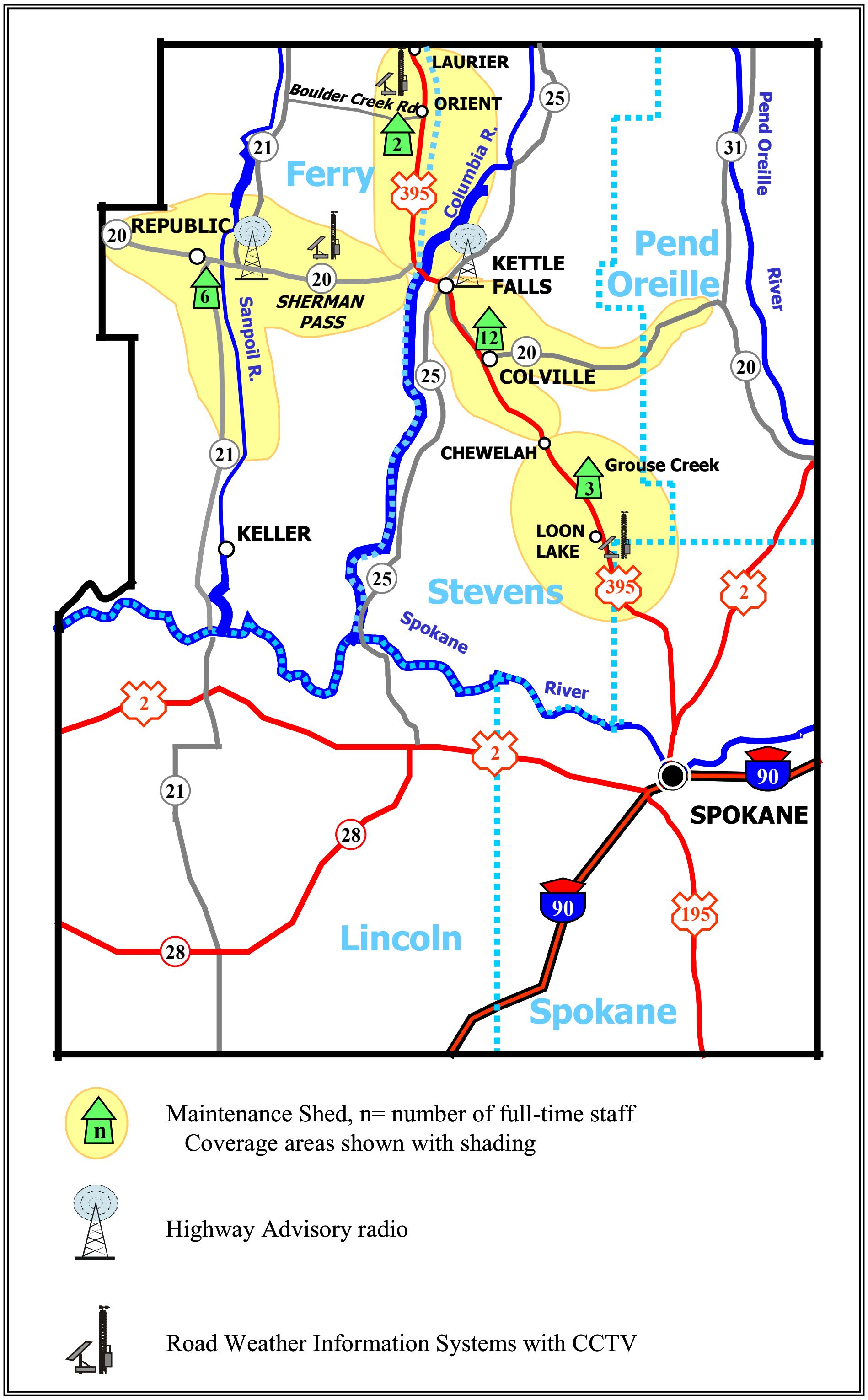
The information from the sensors and cameras was disseminated to travelers primarily through the WSDOT traveler information website. The HARs were used primarily to notify travelers of road and weather conditions on Sherman Pass and were therefore located on either side of the pass in Republic (west) and Kettle Falls (east). The map (Figure ES-1) of the project area illustrates the corridor.

Evaluation Approach

The Battelle Memorial Institute, teamed with Meyer, Mohaddes Associates, was contracted by the U.S. DOT's Joint Program Office to conduct an independent evaluation of this project in order to better determine and document the benefits of such rural road weather and traveler information ITS deployments. The purpose of the evaluation was to test hypotheses about the impacts that the ITS installations were expected to have on the efficiency, safety, and traveler behavior/decision processes by those using the corridor or responsible for maintaining the roads in the corridor. A focus was placed on whether the new information changed the users' decisions (maintenance procedures, trip timing, trip routing, or level of preparedness).

The evaluation focused on three primary users: WSDOT Operations and Maintenance (O&M) crews, commercial vehicle operators, and general travelers. In addition, the evaluation assessed the overall system performance, including the system integration with the Eastern Washington Transportation Management Center (TMC) located in Spokane where the data were managed, and safety.

[1] Policy Forum on Weather and Highways, Washington, D.C., November 5, 2003.



Map not to scale

Figure ES-1. Map of ITS installations and WSDOT maintenance facilities for U.S. 395 Spokane evaluation

The main hypotheses to be tested in this evaluation are listed below. Additional detailed hypotheses are presented in the report as they pertain to each of the component evaluation tests.

The core hypotheses – better information provided by ITS will lead to:

- Increased efficiency of WSDOT operations and maintenance.
- Better informed travel decisions and enhanced preparedness for commercial vehicle operators.
- Increased awareness and use of traveler information, and increased satisfaction on the part of general travelers.
- Increased travel safety for commercial and general travelers and operational safety for WSDOT operations and maintenance road crews.

Anticipated benefits from the planned ITS improvements in this region include: more accurate, up-to-date road weather information to facilitate the mobility of commercial and private vehicle travel; increased efficiency and cost savings for roadway operations and maintenance; high quality functional operation of the various ITS installations; and, safety improvements for both travelers and operational staff. The general approach for evaluating each of the project components was to specify measures of project-induced changes or impacts associated with selected project goals, along with available data sources and methods for collecting the data. The evaluation established a baseline (before equipment installation) during the 2000-2001 winter season, where possible, and collected post-deployment data during the winter 2002-2003. The findings from each of these evaluation areas are summarized below.

WSDOT Operations and Maintenance Findings

WSDOT Operations and Maintenance personnel were asked to complete an event log during the winter seasons by location for each winter weather event that significantly affected road conditions. Additionally, interviews were performed before, during and after the evaluation period to enhance the understanding of the event log data. The new ITS-based information significantly impacted maintenance operations during the evaluation winter period and thoughts for future use and expansion of the equipment. The following summarizes the evaluation findings, *which support the hypothesis that the ITS installations will increase the efficiency of WSDOT operations and road maintenance:*

- The weather data and camera images were used by the O&M crews to keep them informed in real-time of conditions in the more remote and inaccessible portions of their work areas, especially on Sherman Pass and at Laurier, where US 395 crosses the Canadian border. A number of instances were documented where they could use this information in lieu of having to send a truck to these areas to observe conditions first hand, which had been the standard procedure. *WSDOT believed they experienced savings in time and resources that could then be applied more productively elsewhere in their service area.*
- Because better information was available to travelers in the post-deployment period regarding conditions on Sherman Pass, the WSDOT office at Colville experienced *a reduction in public requests for road condition information* compared with the baseline period, thereby freeing up staff for more important tasks.

- RWIS-ESS data and National Weather Service forecasts were used extensively to determine when and how much to deploy liquid anti-icing chemicals prior to a storm arrival.
- The WSDOT Maintenance Superintendent reported using half as much sand as had been anticipated during the 2002-2003 winter. Although this savings can not be fully attributed to ITS deployments, he estimated the use of RWIS-ESS information contributed significantly to this reduction, perhaps as much as 50% of the total savings in resources.
- The Superintendent also reported that use of RWIS-ESS data and camera images increased his staff's level of interest in weather and road condition information to accomplish their jobs more efficiently. They want more information to minimize unnecessary trips and focus road maintenance activities.
- During the evaluation no road closures were issued. However, several road restrictions regarding chain requirements were issued for Sherman Pass. The RWIS-ESS equipment was reported to have been used extensively to facilitate these decisions, and the mobile HARs were also used to disseminate the information to travelers.
- As a result of this project, WSDOT has developed plans to expand and enhance the use of RWIS-ESS (including camera images) in the project corridor to cover other critical road maintenance areas.

Commercial Vehicle Operation Findings

Commercial vehicles constitute a significant component of the total traffic in the U.S. 395 corridor region. The impacts of hazardous road and weather conditions on commercial vehicle operations affect the trucking businesses and the economic viability of the communities that they serve. The evaluation team identified approximately 40 carriers that operate an average of 6 trucks each[2] in the project corridor who were willing to participate in a "before" and "after" survey (phone interview) process. Although some of the operators were newly contacted in the post-deployment data collection, 35 (90%) of them were the same companies that were interviewed to establish the baseline conditions. These carriers transported a variety of goods with several truck types and were selected to be a representative sample of the commercial trucking community in this region. The commercial operators are primarily hauling lumber and related wood products (19, or 49% of the operators surveyed).

The type of information provided with this project was thought to improve Commercial Vehicle Operator (CVO) safety for truck drivers, increase efficiency of operations, and enhance preparedness of trips during inclement weather and resulting poor road conditions. The primary evaluation findings, *that support the main hypothesis that CVOs are able to make better informed travel decisions and report that they are better prepared for their trips,* are as follows:

- About one-third of the CVOs said they would change routes based on information about road weather conditions, but few were able to identify viable alternate routes for their typical trips in the study corridors.

[2] The commercial operators interviewed reported 1 to 26 trucks that they operate in the region, with a median number of 3, indicating there are many smaller operators and a few larger ones in the interview sample.

- Many CVOs reported that they regularly accessed and used the newly available road weather information, and they felt better prepared for their trips as a result. Eighteen (46%) of post-deployment operators indicated they used the Internet to access weather and road condition information compared to only 12 (29%) during the baseline survey just 2 years prior.
- Twenty-two (56%) of those interviewed reported that they tuned to one or both of the HAR stations while traveling in the area. The majority found the HAR messages to be "somewhat" or "very" useful.
- The CVOs interviewed in the post-deployment period reported more frequent use of road weather information compared with the baseline period. The CVOs reported that they felt better prepared for inclement conditions in the post-deployment period. While a number of CVOs interviewed were not aware of the availability of camera images on the WSDOT web site, those who were aware indicated that they were particularly valuable to their operations.
- Circumstantial evidence suggested that there were fewer truck-related accidents and road blockages because drivers were notified of conditions ahead, via the Internet and the mobile HARs, to avoid the problem areas or to use extra caution.

General Traveler Findings

Members of the public use the roadways in the study region for a variety of purposes, including commuting, sightseeing, personal business, and recreation. U.S. 395 and SR 20 are also used as routes to access places outside the study area. Travelers in this region have a strong desire for traveler information to help them make decisions regarding trip routing, trip timing, and feeling properly prepared for their trips.

The approach to evaluating the response of general travelers to the new ITS-generated road weather information was to conduct a web-based survey on WSDOT's relevant traveler information and road weather web pages in the 2002-2003 winter travel season, after the new information sources had been available for several months. This strategy yielded responses from 237 individuals who were aware of and used the Internet to consider and plan their travel in this region.

Key findings from the public traveler Internet survey *support the main hypothesis that the new ITS installations will lead to increased awareness and use of traveler information and increased satisfaction with the travel experience,* and they included the following:

- About 93% of the respondents are relatively frequent users of this WSDOT web information, reporting six or more visits to the web site from December 1, 2002.
- More than a third of the respondents (39%) reported no trips during this period, and about 21% reported six or more trips, with the rest equally distributed between one and five trips.
- Concern about weather conditions on trips that the respondent is planning to take is the number one reason for using the web site by a wide margin. The next two primary reasons are to look for mountain pass conditions and to satisfy general interest in weather conditions but not associated with any particular trip.

- Overall, respondents said they used the web site most for planning recreational trips in the region. Personal business was also frequently cited, and it was the most frequently cited type of trip for which respondents said they accessed road weather information on the web site.
- Camera images, current weather information, and pass reports were used by the majority (between 94% and 99%) of these respondents.
- Agreement was highest (94% agree or strongly agree) that the web site road weather information makes travelers better prepared for their trips. Respondents value the safety benefits, accuracy of current information, and the level of comfort afforded by the information. Over half the respondents (56%) agree that the information helps them avoid travel delays, but only 22% strongly agree with that and 20% are undecided.

System Performance Findings

The performance of the various ITS deployed in the project is essential to the effective use of the information that they provide. Through various data logs and interviews with key project participants, the following lessons learned were identified by the evaluation team regarding system performance:

- **RWIS-ESS.** The performance evaluation of the RWIS-ESS covered the tower, atmospheric and pavement sensors, computer processing equipment, and power supplies but not the communications equipment and CCTV images. The three RWIS-ESS stations located at Loon Lake, Sherman Pass, and Laurier performed well with no known system failures or outages during the evaluation period. However, there were apparent communication gaps with the Sherman Pass RWIS-ESS for as much as 20% of the time when precipitation was occurring. The cabling to the Sherman Pass pavement sensor also was damaged by snow plowing activities, and maintenance crews reported a number of problems with workstation connectivity to the RWIS information, which are being addressed.
- **RWIS-ESS Siting Issues.** The Sherman Pass RWIS-ESS was required by the U.S. Forest Service to be placed in heavy timber close to and taller than the tower itself to make the installation less visually prominent. This resulted in several short-comings: low detail camera images, damage due to falling limbs, increased susceptibility to vandalism, and severely impaired wind measurements. The U.S.F.S also required the tower and enclosure to be painted flat black. It is logical to assume the proximity of these dark surfaces also altered the reported air temperature from a more area representative measurement. This is unfortunate since no weather stations are near-by and information from the Sherman Pass ESS could be extremely valuable to U.S.F.S fire weather forecasters.
- **CCTV Images.** CCTV cameras were installed at all three RWIS-ESS to provide video images of weather and pavement conditions. The Sherman Pass camera could have used a higher magnification lens to view the roadway more clearly, though a workable solution was not found for this winter season. The same concern applied to the Loon Lake CCTV image. The cameras generally worked well and stayed clean and free of debris enough to provide images that were clear and useful to maintenance personnel and other users. However, the Sherman Pass camera image was often “down” on the WSDOT web site

primarily due to cell phone communications problems, eliciting comments by respondents to the web survey as well as maintenance workers.

- **CCTV Siting Issues.** Comments were made regarding the lack of clarity of CCTV images at Sherman Pass due to the distance of the camera from the road
- **Highway Advisory Radio (HAR).** The two mobile HARs were deployed on SR 20 on both sides of Sherman Pass to provide information to motorists on road conditions, weather, and restrictions. Though they were designed for intermittent use during severe driving conditions, WSDOT decided to use them continuously to relay pass conditions, which caused several problems. The HARs were designed to operate on solar power, but the predominantly overcast winter days resulted in inadequate battery power for full-time use. WSDOT later decided to install permanent power to the HAR pads, thereby solving that problem for future winter applications. However, the warning flashers were turned off to conserve power during the study period, potentially causing confusion to travelers who might not have been aware that messages were active on the HARs. Finally, cell and pager communications to operate the HARs (flashers and messages) turned out to be unreliable, and WSDOT is considering hard-wiring the HAR pads. The lessons learned through the system operation this past winter will help to improve the performance and usefulness of the system in future years.
- **Information Access.** The maintenance personnel suffered from lack of consistent Internet access at the maintenance sheds. Problems were experienced with the satellite connection; lack of adequate horizon clearance, poor signal on bad weather days, and snow accumulation during weather events. This had an impact on the use of the RWIS data by some maintenance personnel during critical winter events. During this period efforts were made to optimize the satellite Internet connection. This has been a difficult task that has been successfully accomplished so far at some of the maintenance sheds and not yet at others.
- **TMC Integration.** The Spokane Regional Traffic Management Center (TMC) was used to collect and disseminate the information. Although there were some breakdowns in communications between the WSDOT maintenance personnel and TMC operators regarding use of the HARs, the system generally worked well, and the integrating role of the TMC was highly valued. Beginning in the fall of 2003, the TMC will be operated 24 hours a day, 7 days a week.

Safety Findings

Safety is an important aspect of any ITS evaluation, but is often difficult to quantify. This was also the case in this project. Although baseline crash data were collected for the entire region from 1992 to 2002 (with two years of missing data for 1997-1998) and at selected locations in the corridors known to have a high level of crashes, the post-deployment evaluation data collection period (2002-2003 winter season) offered only one year’s worth of data. Analyses of these data indicate the total number of accidents varied widely year to year and the proportion of weather-related accidents also varied. In the 10 year baseline period, annual accidents ranged from 44 to 68 on U.S. 395 and from 18 to 38 on SR 20. The percent of baseline accidents that were classified as weather-related ranged from 32% to 61% on U.S. 395 and from 44% to 68% on SR 20. Comparable data for the post-deployment period are only partial but they suggest that the safety experience is not particularly out of the baseline range, though for SR 20 the percent of weather-related accidents is lower than any single year in the baseline. Nevertheless, the numbers of events are too small to ascribe statistical significance to these differences. Useful perspectives on the safety impacts due to the deployment of the ITS equipment come from maintenance personnel, commercial vehicle operators, Washington State Patrol, and general travelers.

The main hypothesis is supported that the new ITS capabilities are perceived by commercial and general travelers in the region to enhance travel safety, and WSDOT operations and maintenance crews report that the roads can be made safer more quickly and efficiently using the ITS information. Reports from surveys and other interviews of key project participants indicate the following important safety impacts of the ITS equipment deployed in this project:

- 88% of the general travelers who responded to the web-based survey either "strongly agreed" or "agreed" with the statement: "I feel that my use of this website makes my trips safer."
- 41% of the CVOs interviewed reported increased safety in the region. They responded with "a lot safer" or "somewhat safer" to the question: "Has the availability of HARs, camera images of key roadway segments, and enhanced Internet information affected driving safety for you in this region."
- The maintenance crews working on Sherman Pass indicated far fewer jack-knifed trucks during the post-deployment evaluation period compared with prior years. They attribute this finding to better pass condition information being available, noting that the post-deployment winter was about average for the area and that CVO operators tend to be especially responsive to posted and enforced condition advisories.
- The Washington State Patrol reports no reduction in public inquiries regarding road conditions, suggesting awareness of the new information available over the Internet and on the HARs was low this first post-deployment winter. However, their perception is that safety preparedness and travel decision making has improved for those general and commercial travelers who do access the new information. In addition, they themselves have benefited directly from their access to the improved RWIS and camera information.

Conclusions

The ITS equipment installed in the rural corridor north of Spokane, Washington to the Canadian border in support of enhanced traveler information has resulted in significant benefits for operations and maintenance, commercial vehicle operations, and general travelers in the region.

Primary impacts of the HAR, CCTV and RWIS-ESS working in concert include:

- Improvements in winter road maintenance efficiency due to increased availability of relevant and geographically significant RWIS data and camera images.
- Safer, more confident travel decisions (when, where) by commercial and general travelers after obtaining the new weather and road condition information.
- Better prepared travelers in the region with improved knowledge of weather and road conditions that will be faced during planned trips (commercial and general travel).

- Perception by most users that this type and extent of traveler information improves safety in the project corridor.
- Trends from all users indicating a heightened interest of this type of information, suggesting increased use in the future to improve efficiency, safety, and comfort in traveling in this region.
- While benefits are substantial and measurable, concerns remain that public awareness of the enhanced information, especially for use in pre-trip planning, is low, and more attention needs to be paid to promoting the information services.

The evaluation team feels this was a productive and meaningful evaluation of ITS-based sensing and traveler information dissemination in a rural area. The evaluation concludes that even limited ITS road weather information systems can offer significant benefits both to state DOT operations and to commercial and private travelers in these rural areas. Although system bugs need to be worked out, and in spite of a noticeable learning and trust-building curve in the short run, in the long run both operators and travelers adjust their behaviors to access and use quality real-time information when it becomes available to them. The findings in this report can be used by DOTs in other rural areas to effectively deploy similar ITS to enhance travel.

As a result of this earmark project, and based on findings from the evaluation, WSDOT plans to expand and enhance the use of RWIS, including camera images, in more locations in the project corridors to further extend the coverage throughout their maintenance jurisdiction. Based on their experience deploying these initial systems, they anticipate that the costs of adding additional equipment will be reduced and that the lessons they have learned along the way will lead to greater efficiencies in the operation and maintenance of these systems. They also believe that the overall benefits to be derived from such systems will be much greater once the capabilities are more widely disbursed in the region and more routinely used by both travelers and WSDOT operators.

1.0 Introduction

1.1 Background

The U.S. Federal Highway Administration (FHWA) has provided funding to the Washington State Department of Transportation (WSDOT) to install various Intelligent Transportation Systems (ITS) components including Road Weather Information Systems Environmental Sensor Stations (RWIS-ESS) and Highway Advisory Radios (HARs) in the mostly rural and mountainous region north of Spokane, Washington to the Canadian border. This system is intended to communicate traveler information to commercial vehicle operators, other public motorists, and maintenance crews concerning current weather conditions, road surface conditions, border crossings, floods, slide areas, and other information necessary to assist roadway users in making informed travel decisions. The system includes the installation and operation of ITS information and communication technology, and its integration into a regional ITS that will assist in the collection and dissemination to travelers and WSDOT operators of critical road and weather information in the U.S. 395 corridor. Enhanced traveler information can increase safety, improve the efficiency of commercial vehicle operations, benefit road maintenance activities, and provide the general traveler with an increased level of knowledge and comfort regarding the conditions that they may encounter.

Sherman Pass winter view from RWIS-ESS

U.S. 395 north of Spokane, Washington is a rural, mostly two-lane highway that carries a mix of traffic including commercial vehicles, local and general business commuters, and recreational motorists throughout the year. Commercial traffic in the U.S. 395 corridor is of particular economic importance to the region. The six-year Eastern Washington Intermodal Transportation Study reported that, "The volume and economic value of cargo passing within or through the U.S. 395 corridor area is substantial. During a typical week day, 5,600 trucks carrying over 100,000 tons of cargo, worth over $139 million in 1994 prices, pass within and through the region over a 24-hour period."[3] As shown in Figure 1, U.S. 395 is a major north-south trunk-line highway to Canada with traffic flows to and from SR 21, SR 20 and SR 25. It serves the border crossings of Laurier/Cascade, Frontier/Paterson via SR 25, Boundary/Waneta via SR 25, and county roads, Metaline Falls/Nelway via SR 31, and Danville/Carson via SR 21. It is important to note that U.S. 395 provides the only direct truck access to mainline rail terminals in Spokane. This network of roads serves significant tourism demand with camping, skiing, water recreation, and other summer and winter outdoor activities readily available in the area.

[3] Casavant, K.L., and W.R. Gillis. 1995. *Importance of the U.S. 395 Corridor for Local and Regional Commerce in South Central Washington.* EWITS Research Report Number 8. (April).

The U.S. DOT's ITS Joint Program Office is conducting an independent evaluation of this project in order to better determine and document the benefits of such rural road weather ITS deployments. The Battelle Memorial Institute, teamed with Meyer, Mohaddes Associates, was selected to perform the independent evaluation. This Phase III report provides the evaluation approaches and the results of the data collection and analysis. The baseline data obtained prior to full deployment of the new ITS capabilities were presented in a Phase II report.[4]

1.2 Project Problem Statement and Deployment Overview

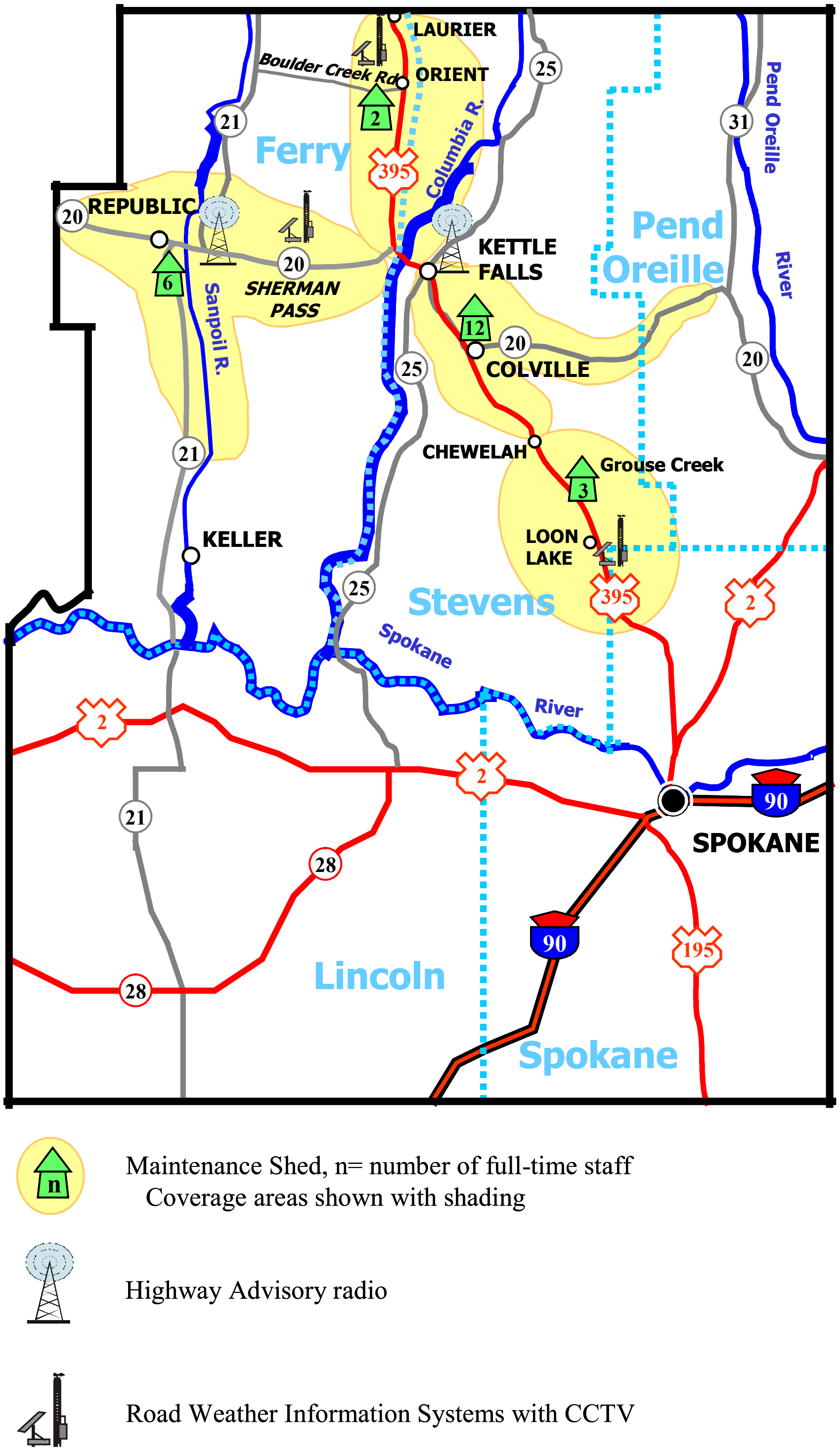
The availability of traveler information regarding accidents, construction activities, road weather conditions, and flooding events is limited in this study region. Prior to this ITS earmark project there was one RWIS-ESS, without a CCTV, at Loon Lake, no HARs, and traffic information on the radio or the Internet only covered conditions in the immediate Spokane area. The concept underlying this project is that with better rural road condition information, commercial and individual travelers will be able to make better decisions regarding their trip timing, route selection, and preparedness leading to a more efficient and safer transportation system. In addition, road maintenance crews and system operators will be able to more efficiently manage the transportation facilities for which they are responsible. The central problem is that it is very difficult in such remote, mountainous, rural areas to efficiently gather accurate information about weather and road conditions and to make good information available to travelers, especially during times of inclement weather. The road maintenance teams can greatly benefit from improved information that helps them provide better services more efficiently and cost-effectively, and can bring road surfaces to level-of-service conditions sooner under winter weather conditions. Using ITS to improve winter road maintenance and provide enhanced traveler information helps travelers be better prepared for driving conditions and enhances their travel safety.

> As used in this report, **Road Weather Information System (RWIS)** refers to the entire road weather system, including equipment, and information gathering and dissemination hardware and software. **RWIS Environmental Sensor Station (RWIS-ESS)** or **RWIS site** refer to the physical roadside installation that collects and transmits road weather data. **RWIS data** and **RWIS information** refer to the outputs from the components of the RWIS or the RWIS-ESS.

The ITS equipment that has been installed under this earmark project includes the following components. The geographic location of each of these components is illustrated in Figure 1.

<u>Mobile HAR facility at Junction of State Routes 20 and 21 near Republic</u>. The HAR equipment was originally based at the Republic maintenance shed; however, the signal did not reach the area where it would be useful to motorists. The HAR was relocated to a pad at the junction of State Routes 20 and 21 on the lower west side of Sherman Pass. WSDOT operators transmit messages remotely, using a solar powered cellular phone, to the mobile HAR as changing road and weather conditions dictate. These messages warn motorists of road construction and restrictions, dangerous driving conditions, border crossing conditions, and similar kinds of information that should enhance the comfort and safety of travel.

[4] *SR 395 Spokane FY99 Earmark Evaluation,* Final Phase II Report, September 20, 2001.



Maintenance Shed, n= number of full-time staff
Coverage areas shown with shading

Highway Advisory radio

Road Weather Information Systems with CCTV

Map not to scale

Figure 1. Map of ITS installations and WSDOT maintenance facilities for U.S. 395 Spokane evaluation.

Mobile HAR at Kettle Falls. This mobile HAR functions similarly to the one at Republic, and information broadcast here includes border closure information, other road closures, weather, and incident and construction updates, as well as traction requirements and vehicle restrictions.

Mobile HAR with solar panel

RWIS-ESS, including camera, at Sherman Pass. Sherman Pass, on SR 20, presents one of the more dangerous driving environments in this area during the winter season, as well as under spring thaw and rain conditions. WSDOT is using cell phone technology and propane power generation to provide communications for this remote rural RWIS-ESS station. A co-located camera allows visual inspection of conditions on the pass in real-time, providing for more rapid and appropriate response by crews and better information dissemination to travelers. RWIS-ESS implemented under this program are tied into the state-wide road weather system being operated out of the University of Washington, and allow WSDOT to provide weather conditions for these localized areas over both HARs and the Internet. The observations made by the sensors include pavement temperature, surface condition, solution freeze point, sub-grade temperature, wind speed and direction, precipitation type and intensity, visibility, air temperature, relative humidity, and atmospheric pressure.

RWIS-ESS with camera at Laurier. Laurier is located where U.S. 395 crosses the Canadian border, and WSDOT has placed a weather station and camera at this site to collect environmental data including wind speed, temperature, precipitation, pavement conditions, and humidity. This information is particularly useful to commercial and general travelers who are traveling between the United States and Canada. The information and images from the Laurier RWIS-ESS are also used by the General Services Administration to support their snow removal efforts at the border crossing.

Camera with the Existing RWIS-ESS at Loon Lake. This RWIS-ESS is located on a portion of U.S. 395 that experiences frequent severe winter weather and dangerous road conditions. WSDOT has installed and integrated a camera with their existing RWIS station. The camera helps to convey current conditions in the U.S. 395 corridor by providing frequently updated images to the WSDOT web pages. This location has been demonstrated to be a bell weather indicator for conditions on most of this north-south route.

Installation costs for these facilities are shown in Table 1. Operations and maintenance costs associated with these earmark components are difficult to separate out in the budget and were not available at the time this evaluation was conducted. The cost data in Table 1 show unit prices for the major components at each installation, including contractor construction costs; WSDOT-provided elements, including contract management and oversight; overheads and contingencies; and miscellaneous post-installation costs associated with replacement or repair of faulty or damaged equipment and other extra expenses not initially anticipated (e.g., new power feeds and wiring, new HAR signs, extra fuel tank, rebuild paging units). The RWIS weather stations came in kits from the vendor that included plans, sensors (road surface, air, wind, precipitation, pressure), wiring, receivers, antenna, cable, remote processing unit, tower, and camera.

Table 1. Construction and installation costs for the Spokane earmark.

Item	Unit Price	Quantity	Cost
Sherman Pass (RWIS-ESS)			
Weather Station w/Cellular Setup	45,384	LS	45,384
500 Gal. Propane Tank (Including installation kit and initial fill)	1,715	1	1,715
Thermoelectric Generator System	14,003	LS	14,003
Fiberglass Enclosure	9,070	1	9,070
Motorola Bag Phone	250	1	250
Phone Line at WTEP Server	50	1	50
Junction Boxes - Type 1	170	7	1,190
Conduit - 1 1/2" RGS (100 LF sections; installed)	2,515	10	25,150
Clearing and Grubbing	2,500	LS	2,500
Traffic Control	2,500	LS	2,500
Project Total (plus overhead, profit, taxes, contingencies)			**$170,006**
Laurier (RWIS-ESS)			
Weather Station	44,383	LS	44,383
Clearing and Grubbing	2,000	LS	2,000
Service Cabinet, Pole, and Wiring	1,150	1	1,150
Conduit - 1 1/2" RGS (100 LF sections; installed)	2,365	1	2,365
Phone Drop at Laurier	50	LS	50
Project Total (plus overhead, profit, taxes, contingencies)			**$83,403**
Kettle/Republic (Mobile HAR)			
Mobile Highway Advisory Radio (Provided to contractor, tax incl.)	0	1	0
FCC Licensing	500	LS	500
Computer	2,000	2	4,000
Clearing and Grubbing	1,000	LS	1,000
CSBC (1 1/4" minus) Pad for HAR Trailer (Method A Compaction)	16	6	96
Permanent HAR Signs w/ Solar Power Supply and Pagers	8,922	3	26,766
Conduit - 1 1/2" RGS (100 LF sections; installed)	2,515	1	2,515
120V Weatherproof Power Receptacle w/ 4' Timber Pole	500	LS	500
Project Total (plus overhead, profit, taxes, contingencies)			**$59,073**
Loon Lake (Camera)			
ESP COHU Color Camera Video Kit Upgrade	858	LS	858
Project Total (plus overhead, profit, taxes, contingencies)			**$1,857**
Below the Line (Not a construction line item)			
HAR Trailers	26,000	2	52,000
Power Receptacle	100	1	100
COHU Camera Upgrade Kit	5,000	3	15,000
Below the Line Total (plus taxes)			**$72,468**
Miscellaneous Items (Post-installation)			
Total			**$60,000**
Grand Total			**$446,807**

Notes: LS = Lump sum; CSBC = Crush Surfacing Base Course; RGS = Rigid Galvanized Steel (conduit)

1.3 Project Implementation Schedule

At the time of the early planning for this earmark evaluation, WSDOT had anticipated the installation of each of the project component facilities would be completed and operational by December 2001. However, due to the need to satisfy procurement and permitting requirements that took much longer than expected, the equipment deployment was delayed and only became operational in the late fall of 2002, about a year behind schedule. WSDOT staff prepared equipment lists, and parts were ordered for the two mobile HAR trailers, two complete RWIS weather stations, and a power source for the Sherman Pass installation. WSDOT applied for a use permit from the U.S. Forest Service for use of the Sherman Pass site. This included submittal of a description of the site, the type of installation required, potential environmental impacts to the area, and expectations for the nature and duration of this use of the site. Constraints imposed by these requirements reduced the potential effectiveness of this RWIS-ESS, due to its distance from the road surface and the inability to pan more of the road segment because of the surrounding trees. This siting also increased the RWIS-ESS's susceptibility to vandalism and falling tree limbs in storms, as well as making it more difficult to service, especially in the winter. The tower and enclosures were also painted flat black at the requirement of the U.S.F.S, affecting the accuracy of measured air temperatures. After all the requirements had been met, the contractor was selected and the work was completed. The equipment was tested and was fully operational in time for the winter of 2002-2003, providing time as well for travelers and operators to become better aware of and acquainted with the capabilities of the various system components and their intended benefits.

Because of the delays in installing the equipment, a decision was made to delay the evaluation for a year, during which time the evaluation monitored developments to be sure everything would be ready for the post-deployment data collection during the winter of 2002-2003.

1.4 Phase III Report Contents

This Phase III Report documents the evaluation of the U.S. 395 earmark project. The report includes discussion of the hypotheses being tested, the collection and analysis of baseline data, and the collection and analysis of the post-deployment data. Phase I included a site visit and an initial project assessment that documented the potential for this project to yield useful evaluation results. An Evaluation Plan was prepared for this project under Phase II and submitted to FHWA on November 3, 2000. That plan presented the strategy and goals for the evaluation, and laid out an evaluation and project management approach to conducting the baseline data collection and analysis phase of the evaluation. The plan defined measures, hypotheses, and methods proposed for the main areas of evaluation focus that included:

- Infrastructure operations and maintenance
- Travel and mobility for commercial vehicles
- Travel and mobility for the general public
- System performance and reliability
- Safety

The Phase II report documented the baseline conditions and set the stage for the final Phase III evaluation, including providing detailed test plans for the evaluation. Each Test Plan contained the approach, data collection instruments, and analysis techniques that are being applied in this evaluation. The format of the Test Plans follows FHWA guidelines to assist in the detailed data collection and analysis. This Phase III report analyzes findings in each of the five main areas of the evaluation and looks comparatively at the differences between the baseline and post-deployment conditions and data to assess the impacts and benefits of the ITS facilities that were funded and installed under this earmark project.

2.0 Evaluation Approach

2.1 Introduction

The objective of this evaluation is to assess the effects of new road weather information system components installed in the U.S. 395 corridor north of Spokane, Washington. Anticipated benefits from the planned ITS improvements in this region include:

- Increased efficiency and cost savings for roadway operations and maintenance;
- More accurate, up-to-date road weather information to facilitate the mobility of commercial and private vehicle travel;
- High quality functional operation of the various ITS installations; and,
- Safety improvements for both travelers and operational staff.

This chapter provides an overview of the evaluation approach and schedule. Each of the goal-focused chapters presents analyses and findings, following the approach laid out in the test plans that were described in detail in the Phase II report.

2.2 Evaluation Schedule

The evaluation schedule is illustrated in Figure 2. The schedule shows both the project deployment and the timeline for the various evaluation components.

2.3 General Methods of Evaluation

The general strategy for evaluating each of the project components is to identify the goal area in which project-related effects can be anticipated, and then to specify measures of project-induced changes or impacts, along with available data sources and methods for collecting the data. Hypothetical statements (called hypotheses) have been framed that express desired outcomes or beneficial effects from elements of the project in a straightforward way that is suggestive of data analysis strategies that can be used to test whether or not the project in fact is having the desired effects or outcomes. The hypotheses serve as a guide for the analysis and help structure appropriate ways of approaching the evaluation and data analyses. For each goal area covered, measures, hypotheses, data collection methods, and analytic methods are discussed in this report.

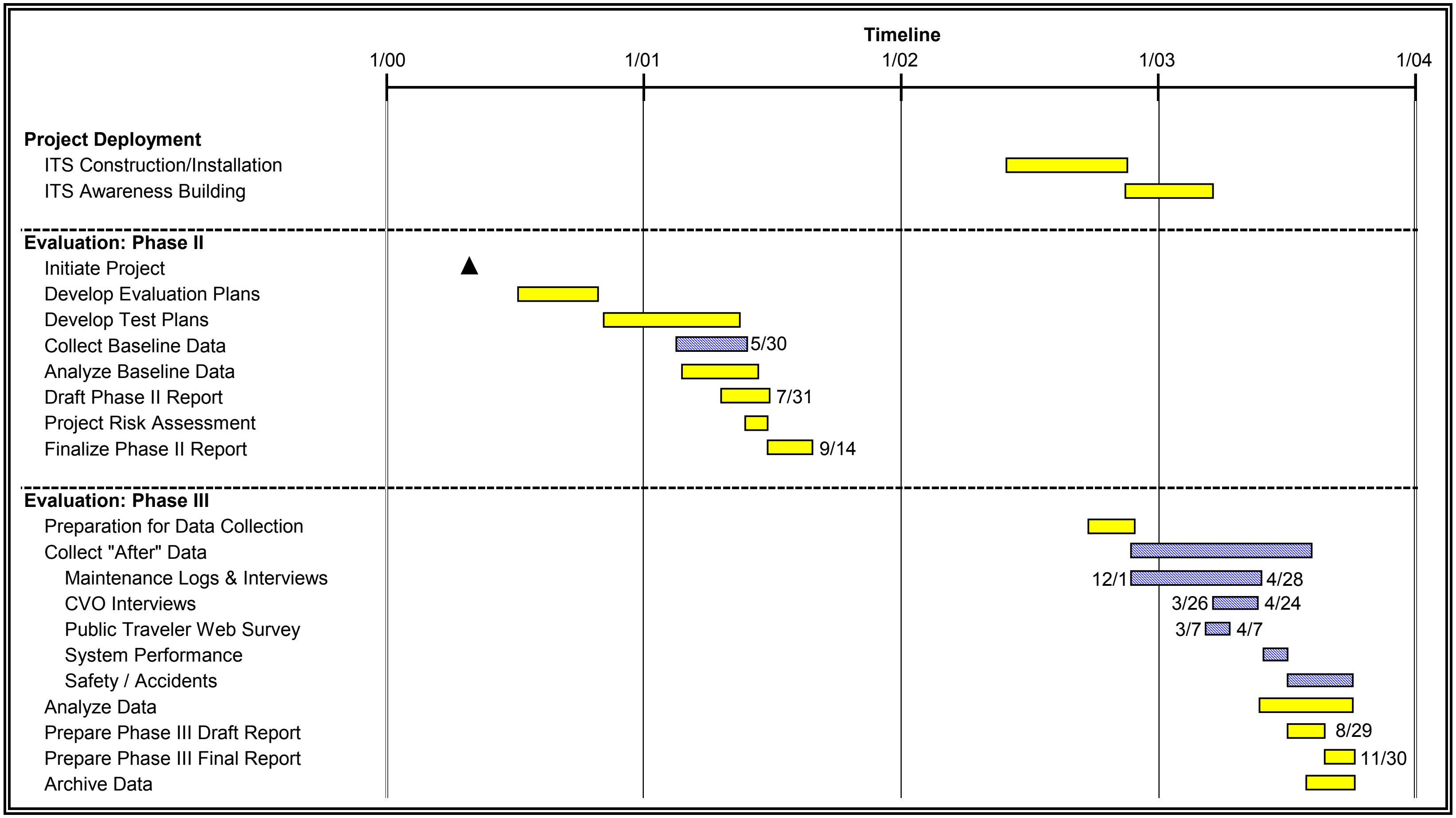


Figure 2. Timeline for Phase II and Phase III, U.S. 395 Spokane evaluation.

The overall evaluation design for each of the goal areas includes two data collection periods, one before any of the ITS project improvements have been implemented, and another after implementation and a period of operations. Data collected in the “before” period described conditions at the project site and provided a baseline against which to gauge any changes that may be attributable to the project after deployment. A challenge in this type of field evaluation is to be able to disentangle the presumed effects of the project from change effects that are due to other, often unmeasured, factors that are present in the project environment. The Phase II report documented the baseline for each of the evaluation goal areas, where possible. A related challenge is to account for changes in baseline conditions that may occur between the time data were collected until the time when the post-implementation data are collected. The most appropriate baseline describes how conditions will be at the time the “after” data are collected, if there had been no project-related effects occurring. Generally, the assumption is made that the “before” data adequately describe those conditions. Other factors that could also account for changes in the measures of interest should be acknowledged, even though they are likely to remain unmeasured directly. Finally, the difference between the “before” and “after” condition is the change or impact. How much of that difference can be attributed to the project, and the interpretation of the significance of that change or impact is part of the evaluation challenge.

Depending on the measures identified as appropriate for each goal area, data collection methods are selected that may include the collection of objectively measured data such as crash statistics, or subjectively measured data such as the perceptions and opinions of drivers. Several methods are used in this evaluation and are described as they apply in each of the goal areas.

3.0 Infrastructure Operations and Maintenance

3.1 Introduction

WSDOT's ability to efficiently and safely manage the road systems depends on knowing where and when to deploy their resources (staff and equipment) to treat pavement in anticipation of a winter storm, address degraded level of service to sections of roadway, sand and plow roadway in the winter, divert or warn drivers of hazardous road conditions, and plan efficiently for the general maintenance and upkeep of the road systems. The new ITS installed under this earmark, including the mobile HAR, RWIS stations, and cameras, were strategically located in areas where WSDOT has had winter road condition problems in the past, including Sherman Pass and Loon Lake areas. These are also areas that serve as leading indicators of weather systems that can potentially impact the road systems in the region. Given limited budgets, it is important to site new road weather information systems strategically to offer the greatest potential advantage to both WSDOT crews and to travelers in this remote region.

Plowing on Sherman Pass, winter 2003.

One of the important aspects of any highway winter maintenance activity is the elevation of the roadway relative to potential impact of adverse winter weather. U.S. 395 crosses the Spokane River just north of metropolitan Spokane and rises to a high point at the Loon Lake RWIS-ESS where it drops to Chewelah and then to the Columbia River again with relatively little elevation gain by the time it reaches Laurier at the Canadian Border. SR 20 rises from its junction with the Columbia River west of Colville to Sherman Pass before descending to Republic. The key elevation points on the two major corridor routes, along with the locations of the RWIS-ESS, cameras, and winter HAR locations are shown in Figure 3.

The standard environmental lapse rates that reflect the cooling of air temperature relative to elevation gain range from 2 ˚F per 1000 feet to 3.6 ˚F per 1000 feet. Under these conditions, air temperatures at Sherman Pass may be between 8 and 14 degrees cooler than Colville and 6 to 11 degrees cooler than Republic. Individual storms can also affect these temperature differences.

Baseline information was gathered through a series of interviews with the Eastern Division Traffic Engineer, who is also the ITS earmark Project Manager, and members of his operations field staff in both the Spokane and Colville offices. The information focused on gaining an understanding of the operational and maintenance procedures. The organization and procedures are detailed in the Final Phase II Report.[5] Specific event data were limited during the baseline period due to mild winter conditions coupled with other institutional factors. More comprehensive and reliable data were obtained during the post-deployment winter.

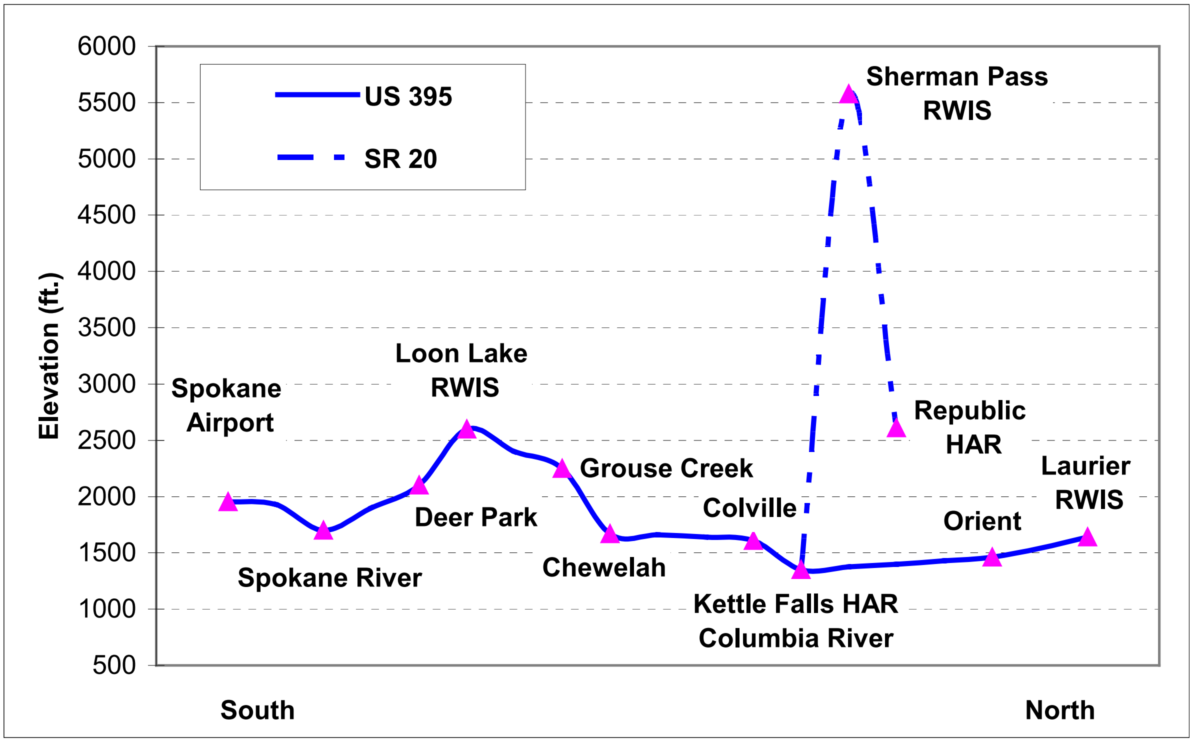


Figure 3. Elevations along U.S. 395 and SR 20 and RWIS-ESS/camera locations.

3.2 *Objectives and Approach*

The objective of collecting and evaluating information related to infrastructure operations and maintenance was to track and highlight potentially safer, more efficient practices and procedures due to information available from the two HARs located at Republic and Kettle Falls and the three RWIS-ESS and web camera sites located at Sherman Pass, Laurier, and Loon Lake. The anticipated impacts and measures described in the Evaluation Plan guided this assessment, and they are summarized in Table 2.

"After" information collected regarding WSDOT O&M procedures was obtained through personal visits, event records, phone discussions with key operations and maintenance personnel, and from WSDOT TMC logs. Standardized Event Logs were designed and used by the field operators to record data for analysis. Phone interviews with these operators followed the occurrence of events to gather additional information about how the ITS equipment may have been used and how it may have affected their operational decisions and procedures in the project corridors.

[5] Battelle Memorial Institute and Meyer, Mohaddes Associates, Inc. 2001. *SR 395 Spokane FY99 Earmark Evaluation.* Final Phase II Report. Prepared for the Federal Highway Administration. Washington, D.C.

A preseason visit in Colville with the regional Maintenance Superintendent and Lead Maintenance Technicians (Lead Techs) from Republic, Orient, Colville, and Grouse Creek was conducted to present the evaluation plan, review their thoughts on how the ITS equipment might affect their practices, and discuss the event log data gathering procedure for the coming winter. The Lead Techs discussed many of the anticipated benefits identified during the baseline period. Effort was made to engage the Lead Techs in defining the event log layout and approach to recording the data to ensure everything would work smoothly without adding to their current workload.

Table 2. Objectives, impacts, measures, and research hypotheses.

Objectives and Anticipated Impacts	Evaluation Measures	Hypotheses
Increase the efficiency and accuracy with which staff and resources are allocated to meet road maintenance needs and achieve high Levels of Service (LOS)	- Reported change in or improvements in the purposeful allocation of resources - Accuracy with which staff are assigned to road problems - LOS performance records	- With better information, road maintenance crews will be assigned more efficiently to locations where the need is greatest - Capital resources, such as snow plows or maintenance vehicles, will be used more efficiently, in terms of spending a higher percentage of time focused on road problems - LOS are met or exceeded using new information sources
Improve the quality of road closure decisions	- Perceived accuracy of road closure decision-making	- Roads are closed more efficiently and accurately using the new information on road weather conditions
Reduce the number and severity of incidents and requirements for incident response	- Incident response times	- Emergency service providers (e.g., police, fire) are able to respond more quickly to incidents, both due to access to better information and due to more efficient and safer maintenance of road conditions

3.3 Data Collection Methods

The intent was to gather information separately for each significant road weather event. An event was defined to include snowstorms, major accidents, flooding, and any amount of freezing rain, icing, drifting snow, or fog that disrupts traffic or causes a safety hazard. A snow event was defined as any storm that deposits an inch or more of snow. Each event was planned to be captured through completion of an Event Log by the individual maintenance sheds. A sample Event Log (for Colville) is provided in Appendix A. This format represents an elaboration of the log form used in the baseline period, with some overlap and some new elements. It was built off a form already being used by the Colville Maintenance Supervisor and is part of their data gathering process. Information was added to help support the evaluation.

The Colville Maintenance-Operations Superintendent already gathered some information about storm events through a similar process. Working with this example from the prior winter, a combined event log was developed. It was designed to meet both the WSDOT and evaluation project needs. A simple-to-complete, one-page event log was developed and distributed to each of the maintenance sheds specific to their route segments. The Event Logs collected information that was reviewed with the Lead Techs or other designated contact in follow-up phone interviews.

From the Event Log, a phone interview format and recording document was designed. The questions were intended to elicit expansion on original log statements and capture information to address the evaluation of the baseline hypotheses. Review of the first interview suggested there were components of the maintenance sheds' efforts not captured so an additional three questions were added to subsequent interviews to encourage thought and comment on their specific use of ITS technologies. Additional questions incorporated in the phone interviews with the Lead Techs included:

- Whether and how they are using technology.
- How it affects their work plans.
- How it is making a difference.

At some sheds the lead worker or supervisor was responsible for completing the Event Log, at others it fell to the person on the individual shift responsible for the route segment. At the completion of the shift during the event, at the end of the event, or the next day following the event, the log was completed and faxed to Colville where it was collected and forwarded on to the evaluation team for entry into a database.

Transportation Management Center, Spokane, WA.

When a log form was received, an evaluation interviewer phoned the shed to arrange a convenient time for the follow-up interview. The responses and comments gathered during the interview were recorded on the interview sheets and subsequently transcribed into electronic format. Each interview took 10 to 25 minutes. Occasionally more than one event was covered by one interview call. The phone interviews confirmed that the respondents did a reliable job of completing the log forms and providing very useful data on events.

A key source of information used in the evaluation was the log kept at the TMC in Spokane. The TMC operators are responsible for updating messages for posting on the HARs. To ensure quality traveler information, a script is followed when HARs are updated (see Appendix B). Current conditions were updated to the HARs every four hours, as conditions warranted, and before the TMC closed for the night. Operators are also responsible for relaying pass conditions reported from the field to the Central Washington TMC in Wenatchee where the currency of pass information on the web and toll-free phone number is maintained. The Eastern Washington TMC (Spokane) is responsible for updating the Eastern Region Lowland Road Report on the toll-free number as often as a change in conditions would warrant.

An example from the TMC log covering entries during storms 10 through 14 is shown in Table 3. Also included is an example of a "normal" operation day, the 6th of February. For consistency a script was followed by the operators in recording the messages. The scripts are provided in Appendix B, along with a definition of all the abbreviations used in the TMC Log Entry in Table 3. The comments under "TMC Log Entry" that begin with "Sherman" describe the pass conditions as recorded and reported. To illustrate, the first comment says:

Current conditions are 22 degrees, clear skies, no new snow, 40 total inches of snow on the ground, bare and dry with ice in places and traction advisory in place. The Central Washington Traffic Management Center was advised, and the Republic and Kettle Falls HARs were updated.

On the 9th of March is a comment regarding the status of the Kettle Falls HAR. The use of the HARs in notifying travelers of the mud slide closure on the 12th of March is also evident in this example.

Table 3. Examples of selected TMC log messages for selected storm events, 2003.

Storm	Date	Time	TMC Log Entry
10	02/02/03	0743	SHERMAN: 22 CLR 0/40 BD IIP TA // CWTMC ADV'D // REPUB HAR UPDATED // KETTLE HAR UPDATED
	02/02/03	1044	SHERMAN: 24, CLR, 0/40, BD, IIP, TA // CWTMC ADV'D
	02/02/03	1403	SHERMAN: 28, CLR, 0/40, BD, IIP, TA
	02/02/03	1721	SHERMAN: 20, NO OTHER CHANGE // CWTMC ADV'D // HARS UPDATED.
	02/03/03	0603	SHERMAN: 23, OC, LTSN, 2/42, CSI, TA // CWTMC ADV'D // BOTH HARS UPDATED.
	02/03/03	0615	395 CHEW-CLAYT: 31, BKN, FGP, 1" NEW, MBW, CSIP
	02/03/03	0615	395 COLV CHEW: 33, OC, BW, FGP
	02/03/03	1054	SHERMAN PASS: 27 DEG, BKC, SNFLR, NN, 42 TOT, CSI, TA // AVD CWTMC // UPDATE HARS
	02/03/03	1425	SHERMAN PASS: 23 DEG, O/C, SN, TNEW, 42" TOT, CSI, TA, // AVD CWTMC // UPDATE HARS
	02/03/03	1729	SHERMAN PASS: 23 DEG, O/C, SNOW, WIND, DRIFTS, TRACE OF NEW, 42" TOT, CSI, TA. // AVD CWTMC // UPDATE HARS
	02/03/03	2127	SHERMAN PASS: 21 DEG, BKN, LT SN, 42" TOT, CSI, TA // AVD CWTMC // UPDATE HARS.
	02/06/03	0631	SHERMAN: 20, CLR, 0 NEW, CSI, TA // CWTMC ADV'D // BOTH HARS UPDATED
	02/06/03	1111	SHERMAN: 24, NO OTHER CHANGE // CWTMC ADV'D
	02/06/03	1405	SHERMAN: 28, CLR, 0, CSI, TA // CWTMC ADV'D // HARS UPDATED.
	02/06/03	1748	SHERMAN PASS: 19 DEG, CLR, NN, 42" TOT, CSI, TA // AVD CWTMC // UPDATE HARS.
	02/06/03	2126	SHERMAN PASS: 17 DEG. CLR, NN, 42"TOT, CSI, TA, // AVD CWTMC // UPDATE HARS.
	02/07/03	0641	19, CLR, 0, CSI, TA // CWTMC ADV'D // HARS UPDATED
11	02/21/03	0742	SHERMAN: 25, BKN, 0/48, CSIIP, WC // CWTMC ADV'D // BOTH HARS UPDATED
	02/21/03	1127	SHERMAN: 30, BKN, 0/48, CSIIP, WC // CWTMC ADV'D
	02/21/03	2120	SHERMAN PASS: 26 DEG, SCT, 2" NEW, 50"TOT, CSI, TA // AVD CWTMC // UPDATE HARS
	02/22/03	0735	SHERMAN PASS: 25 DEG, O/C, LT SN, NN, 50"TOT, IIP, TA // AVD CWTMC // UPDATE HARS
	02/22/03	1351	SHERMAN PASS: 23 DEG, O/C, NN, 50 TOT, IIP, TA // AVD CWTMC
	02/22/03	1717	SHERMAN PASS: 28 DEG, O/C, NN, 50" TOT, CSI, TA, // AVD CWTMC // UPDATE HARS
12	03/06/03	0622	SHERMAN: 23, OC, LTSN, TN/45, IIP, WC // CWTMC ADV'D // BOTH HARS UPDATED
	03/06/03	1105	SHERMAN: 26, BKN, 0/45, SNIIP, WC // CWTMC ADV'D // BOTH HARS UPDATED
	03/06/03	1408	SHERMAN PASS: 30 DEG, BKN, NN, 45" TOT, BWIIP, W/C // ADV CWTMC // UPDATE HARS
	03/06/03	1744	SHERMAN PASS: 21 DEG, SCT, NN, 45" TOT, B/D IIP, W/C // ADV CWTMC // UPDATE HARS
	03/06/03	2134	SHERMAN PASS : 20 DEG, SCT, NN, 45" TOT, B/DIIP, W/C ADV CWTMC // UPDATE HARS

13	03/09/03	0729	ALL RDS OUT OF COLVILLE: 26, SN, 1-3N, CSI
	03/09/03	0758	SHERMAN: 20, OC, LTSN, 1/46, CSI, TA // CWTMC ADV'D // BOTH HARS UPDATED.
	03/09/03	1038	SHERMAN: 26, OC, LTSN, 1/46, CSI, TA // CWTMC ADV'D // BOTH HARS UPDATED
	03/09/03	C	REF LAST ENTRY: UNABLE TO UPDATE KETTLE FALLS HAR-RECORDING SAYS "CELLULAR 1 IS UNAVAILABLE..."
	03/09/03	1206	REF 1038/ETC: TRIED HAR AGAIN-UNSUCCESSFUL
	03/09/03	1354	SHERMAN: 30, OC, 0/45, CSI, SLOR, TA // CWTMC ADV'D // REPULIC HAR UPDATED
	03/09/03	1708	SHERMAN: 28, SCT, 0/47, CSIIP, TA // CWTMC ADV'D // REPUBLIC HAR UPDATED.
14	03/12/03	0637	SHERMAN: 28, OC, 0/44, B W/ IIP, WC // CWTMC ADV'D // REPUB HAR UPDATED // KETTLE HAR UPDATED
	03/12/03	1043	SHERMAN: 32, OC, SNGLT, BW, IIP, WC // CWTMC ADV'D
	03/12/03	1715	MUD SLIDE ON US 20 E MP 322 ONE LANE BLOCKED. SENT MEDIA ALERT 1730 - APPROX 1-2 HOURS.
	03/12/03	1750	SHERMAN PASS: MUD SLIDE EB MP 321.5 - 35 DEG, LT RAIN, 22" TOT, IIP, W/C // ADV CWTMC // UPDATE HARS
	03/12/03	1919	REF 1715: MUD SLIDE CLR, ROAD IS OPEN// ADV MEDIA
	03/12/03	1925	ADV WSP SR 20 IS NOW OPEN.
	03/12/03	2133	SHERMAN PASS: 39 DEG, RAINING, NN, 42" TOT, IIP,W/C// ADV CWTMC // UPDATE HARS

3.4 Data Analysis and Findings

3.4.1 Analysis

Analysis of the adoption of ITS equipment and information into M & O procedures is best seen through examining a sequence of weather events throughout a winter season. Each use of the equipment built upon the previous use; however, each instance of use occurred under different weather conditions. The Event Logs and interview responses provided a wealth of information. To provide a complete picture of operations and maintenance activities and the effect of the availability of new ITS road weather information during the post-deployment 2002/2003 winter, a visual timeline was created. This timeline is presented as a centerfold in this report. The visualization incorporates information from multiple sources for easy comparison and reference. Individual event logs created the framework and sequence across a series of 15 periods over a three-month time frame from Storm 1 through Storm 15. Additional information displayed came from the TMC log which included times when the HARs were updated or not working, pass conditions and restrictions, and reported traffic incidents. The TMC log supplemented the questions regarding HAR operation included in the Event Logs.

The timeline of storm events, HAR and RWIS-ESS operation, Internet access, pass travel restrictions, and weather conditions at National Weather Service reporting locations is presented in the following foldout Figure 4 for the entire winter evaluation period. The 32 Event Logs filled out during the winter were organized into 15 individual storm events. In the case of Storm 1 there were four event logs; one for December 2nd from Colville, one each day of the storm from Grouse Creek, and one from Republic. Icons as identified in the legend show a pre-event all-liquid application by both Colville and Republic sheds. One crash was reported on the first Grouse Creek Event Log and Republic reported two crashes. This was a widely forecast event that did not materialize along the segment of U.S. 395 under Colville responsibility, but rather manifested as a freezing fog event to the south along the Grouse Creek segment.

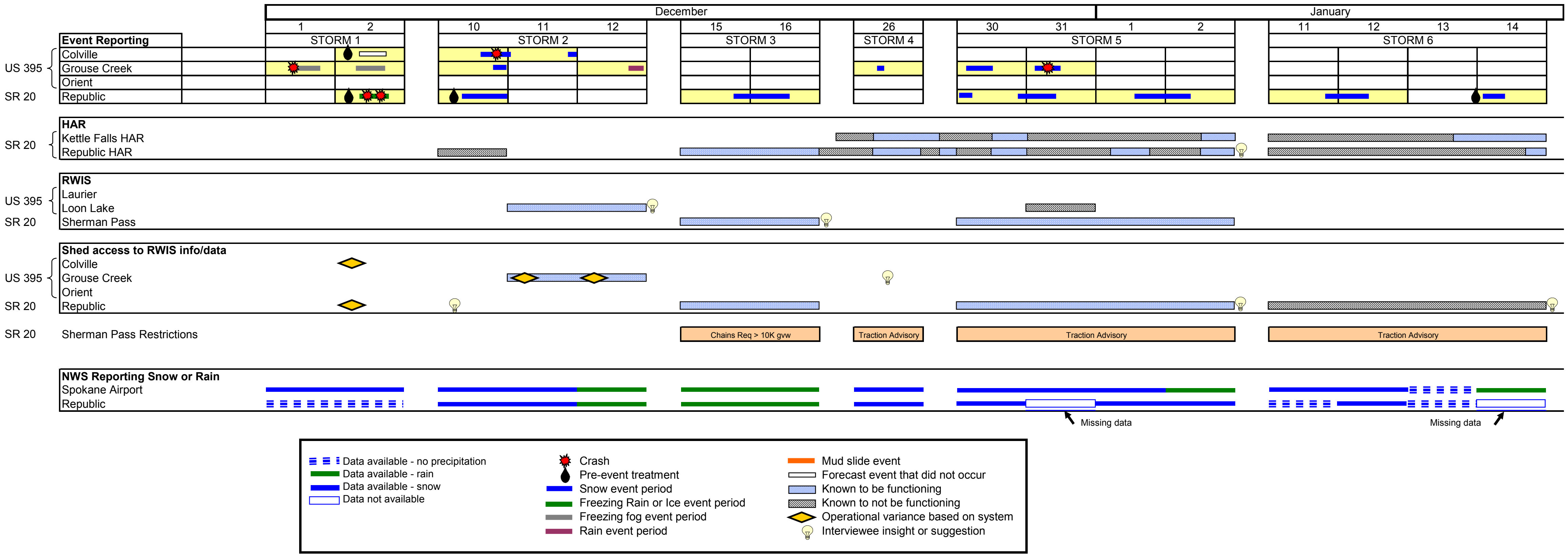


Figure 4. Timeline for storm events during the 2002-2003 winter evaluation period.

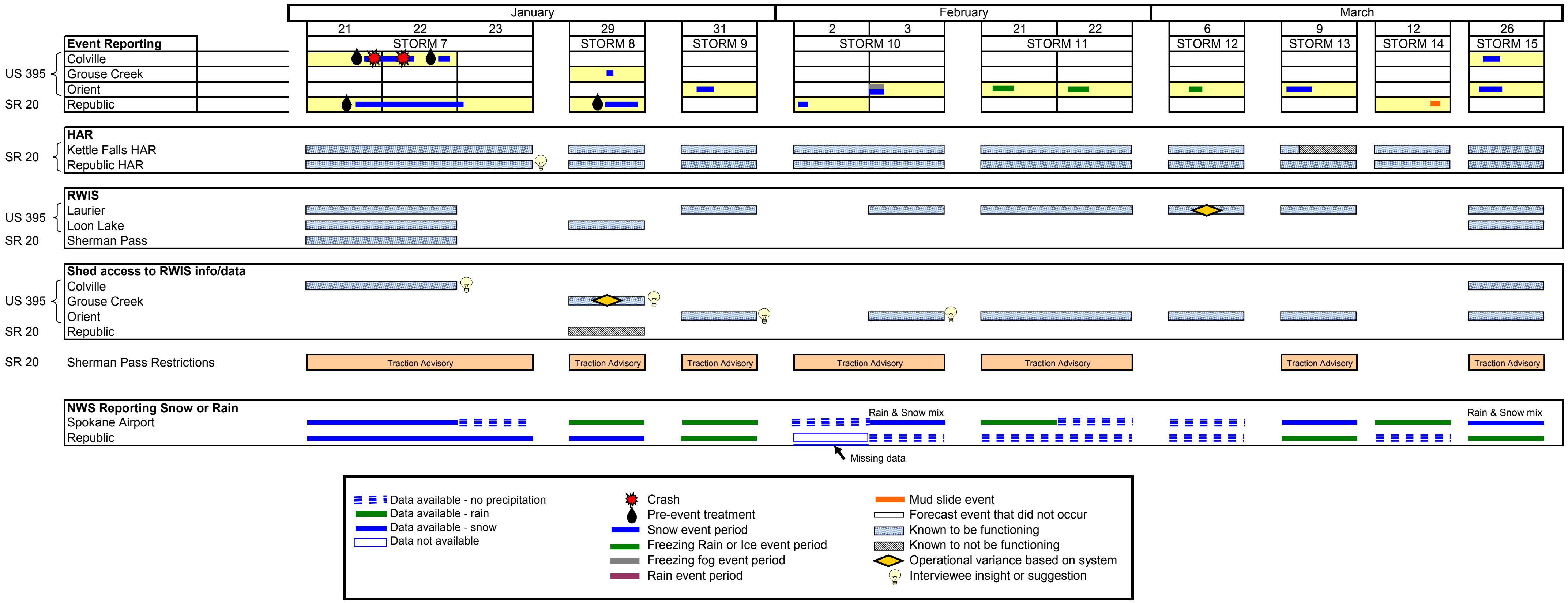


Figure 4. Timeline for storm events during the 2002-2003 winter evaluation period (continued).

In the next band down, the reader can see there is no evidence that the RWIS-ESS or HARs were not functioning. Below the two bands describing the system performance is one that presents information on how the maintenance crews interacted with the ITS elements. If access to the information (i.e. Internet) was known to specifically be available or unavailable, this is indicated. Also shown in this band are references to actions, decisions, insights, or suggestions that were recorded on the Event Log or from the follow-up interviews. Travel restrictions as posted for Sherman pass during each event are shown in the next band.

To validate the number of storms reported through the Event Log process, National Weather Service records were researched. Two regional locations were used, the NWS at the Spokane International Airport (Gieger Field) and the NWS cooperative reporting station at the Republic Forest Service location. Interpreting the precipitation observation and reported air temperatures with a simple environmental lapse rate, conditions were extrapolated for Sherman Pass and Colville. From this it is estimated over 80% of the snow events at the various maintenance sheds were included in this set of Event Logs.

3.4.2 Findings

In spite of initial uncertainty about the post-deployment weather patterns and whether adequate data would be available on WSDOT operations in the study region, a wealth of useful information was obtained for the evaluation. The information gathered on each of the 15 storm events during the 2002/2003 winter evaluation period provided an opportunity to carefully observe WSDOT O&M responses, their uses and discovery of ways to benefit from road weather information, and their level of efficiency in responding sooner and more effectively to each new weather event. This section discusses the analysis of the data and findings on a storm-by-storm basis. These individual event histories are presented separately from the composite timeline in Figure 4 in order to present greater detail on the event and WSDOT's response to each event.

The events can be evaluated in terms of changes in procedures resulting from the use of ITS equipment and information that were discussed with the WSDOT maintenance personnel in the baseline interviews. The kinds of procedure changes and envisioned effects documented in the baseline report are:

Increased efficiency through adjustment or balance of resource use.

a) More accurate weather information from specific locations (both sensors and camera images) could help guide decisions about if, when, where, and what resources are dispatched. With better real-time information in hand, this may mean sending a smaller truck out on a job when the bigger truck is not needed.
b) New camera views can help maintenance crews see what the conditions are like in hazardous or distant areas, such as Sherman Pass and Loon Lake. As they come to use this new information on a regular basis, they will no longer feel the need to send reconnaissance trucks to investigate every possible situation that can be assessed remotely, resulting in more efficient use of available resources.
c) The amount of resources expended, such as sand used on the roads, is not the best measure of efficiency gains because of the huge variability from season to season. However, examining specific responses to specific events can reveal improvements in the

application of sand or liquid anti-icing/deicing chemicals, for example, based on access to better information about conditions. ITS technologies may provide other information useful in formulating performance measures.

Reduction in secondary crashes.

a) Use of HARs could help reduce or prevent collateral problems occurring in an already dangerous condition by diverting vehicles. This would reduce safety risks and extra, more costly work on the part of maintenance crews.

Improved timeliness and reliability of public information.

a) Use of HARs can divert traffic from hazardous areas with little delay between the occurrence of an event and notification in real-time to the public travelers.
b) The availability of camera images is expected to greatly increase the timeliness and reliability of information WSDOT routinely conveys to the state's radio stations for public broadcast and for placement on WSDOT's web sites.
c) Commercial operators are expected to benefit significantly from the information offered on the mobile HARs and to use them frequently to make route or timing decisions or to help better prepare for existing or forecast road conditions.
d) More ways for travelers to access real-time road weather information, such as through the new HARs and Internet content, is expected to lead to a reduction in the number of calls to maintenance offices from motorists.

Institutional adaptation and obstacles to new ITS capabilities.

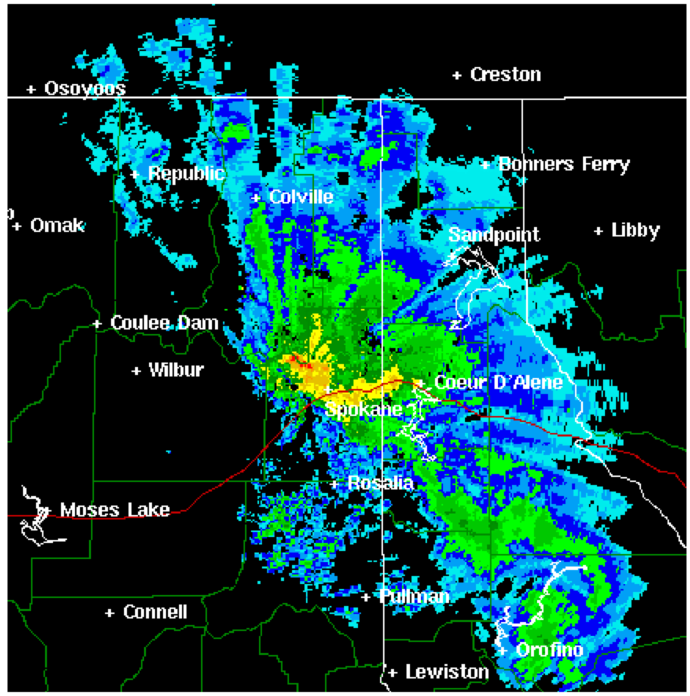
a) It is expected to take a little time for the computer equipment to be available at all the sheds, to get crews trained on the Internet, and for them to become comfortable with it, to use it consistently, and to trust the information it provides.

Changes in workload and labor requirements.

a) Many of the events in which maintenance crews respond are due to dangerous driving conditions resulting in numerous crashes. If fewer crashes are the result of more effective and efficient maintenance actions, this can reduce the workload of the maintenance personnel at the event sites.

3.4.3 Individual Storm Events

The following pages present each storm individually. The event reporting, action and insights portion of the evaluation timeline provides the framework to picture the storm progression. Further data compiled from the Event Logs gives the duration and other details. It is presented in this manner to allow for the interpretation of the data in terms of the class of storm as it relates to winter maintenance activities such as anti-icing. For example, Storm 1 air temperatures began below freezing and were steady with freezing rain. A short narrative drawn from the event interviews follows the data table.



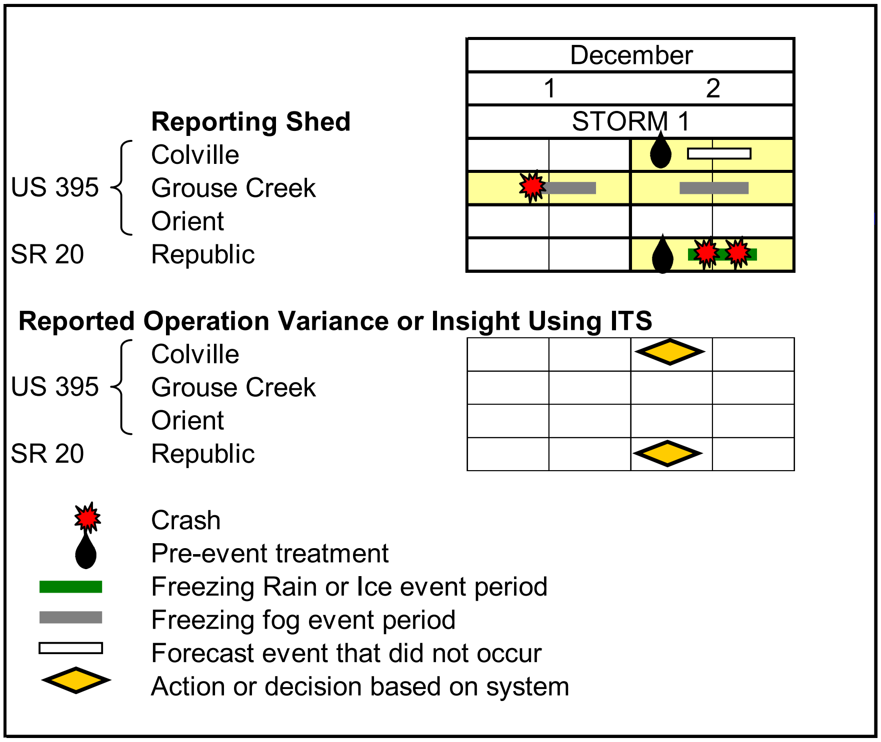
National Weather Service radar image of Storm 15.

Some of the most valuable findings of the evaluation were the actions and insights of the maintenance crews as they adapted to each event during this winter season.

Abbreviations for the event types identified in the storm sheets are as follows:

FG = Freezing Fog
FR = Freezing Rain
R = Rain
S = Snow
BS = Blowing Snow
FI = Frost or Ice

Storm # 1



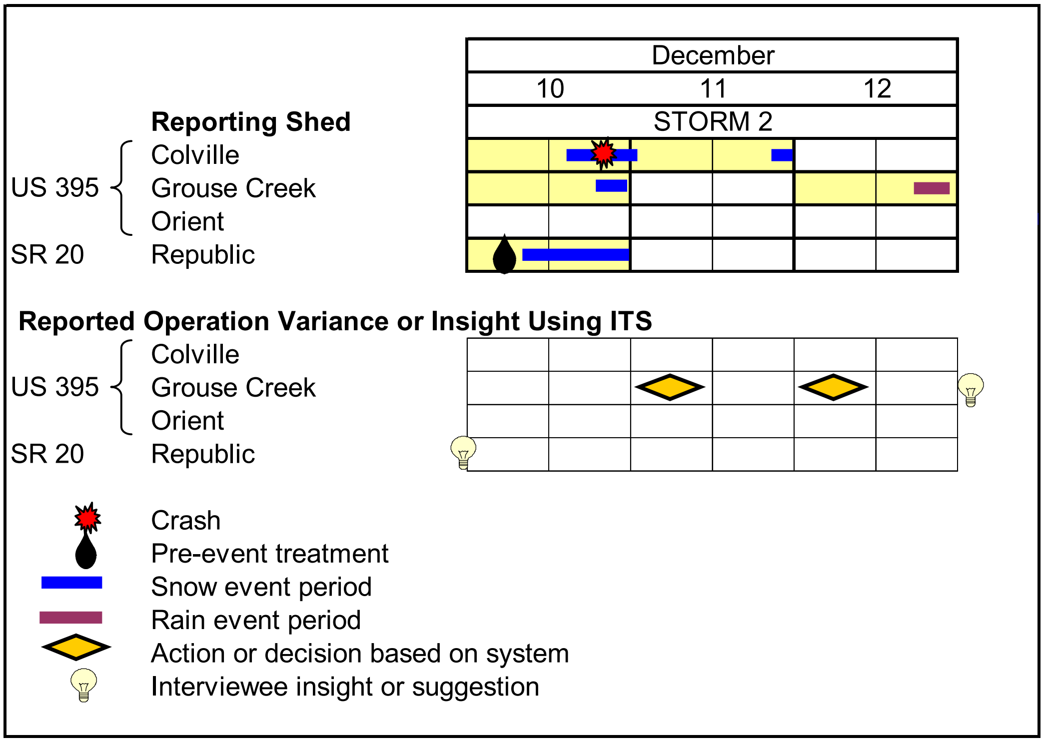
			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
1	Republic	FG	12/2/2002	0500	12/2/2002	1400	na	28	STEADY
1	Colville	FR	12/2/2002	0500	12/2/2002	1400	na	28	STEADY
1	Grouse Ck	FR/FG	12/2/2002	0400	12/2/2002	1230	na	23	STEADY
1	Grouse Ck	FR/FG	12/1/2002	0930			na	28	STEADY

Storm Description: This was the first reported storm of the winter. Freezing fog localized in the Grouse Creek area later became more widespread. It was predicted for the Colville area but did not materialize there. The crash in the Grouse Creek segment of US 395 cannot be definitively associated with the weather impacts. The crashes on SR 20 were much more likely to have weather as a contributing factor. The Camera images and RWIS data were accessed and used during this event. During this storm on December 2nd, a drop in temperature caused several icy spots to develop in the Grouse Creek segment. These were isolated and not close to the RWIS-ESS. HAR was not used.

Actions & Insights:

	At the Colville maintenance shed a decision was made to distribute pre-event liquid treatment to the pavement. This was based on forecast precipitation obtained from the Internet.
	Personnel at the Republic shed also applied pre-event liquid treatment and were later able to verify that the pavement was bare and wet with 4% chemical on it by using the RWIS data thereby eliminating the need to send a truck.

Storm # 2



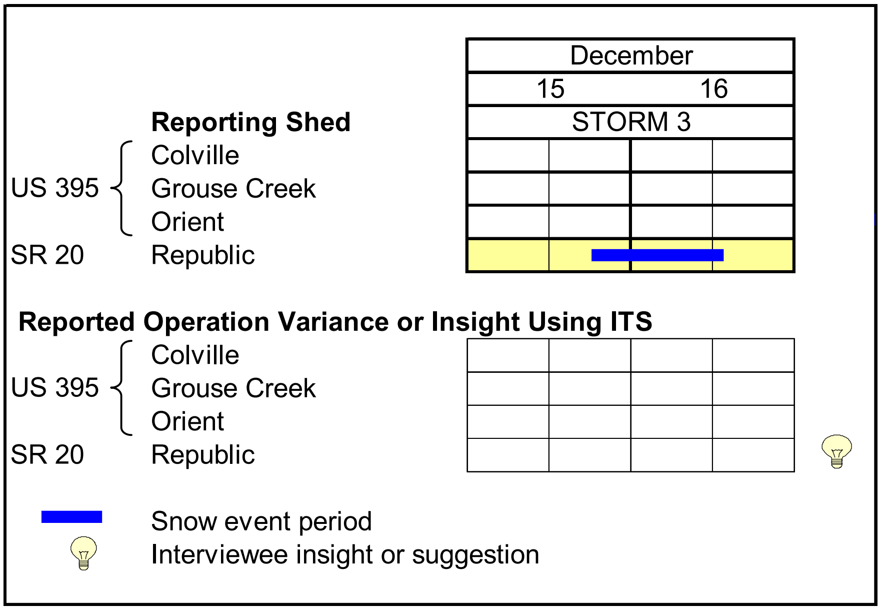
			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
2	Republic	S	12/10/2002	0500	12/10/2002	eos	2	25	STEADY
2	Grouse Ck	S	12/11/2002	1430	12/11/2002	2330	0.5	33	STEADY
2	Grouse Ck	R	12/12/2002	1735	12/12/2002	2300	na	41-39	FALLING
2	Colville	S	12/11/2002	2100	12/11/2002	2400	4	30	STEADY
2	Colville	S	12/10/2002	1500	12/11/2002	0100	3	31	RISING

Storm Description: This storm took place over several days generating precipitation primarily in the form of snow. Precipitation rates appear to have been light and covered a significant area within the corridor region. There was a roll over crash during the storm, which required helicopter evacuation. HAR was not used.

Actions & Insights:

	The maintenance crew at the Grouse Creek shed uses the RWIS-ESS and camera images regularly and modifies their operations based on the information collected. Decisions regarding distribution of trucks were made during this event based on the information.
	The Republic maintenance shed had difficulties accessing the RWIS information and camera images. The cause of this was later revealed to be inadequate communications facilities to the shed. The knowledge that the ESS equipment was in place combined with the inability to access the information was a discussion point during the interview.
	There was a suggestion that the camera angle on the Loon Lake sensor could be adjusted to capture a better image of the roadway. Another suggestion indicated that nighttime observations of precipitation could be made using the camera if a light were installed at the sensor site.

Storm # 3



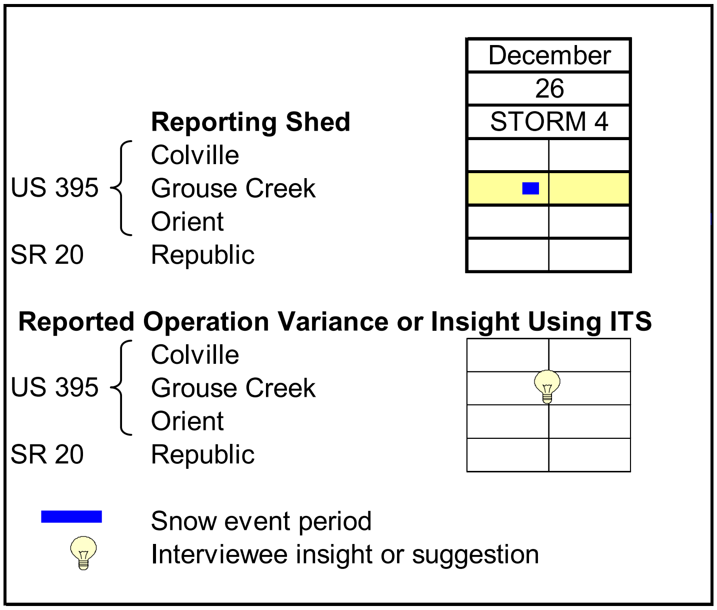
			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
3	Republic	S/BS	12/15/2002	1800	12/16/2002	1400	20	30	STEADY

Storm Description: Interestingly, this significant snow and blowing snow event impacted only the Republic shed. Snowfall was reported continuous and heavy, however, it was focused in the southern portion of the county. The Sherman Pass HAR was used during this event to broadcast pass condition information but apparently stopped working just after this storm. During this storm, chain requirements for vehicles over 10,000 lbs were imposed on Sherman Pass.

Actions & Insights:

Accessing the RWIS information becomes inconvenient and time consuming when maintenance personnel are busy during an event. Computer and Internet access speed continued to be a problem for the Republic shed. There was a suggestion that the TMC broadcast weather updates to maintenance vehicle drivers during storms in order to keep them up to date on developments and forecasts.

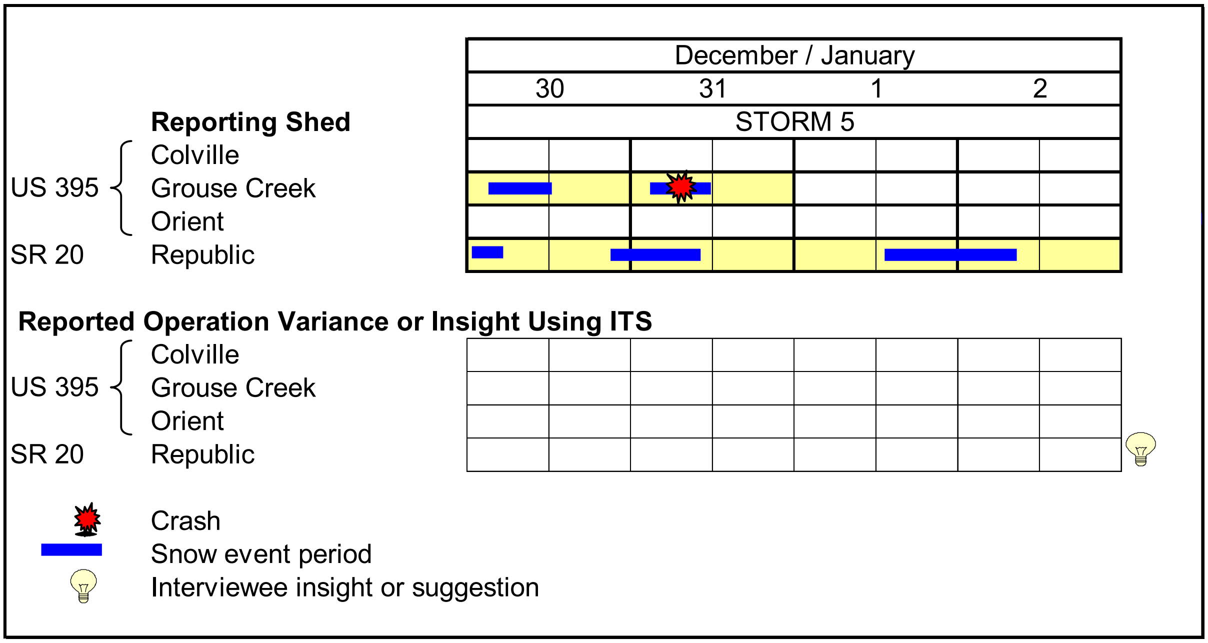
Storm # 4



			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
4	Grouse Ck	S	12/26/2002	0400	12/26/2002	0900	4	32	STEADY

Storm Description: This storm was of relatively short duration during which it snowed continuously in the Loon Lake summit area. There was a traction advisory issued for Sherman Pass during this storm. There were no crashes reported and the HAR was not used.	
Actions & Insights:	
	There was an indication that the Loon Lake camera image was poor (blurry or out of focus) and needed some adjustment to be useable. In addition, some data fields displayed on the RWIS information were not populated with data, in particular, the pavement data were not available.

Storm # 5



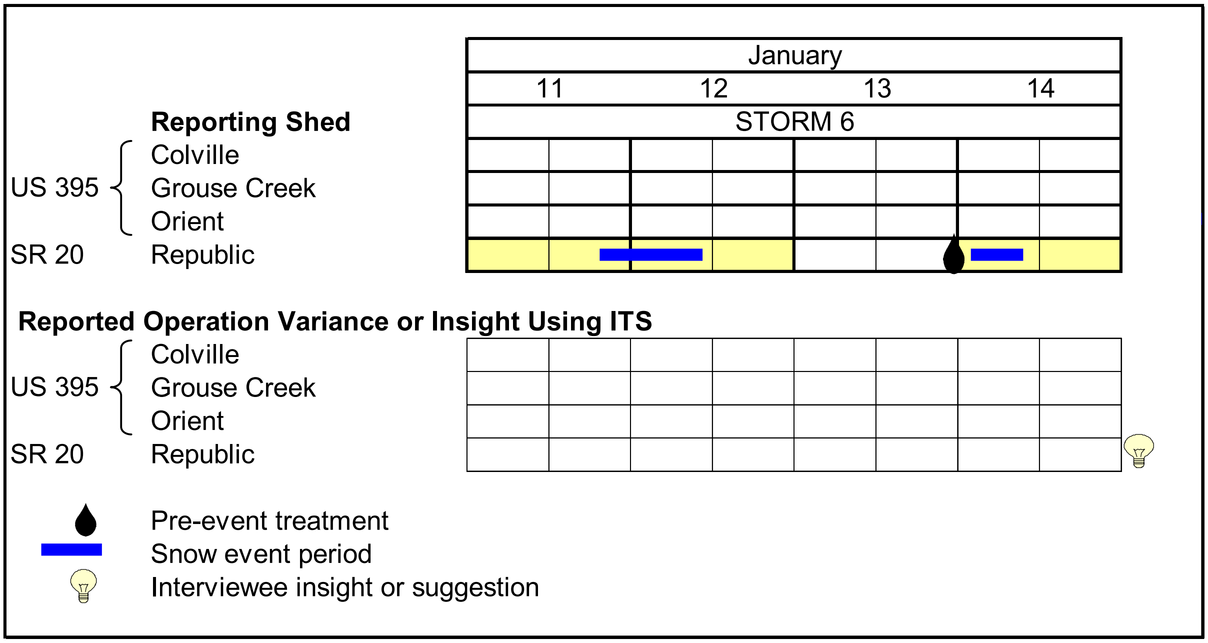
			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
5	Republic	S/BS	12/30/2002	2000	12/31/2002	1000	2	23	FALLING
5	Republic	S	12/30/2002	0100	12/30/2002	0500	1	15	RISING
5	Grouse Ck	S	12/30/2002	0400	12/30/2002	1230	3	27	STEADY
5	Grouse Ck	S	12/31/2002	0400	12/31/2002	1230	6.5	28	STEADY
5	Republic	S/BS	1/1/2003	1300	1/2/2003	0800	4	23	STEADY

Storm Description: The individual snow events that make up this storm occurred over a period of three and a half days. On the 31st there was a power outage at the Grouse Creek maintenance shed, which made access to the RWIS data impossible. The crash on the 31st likely has weather related contributing factors. There was a traction advisory issued for Sherman Pass during this storm. The Republic and Kettle Falls HARs were not working during much of this event.

Actions & Insights:

The level of service on Sherman Pass diminished during the morning on the 31st due to redistribution of trucks out of Colville. This was observed from Republic on the Sherman Pass camera.

Storm # 6



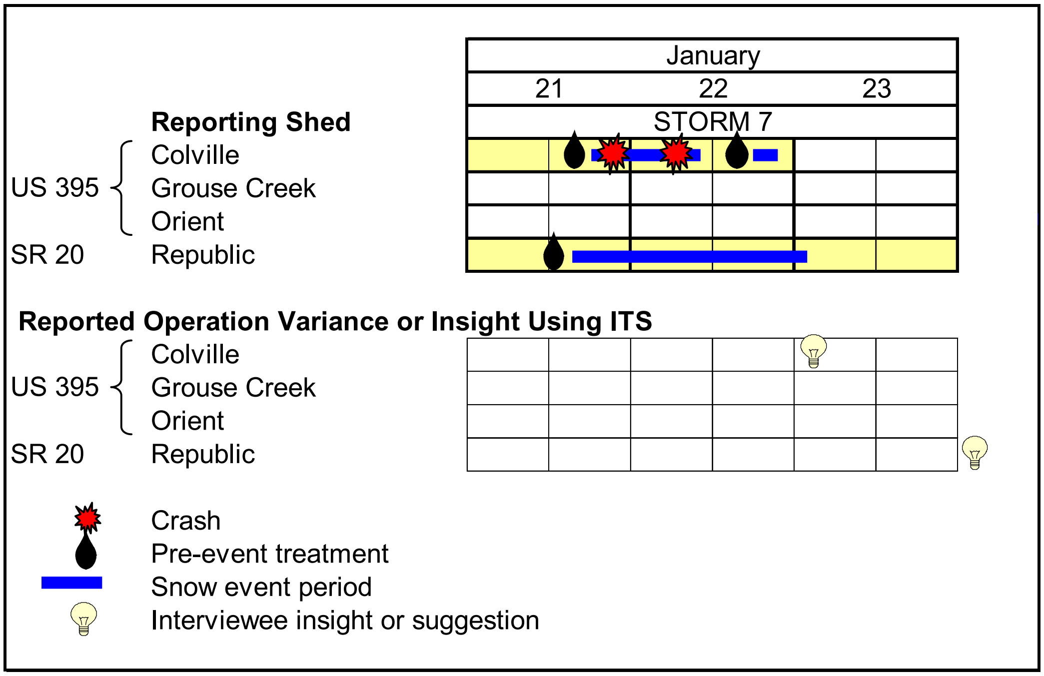
			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
6	Republic	S	1/11/2003	1900	1/12/2003	1100	4.5	27	STEADY
6	Republic	S	1/14/2003	0100	1/14/2003	0800	3.5	27	FALLING

Storm Description: Although this storm covered four days, the individual snow events that make up this storm occurred over a period of two and a half days. There was no log submitted for the 13th, but there were indications that there may have been some snowfall. There was a traction advisory issued for Sherman Pass during this storm. Redistribution of trucks out of Colville generated a need for overtime hours for personnel at the Republic shed in order to maintain the level of service on Sherman Pass. The Republic and Kettle Falls HARs were not working during this event.

Actions & Insights:

The problem of access to the Internet from the Republic shed continues. Access is inconsistent at best.

Storm # 7



			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
7	Republic	S	1/21/2003	1300	1/23/2003	0100	7	22	RISING
7	Colville	S	1/21/2003	1530	1/21/2003	2400	3	27	STEADY
7	Colville	S	1/22/2003	1430	1/22/2003	2200	4	28	STEADY

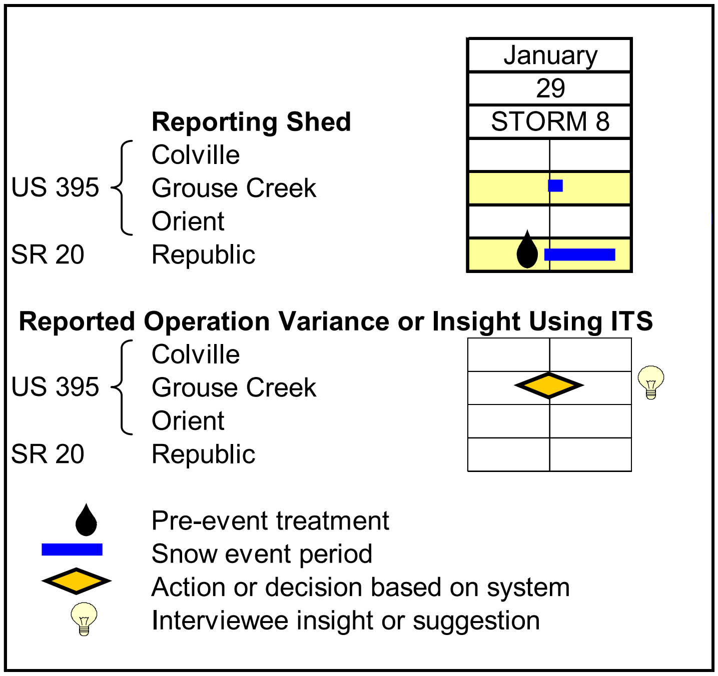
Storm Description: This was a moderate intensity storm depositing significant snow over a wide area during which there were two reported crashes on US 395 in the Colville area. There was a traction advisory issued for Sherman Pass during this storm. The Sherman Pass HARs were used to help manage traffic problems that developed due to the weather on Sherman Pass. Maintenance personnel in Colville and Republic monitored the HAR messages, which are controlled by the Spokane TMC. Comments indicated that the message was current and accurate.

Actions & Insights:

Colville personnel indicated that, while they use the RWIS information extensively, it provides only a part of the more comprehensive understanding of conditions needed to properly manage maintenance activities. The information does provide an increased level of confidence in the decisions being made.

The problem of access to the Internet from the Republic shed continues. Access is inconsistent at best. The knowledge that the RWIS-ESS equipment was in place combined with the inability to access the information was a discussion point during the interview.

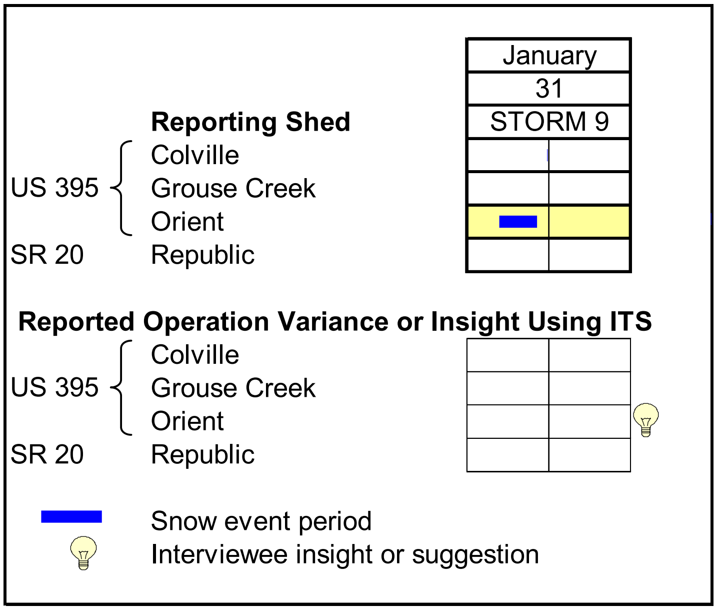
Storm # 8



			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
8	Republic	S	1/29/2003	0900	1/29/2003	2000	2	20	RISING
8	Grouse Ck	S	1/29/2003	1200	1/29/2003	1230	1	34	STEADY

Storm Description: This was a light intensity, continuous snowstorm during which the Republic shed was unable to access the RWIS information due to slow or nonexistent Internet access. There was a traction advisory issued for Sherman Pass during this storm and no reported crashes. The Sherman Pass HARs broadcast pass conditions during this storm.	
Actions & Insights:	
	When it began snowing around noon, Grouse Creek personnel checked the web site and found both the image and the data to be helpful in making a decision to not send a truck out. They showed the pavement to be wet but clear. They felt that this saved them some overtime and fuel.
	Grouse Creek Lead Tech again stated that the camera image quality was not good, that the camera angle needs to be improved, and that the current lights tend to create some glare. He also stated that the data available no longer included chemical content at the pavement surface and that he would like this information.

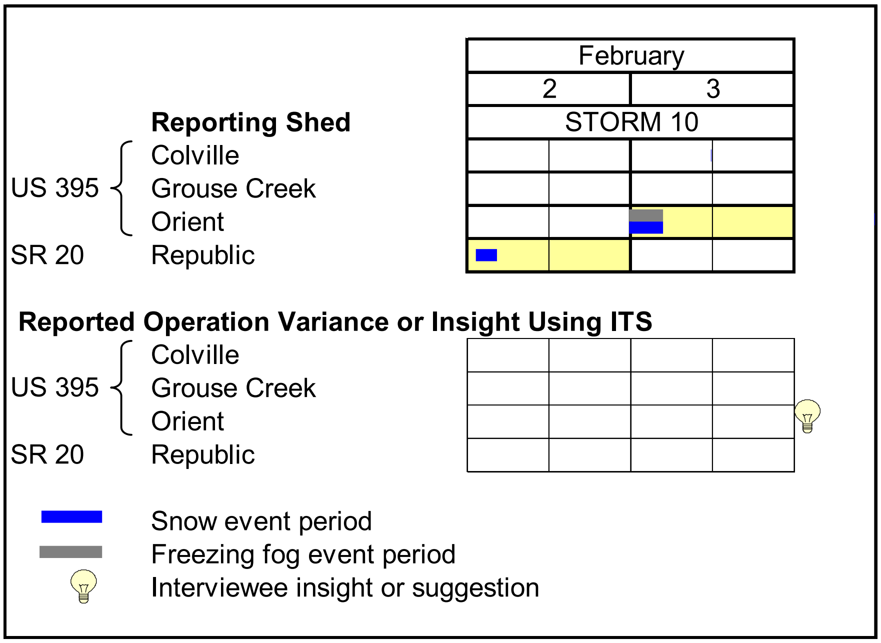
Storm # 9



			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
9	Orient	S	1/31/2003	0400	1/31/2003	1100	3	20	RISING

Storm Description: This was a minor snowstorm that affected US 395 north of the junction with SR 20. There was a traction advisory issued for Sherman Pass and the Sherman Pass HARs broadcast pass conditions during this storm. There were no reported crashes during this event.	
Actions & Insights:	
	At least one member of the Orient crew commutes past the RWIS site and reports conditions upon arrival. This in combination with a slow Internet connection precludes the use of the RWIS information for many storms. There was an indication that the connection speed was being upgraded in the near future.

Storm # 10



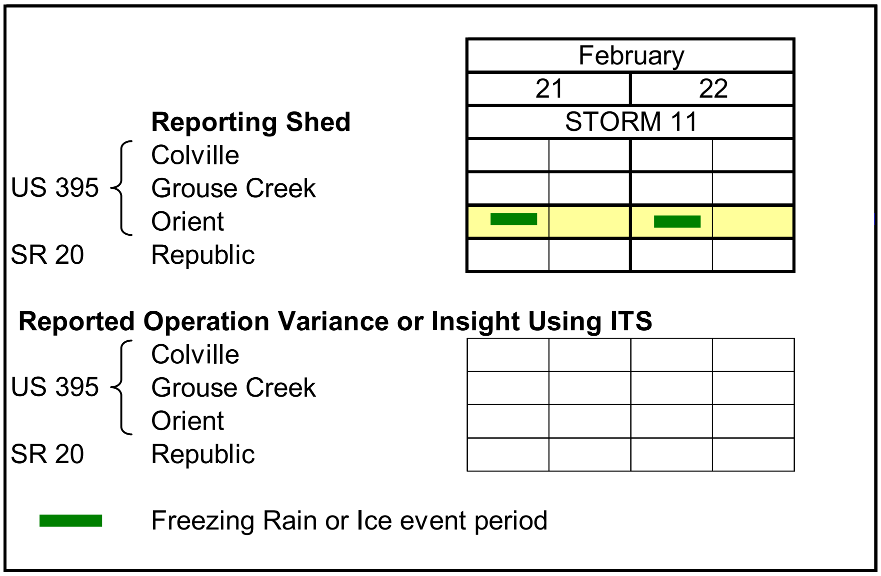
			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
10	Republic	S	2/2/2003	0130		0500	3		STEADY
10	Orient	S/FG	2/3/2003	AM	2/3/2003	0400	0.5	30	RISING

Storm Description: This was a minor snow and freezing fog event that impacted US 395 north of the junction with SR 20 and Sherman Pass. There was a traction advisory issued for Sherman Pass and no reported crashes during this event. The Sherman Pass HARs broadcast pass conditions during this storm. There was a comment that the RWIS information as well as the camera image for Sherman Pass are unavailable at night.

Actions & Insights:

At least one member of the Orient crew commutes past the RWIS site and reports conditions upon arrival. This in combination with a slow Internet connection precludes the use of the RWIS information for many storms. There was an indication that the connection speed was being upgraded in the near future.

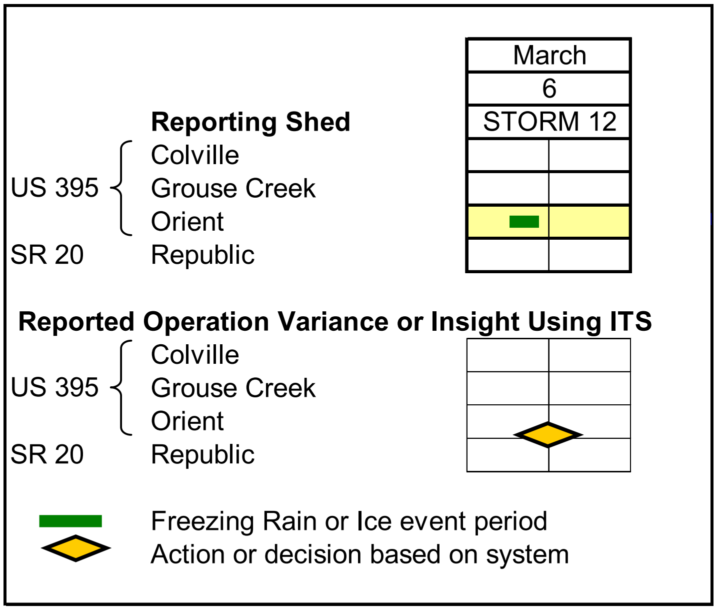
Storm # 11



			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
11	Orient	FR	2/21/2003	0400	2/21/2003	1000	0	34	FALLING
11	Orient	FR	2/22/2003	0400	2/22/2003	1000	0	32	RISING

Storm Description: This was a minor freezing rain event that impacted US 395 north of the junction with SR 20. There was a traction advisory issued for Sherman Pass, which is evidence that the storm also impacted maintenance efforts of the Colville and Republic sheds. There were no reported crashes during this event. The Sherman Pass HARs broadcast pass conditions during this storm. The Orient crew was apparently alerted to a forecast storm, however, by using the information and camera image available via the Internet, they were able to forego a maintenance patrol toward Laurier during the time frame that the forecast called for precipitation.

Storm # 12



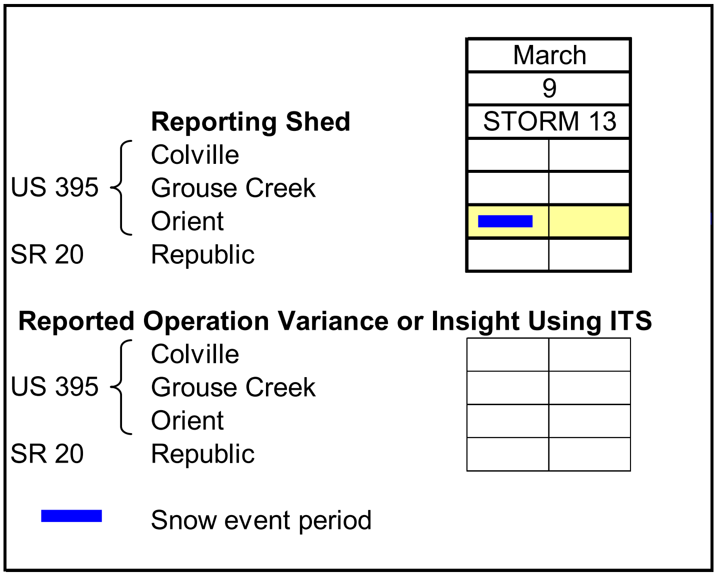
			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
12	Orient	FI	3/6/2003	0600	3/6/2003	1100	0.25	27	RISING

Storm Description: This was a light intensity, scattered ice storm that impacted US 395 north of the junction with SR 20. The Sherman Pass HARs broadcast pass conditions during this storm. There were no reported crashes.

Actions & Insights:

	The Orient crew was apparently alerted to a forecast storm, however, by using the information and camera image available via the Internet, they were compelled to send a truck out based on RWIS information during the event.

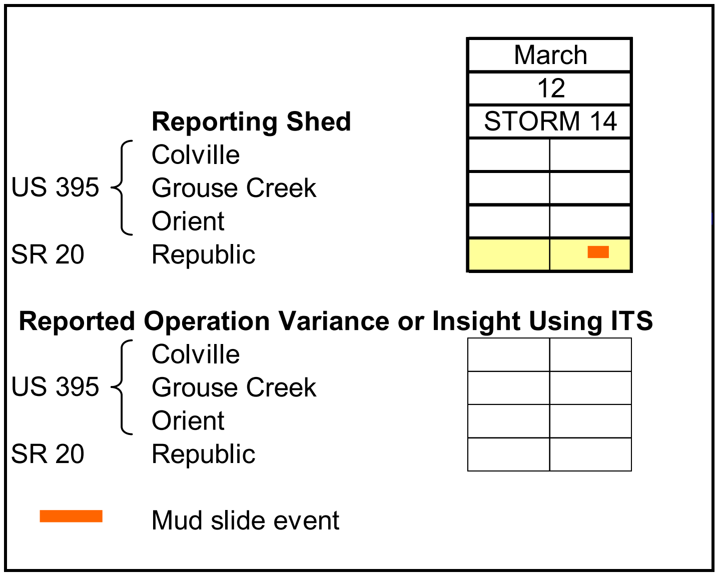
Storm # 13



			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
13	Orient	S	3/9/2003	0600	3/6/2003	1000	2	24	RISING

Storm Description: This was a minor snow event that impacted US 395 north of the junction with SR 20. There was a traction advisory issued for Sherman Pass, which is evidence that the storm also impacted maintenance efforts of the Colville and Republic sheds. There were no reported crashes during this event. The Republic HAR broadcast pass conditions during this storm, but the Kettle Falls HAR apparently did not.

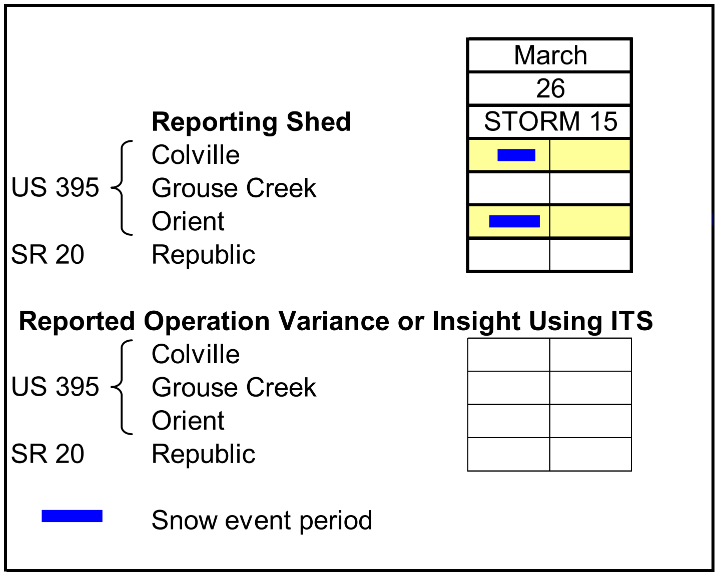
Storm # 14



			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
14	Republic	R	3/12/2003	1715	3/12/2003	1919	na	35	RISING

Storm Description: The details of this event were collected from the TMC HAR log. The Sherman Pass HARs were used to alert the public to the mud slide and resulting lane closure. No event log was submitted for the event, but it is evidence of the HAR usage.

Storm # 15



			Timing				Weather		
Storm Number	Shed	Event Type	Begin Date	Begn Time	End Date	End Time	Snow Total Inches	Start Temperature	Temperature Trend
15	Colville	S	3/26/2003	0500	3/26/2003	1030	2	31	RISING
15	Orient	S	3/26/2003	0500	3/26/2003	1100	1	30	RISING

Storm Description: This was a minor snow event that impacted US 395 north of the junction with SR 20. There was a traction advisory issued for Sherman Pass, which is evidence that the storm also impacted maintenance efforts of the Colville and Republic sheds. There were no reported crashes during this event. The Sherman Pass HARs broadcast pass conditions during this storm.

Camera Images during Storm 15, left to right: Sherman Pass, Loon Lake, and Laurier.

The additional questions included in the post event interviews provided some valuable information as well. The WSDOT road maintenance crews ranked pavement information from the RWIS site as the most useful of the ITS technologies, followed by the camera images and Internet. Radar images were their preferred way to access weather information on the Internet, and the Internet also provided them with reliable access to weather forecasts.

Examples of successes can be attributed to the specific areas of anticipated improvements associated with the new ITS information services as described previously. Below are comments and perspectives distilled from many of the Event Logs and interviews.

Increased efficiency through adjustment or balance of resource use.

a) A prime example of this benefit is the use of the camera at Laurier by the Orient crew to determine whether they make a round trip to the border before heading south over the more heavily traveled section of road.
b) Republic verified the persistence of chemical on Sherman Pass during an early season storm eliminating the need to send out the all-liquid truck.
c) Grouse Creek cited the use of the camera and RWIS data during storm 8 as saving them fuel and overtime.
d) Late in the season when WSDOT is short of staff and they are converting trucks and equipment over for summer work, the technology can help them anticipate and respond to a late season storm.
e) RWIS data were used successfully to determine when to deploy liquid anti-icing/deicing chemicals.
f) The WSDOT Maintenance Superintendent reported sand usage reduced by half in this post-deployment winter season. Although this can not be fully attributed to ITS deployments, he estimated use of RWIS information contributed significantly (perhaps 50% of the effect) to the reduction in this resource that is costly to obtain and apply.

Reduction in secondary crashes.

a) There is inadequate data to conclude anything regarding the potential to reduce secondary crashes; however, interview responses for storm 7 indicated HAR use was successful in managing traffic due to problems developing as a result of weather.

Improved timeliness and reliability of public information.

a) The crews working Sherman Pass experience far fewer (nearly none) jack-knifed trucks due to vehicle traction versus road conditions. They attributed this to better pass condition information being available.
b) Though some CVOs reported the HAR and website information to be quite useful, the WSDOT office at Colville continued to receive information requests from CVOs regarding timing of removal or downgrade of traction restrictions.
c) Front office personnel at the Colville WSDOT facility noticed a distinct decrease in inquires over the course of the winter as a result of informing callers that Sherman Pass information, including camera images, was available on the web.

d) Camera images available at each RWIS-ESS significantly alleviated any hesitation to trust the weather data being reported.
e) This was positively confirmed through the TMC log indicating numerous times when the operators accessed current pass conditions from the RWIS-ESS to report via the web and HAR when maintenance personnel were not available to report in. See storm 14 for additional examples in the case of a mudslide on Sherman Pass.

Institutional adaptation and obstacles to new ITS capabilities.

a) The crews were familiar enough with the Internet that they experienced frustration at the access problems described in the individual storm events and Chapter 6, System Performance. As a rule, highway maintenance crews rapidly assimilate technologies that provide benefits to their tasks. They expressed a primary desire for learning better skills in using the technology and that technologies deployed at the shed level be piloted and fully bug-free prior to expectations of their operational use.
b) The addition of anti-icing capability to the operational resources of the maintenance sheds increased the need for quality, timely weather and pavement information to make the best use of that new resource.
c) The best way to describe the usefulness of ITS technology to the maintenance personnel is through analogy. ITS is a piece of the puzzle, another tool in the toolbox, not something that can accomplish the task by itself, but very useful in the bigger picture. Consider the example of a stuck lug nut: eventually one will be successful in getting it loose with a wrench but an extension on the wrench handle makes it much more efficient and expedient. In the same way, the RWIS-ESS and camera images leverage the ability of the highway winter maintenance crews to better solve problems and get their job done.
d) An additional benefit of the deployment is increased or new interaction between groups such as the field maintenance personnel and the TMC staff. The maintenance personnel were quick to see ways in which the TMC staff could help their efforts as well as the TMC staff suggesting ways to improve the information and technology processes.

Changes in workload and labor requirements.

a) The WSDOT Maintenance Superintendent reported that use of RWIS data this past winter increased his staff's interest in weather information to accomplish their jobs more efficiently. They want more information to minimize unnecessary trips and focus road maintenance activities more efficiently.
b) In the case of Loon Lake, one of the Grouse Creek staff comes to work that direction and provides a better observation of route conditions than a single observation site might. This often seems to reduce the value of the site except when conditions change during the shift. Hiring personnel in the coverage area has always helped in the effectiveness of operations. By having a remote site linked to the Colville Headquarters, as in the case of the Laurier RWIS-ESS, opens the potential employment pool area to the immediate vicinity rather than needing to seek skilled personnel from the rural Orient area.

3.4.2 Baseline and Post-Deployment Winter Comparison

Evaluating the effects of the new ITS information services and capabilities requires addressing the potentially contaminating effects of different weather conditions between the baseline and post-deployment periods. There has been some work to establish a normalized performance measure for winter maintenance but there has been no consensus reached or standard adopted by the industry. To provide this background for this report, climate data collected by the National Weather Service is described here. The National Weather Services Cooperative Network includes observations from the Republic Ranger Station. This data set covers the years 1948 through 2003 and provides quality descriptive statistics of the local climate. Figure 5 illustrates the differences between the baseline winter, the post-deployment winter, and the historical averages.

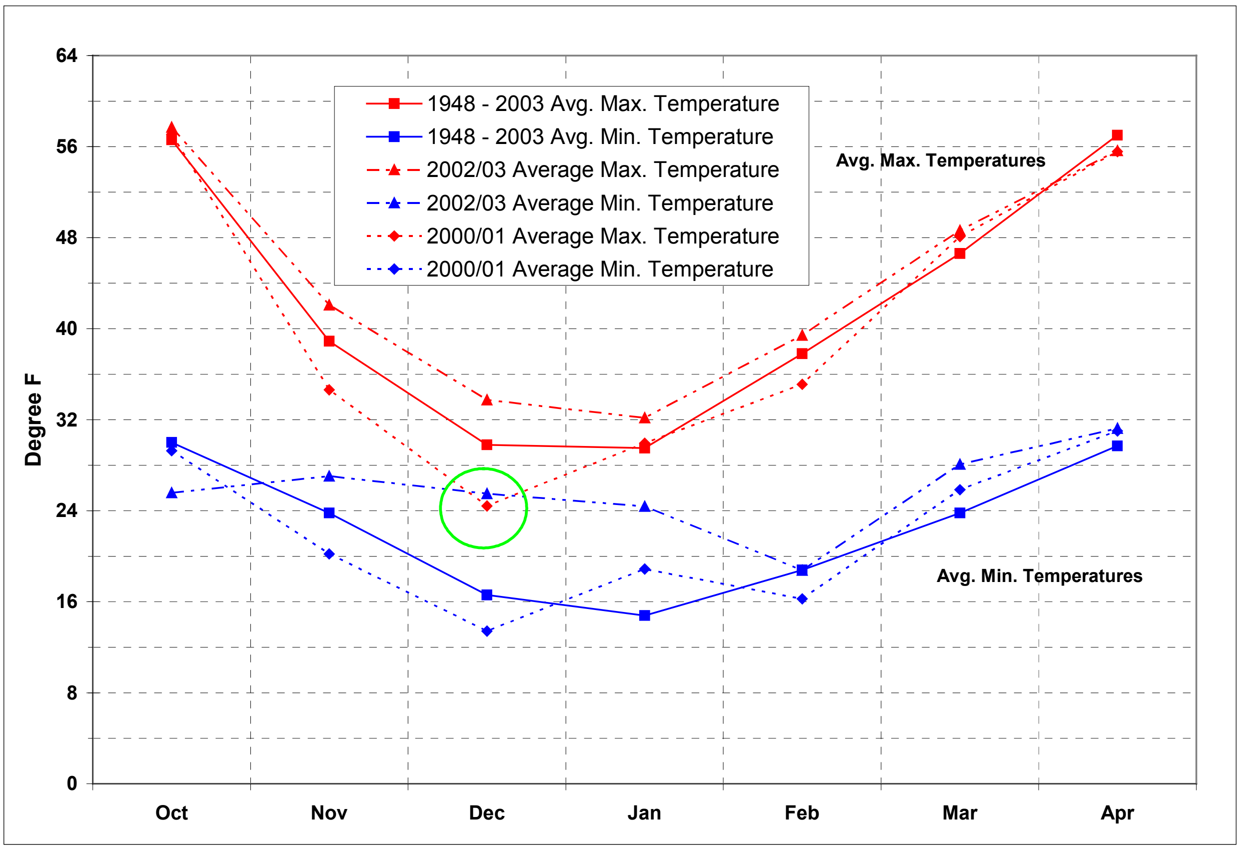


Figure 5. Comparison of average minimum and maximum air temperatures.

Figure 5 shows the average monthly daily maximum and minimum air temperatures. The baseline and post-deployment years are compared to the 55-year average of the monthly averages of minimums and maximums. The post-deployment winter was warmer than average. Both average minimums and maximums for the months of November through March were warmer than the 55-year averages. The conditions during the baseline year were colder to much more average as seen in Figure 5. An interesting observation is circled in the month of December. The average minimum temperature of the post-deployment year for December is about the same as the average maximum temperature of the baseline year for that month.

The precipitation measured in inches of water equivalent shows the baseline year generally drier than average. The post-deployment winter precipitation begins later than usual, is dramatically greater during mid-winter, drops off to nearly nothing in February, and finishes close to average in March. Figure 6 shows the relative amounts.

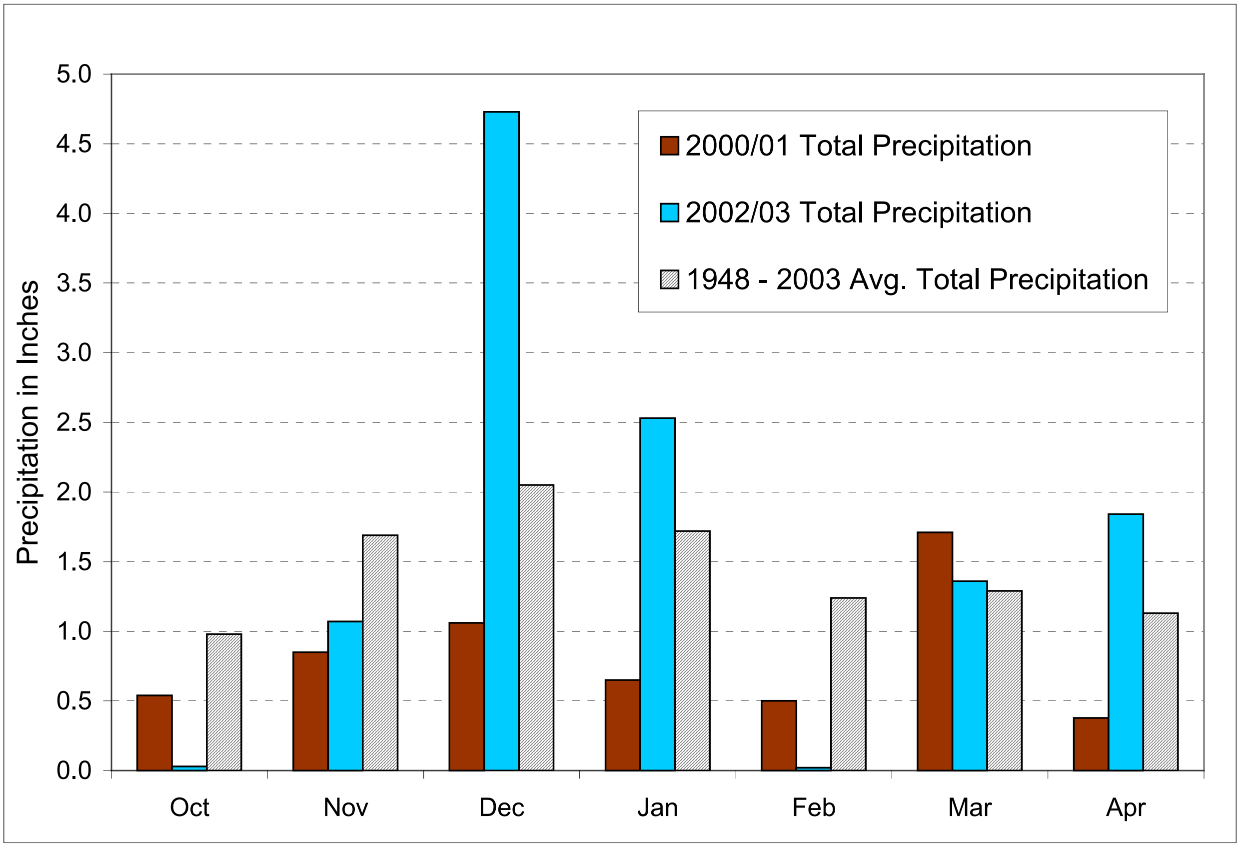


Figure 6. Relative monthly precipitation amounts for Republic, WA.

Figure 7 shows the monthly snowfall in inches recorded at Republic against the 55-year average monthly snowfall amounts. There is a problem in using annual snowfall or precipitation amounts to measure or compare winter maintenance activities. The preferred measure of maintenance performance is the duration of the event and period of departure from desired pavement level of service. For the purpose of this evaluation the assumption is made that both the baseline and post-deployment winters were generally sub-average or milder than normal.

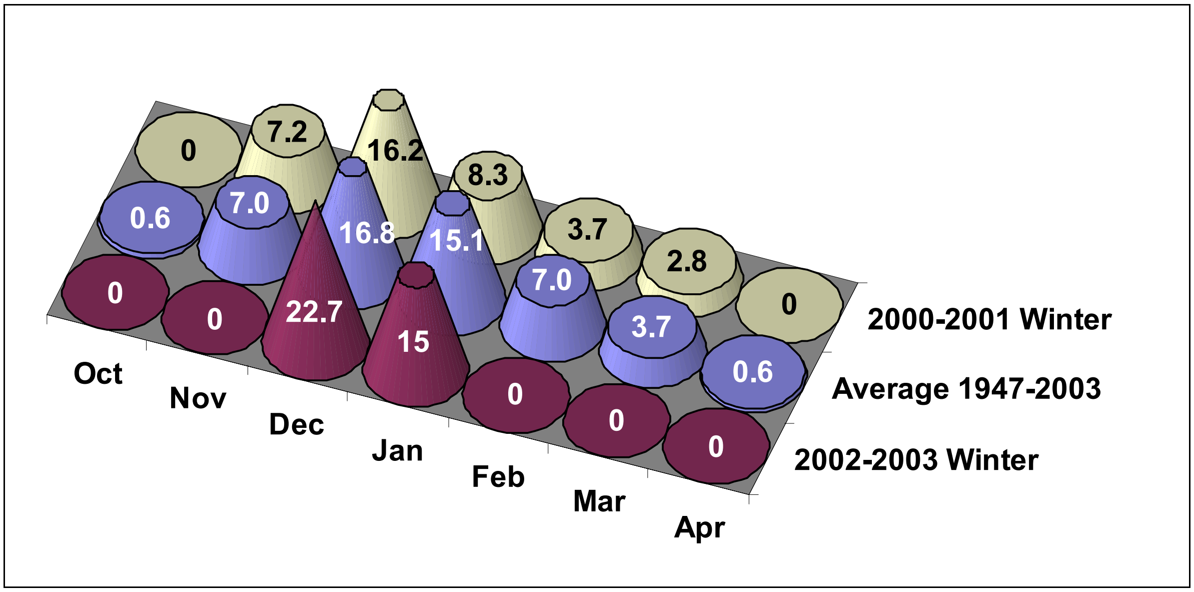
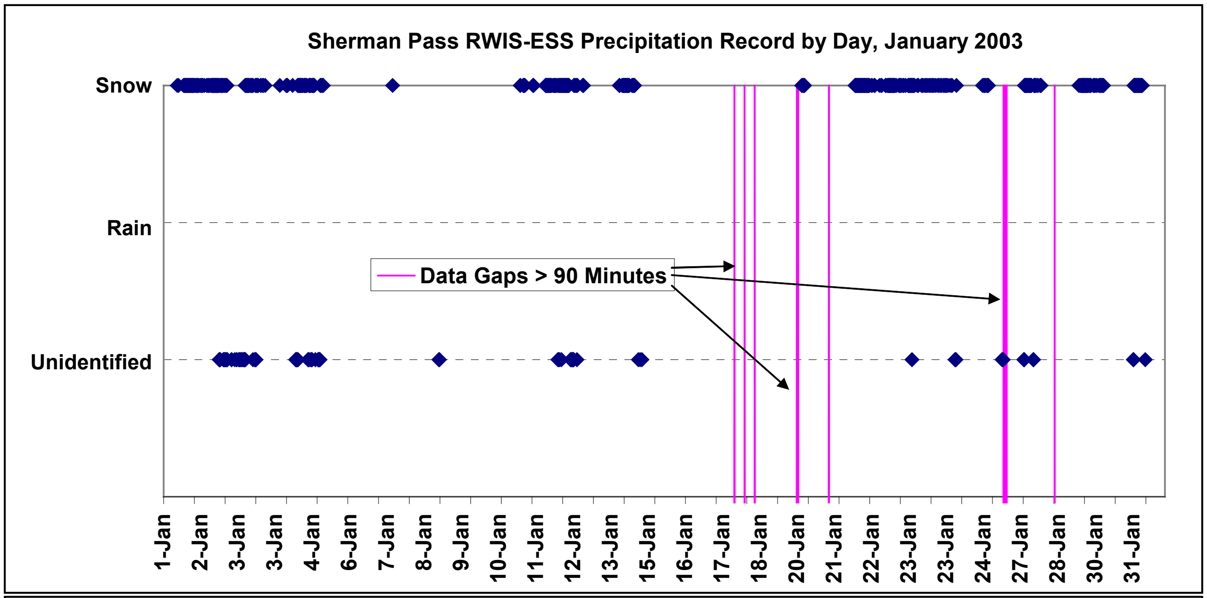


Figure 7. Monthly snowfall amounts (inches) for Republic, WA.

The uncertainty of adequate data for evaluations based on activities due to weather is high as shown by the very limited baseline data collection and its cause attributed to being such a mild winter. Even though the baseline and post-deployment winters are assumed to have been equally mild relative to historical averages, there were many fewer events documented in the baseline period (2 Event Logs) compared with 15 Event Logs gathered in the post-deployment period. This in part is due to the redesign of the data gathering instrument and the integration of that log format with one that was initiated independently by the WSDOT Colville office in the post-deployment winter period.

WSDOT anti-icing liquid truck.

Another issue in using total inches of snowfall as an indicator is that observations are often not collected at a site that is close to or sufficiently similar to the area being evaluated. One way the RWIS data can be very useful is by showing the number of minutes by identified precipitation type for the analysis, as seen in the example of Figure 8 for January 2003. From this chart one could ascertain that precipitation occurred during approximately 22 days in January 2003. With a closer examination of one day, January 2, 2003 (Storm 5), the data indicate that snow was recorded at 56 of the observation time periods over 24 hours that day (the system is configured to record data whenever significant variables change, thus the non-periodic spacing of times). This more detailed way of presenting actual snowfall is more closely linked to demand on O&M than the NWS report for the same 2 days at Republic that showed eight periods of snowfall reported by the RWIS-ESS totaling nearly twelve and a half hours on January 2, 2003.



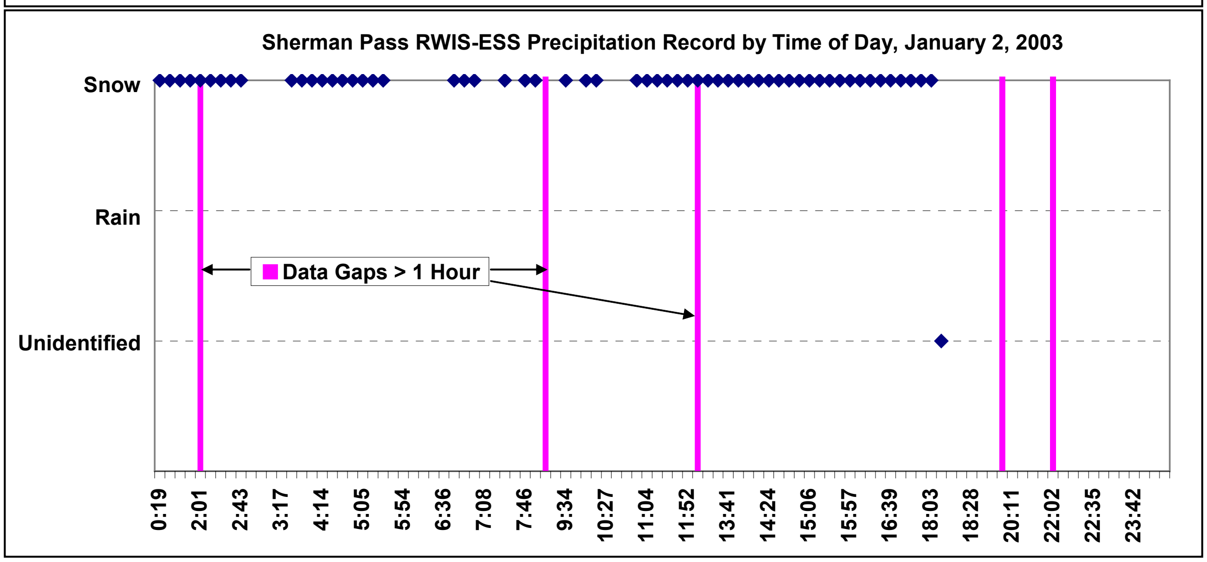


Figure 8. Sherman Pass RWIS-ESS reported precipitation types and periods: January 2003.

A final important difference between the baseline and post-deployment winters is the introduction of anti-icing agents to the winter maintenance resources for managing road weather conditions. WSDOT is making much greater use of these chemicals to control ice compared with the baseline period; however several application parameters must be observed to ensure cost effective use. First, anti-icing agents can be applied from a point well in advance of a storm until some time after snowfall has begun depending on the rate of precipitation. The advantages of applying anti-icing agents prior to the arrival of a storm highlight the importance of access to reliable weather forecasts by maintenance personnel. This is one key factor in understanding the ongoing changes in utilization of weather information by operations and maintenance personnel.

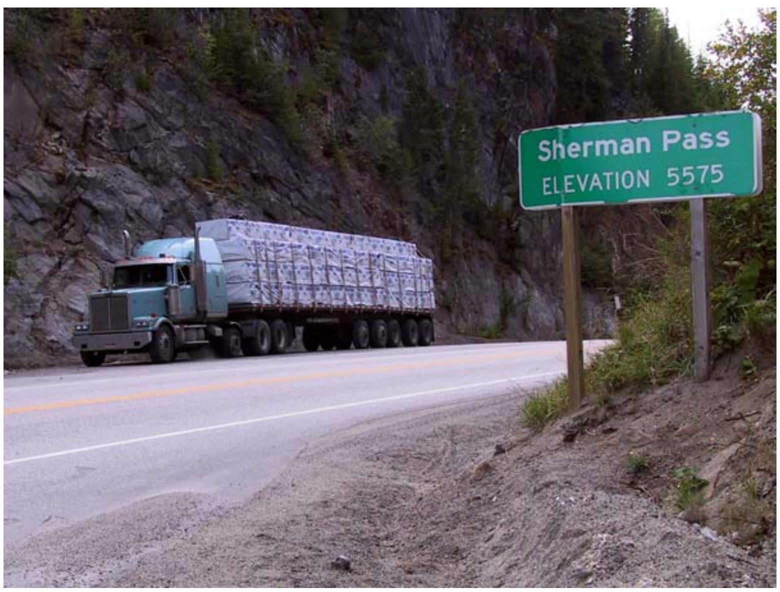
In addition, the humidity level is an important consideration in application of anti-icing agents. This emphasizes the need for maintenance personnel to have access to current conditions and may further explain increases in their use of RWIS data.

4.0 Travel and Mobility for Commercial Vehicles

4.1 Introduction

Commercial vehicles constitute a significant component of the total traffic in the U.S. 395 corridor region. The impacts of hazardous road and weather conditions on commercial vehicle operations affect the trucking businesses and the economic viability of the communities that they serve. Deployment of the new ITS services in the region is expected to:

- Improve safety by helping commercial drivers better prepare for or avoid dangerous road and pass conditions, whether caused by snow, ice, rain, slides, construction, or other road hazards.
- Increase efficiency of operations for the CVOs by providing information to dispatchers and drivers that can help in the timing and routing of truck trips to avoid potential problem areas, enhance on time delivery of goods and services, and reduce costs of operations caused by travel disruptions.
- Enhance preparedness and reduce stress for CVO drivers by providing them with more accurate and current information about conditions on the routes they plan to travel.



Truck crossing Sherman Pass, elevation 5575 feet. RWIS and camera on hill to right (not in view).

The evaluation of road and weather information used by commercial vehicle operators will provide an integral piece of the overall picture of ITS effectiveness in the study area. Data collected from commercial vehicle companies regarding their use of road weather information was needed to evaluate the information dissemination technologies over a representative range of potential users. The purpose of this section is to present the findings relative to the analysis of data collected regarding commercial vehicle operations.

4.1 Objectives and Approach

The approach to evaluating the impacts of increased technology-related information dissemination efforts on the safety and efficiency of commercial vehicle operations was to conduct interviews with trucking firms and other companies that incorporate a trucking element into their business both before and after the implementation of the ITS elements associated with this project. The objective of this effort was to collect information from a variety of companies that would indicate how effectively the project addressed the evaluation measures.

The anticipated impacts, measures, and hypotheses that guided this component of the evaluation were described in the Evaluation Plan and Test Plan, and they are summarized in Table 4.

Table 4. Evaluation objectives and measures for commercial vehicle operations.

Objectives and Anticipated Impacts	Evaluation Measures	Hypotheses
Increase safety	- Number of accidents - Perceived safety improvements	- The number of accidents and incidents due to weather and bad road conditions will go down - Drivers report improvements in safety due to ITS
Increase mobility	- Travel time - Travel decisions/behavior - Problems encountered on roads	- Better trip planning leads to more timely, reliable trips - Use of information alters trip decisions/behaviors, leading to enhanced mobility - Ability to avoid weather and hazard problems on roadway increases mobility
Increase satisfaction	- Awareness of information - Use of information - Reported satisfaction	- Drivers are more aware of information availability - Drivers make more use of available information - Drivers' comfort increases and stress associated with potentially dangerous driving situations decreases

4.2 Methodology

Evaluation of impacts to commercial vehicle operations began with collection of baseline data for the 2000-2001 winter. The first step was to develop a comprehensive list of all the CVO companies that have active operations in the study region. WSDOT provided a list of company contacts that they keep in order to notify these companies by phone when there is a road closure due to a hazardous situation in the region. A much more comprehensive list was obtained from the Washington Trucking Associations (WTA), whose membership includes most of the trucking companies in the state and all of the major operators. WTA provided names, addresses and phone numbers for their Spokane chapter members and any others they believed operated trucks in the study area. The trucking associations of Oregon, Idaho, and British Columbia were also contacted to supplement the list.

Eighty-six commercial vehicle operators were originally identified during the data collection phase through input from WSDOT and the Washington Trucking Association. Forty-two of the companies on the list (49%) agreed to participate and provided input into the baseline data through telephone interviews conducted during the spring of 2001. For the post-deployment phase of data collection, the list was reviewed and supplemented. The trucking companies interviewed during baseline data collection were again contacted in an attempt to collect follow up information; however, not all were able to participate. Therefore, several additional trucking firms were contacted and interviewed. More detail is provided in Table 5.

Table 5. CVO interview statistics.

Baseline interviews	42
Baseline contacts that did not participate in the Post-deployment Interviews	7
1) Went out of business 2 2) No longer haul in the corridor 2 3) Unable to participate 3	
CVOs that were interviewed both times	35
New contacts for the Post-deployment Interview	4
Post-deployment interviews	39

Post-deployment telephone interviews were conducted using a guide similar to the one used during the baseline interviews. Some modifications were made based on information collected during the baseline operations and to address their use of any of the new ITS services installed since the baseline. The process of refining the interview guide included examining the preliminary guide to ensure that the following issues would be addressed:

- Do questions solicit appropriate responses?
- Would closed or open-ended questions provide the best information?
- In what order should the questions appear?
- How long should the interview take?
- Does the interview guide adequately address the evaluation hypotheses?

The resulting post-deployment interview questionnaire is included in Appendix C.

The results from both the baseline and post-deployment interviews were tabulated and analyzed. The results from the baseline analysis were presented in the September 2001 Phase II report.

Several interview questions allowed a fairly straightforward comparison, but many questions required a more thoughtful interpretation to draw conclusions regarding the use of road weather information by commercial vehicle operators. The data were analyzed to identify relationships among company business type, responses regarding information access and use, and perceived needs and benefits of the ITS services.

4.3 Findings

The findings from the data analysis are presented here. The findings resulting from the analysis of the post-deployment responses are presented first, followed by a discussion of the comparison with the baseline data. The remaining subsections present additional insights from comments, suggestions, and the more general discussions during the CVO interviews.

4.3.1 Descriptive Results

Many of the companies contacted are small, one or two truck businesses. These businesses often consist of an owner-operator and a single tractor. The percentages of the motor carriers interviewed fitting into size categories based on number of trucks are shown in Figure 9 below. Fourteen (35%) of the companies interviewed operate just one or two trucks and 31 (79%) operate fewer than 10 trucks.

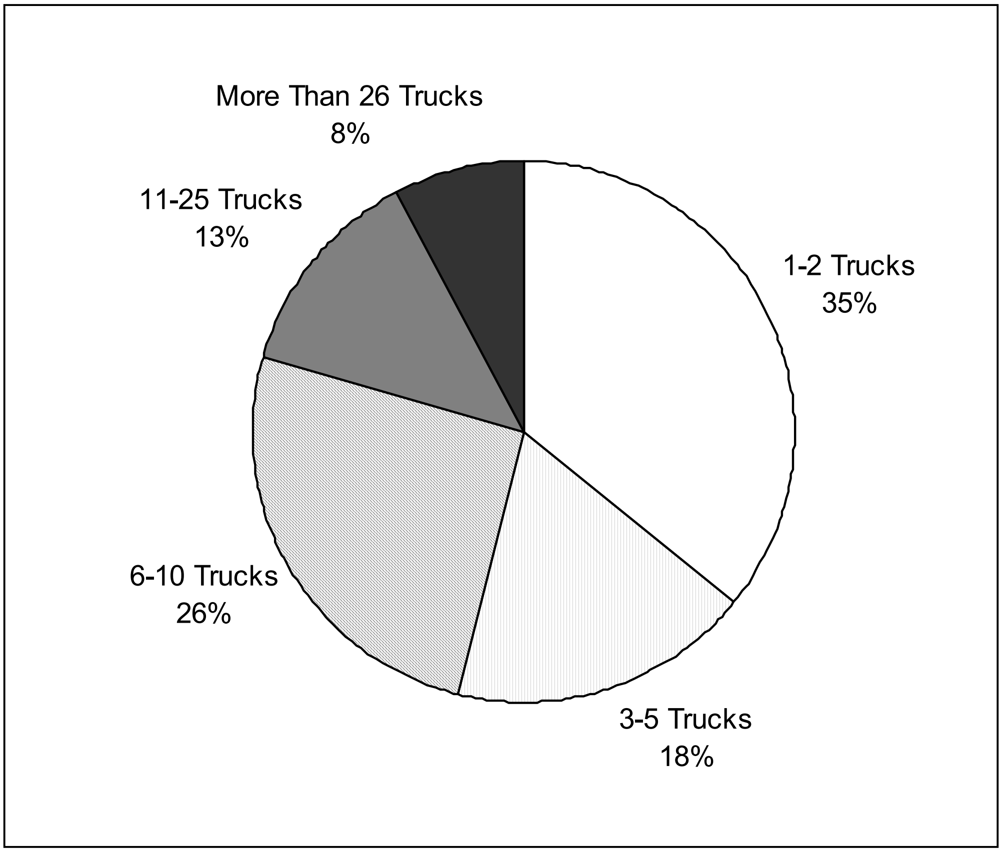


Figure 9. Distribution of motor carriers interviewed based on numbers of trucks.

Many of the small companies interviewed are part of primary industries in the region. Logging and related byproducts generate many of the truck trips on the study routes. As shown in Figure 10, 19 (49%) of the businesses interviewed primarily transport logs, lumber, or wood byproducts.

In the baseline analysis there was some evidence that log and lumber trucking companies might be different from other CVO types in such factors as driver independence, ability of their vehicles to handle difficult winter driving conditions, and use of a dispatch service. The data from the post-deployment interviews were examined to see whether certain CVO cargo types appeared to cluster together in ways that might be correlated with how they used and benefited from the new ITS services. The findings were not conclusive, likely because of measurement error and the large variability in the structure of the companies interviewed.

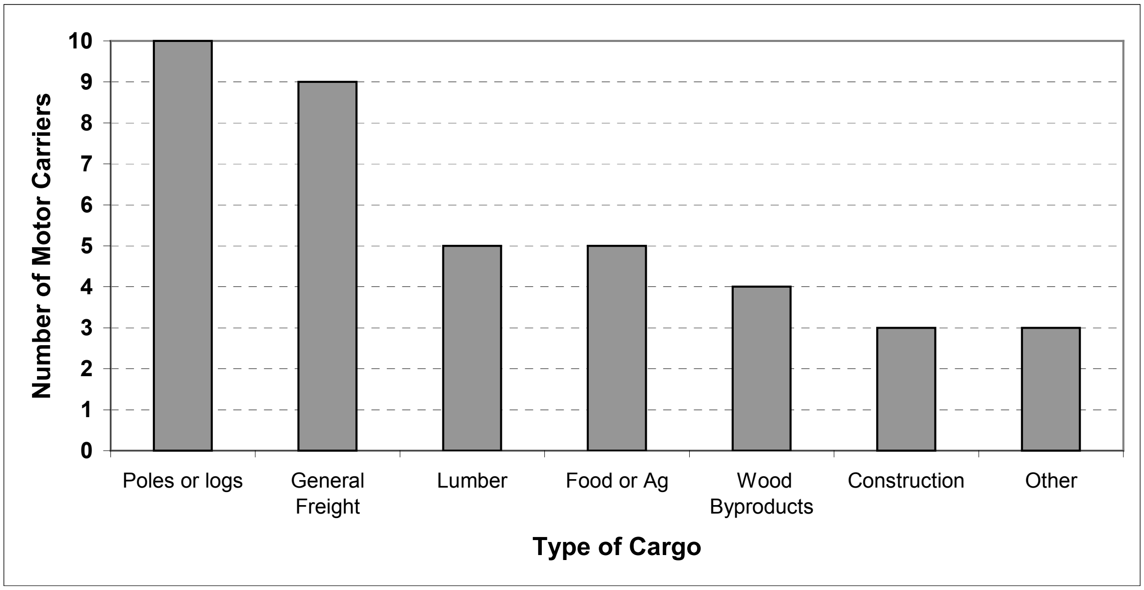


Figure 10. Types of cargo being transported in the region.

While most of the vehicles being used in the region are tractor semi-trailer configurations, Figure 11 shows that there are a variety of truck types being used in the study corridors. This is important when considering the options available to CVOs in changing vehicle configurations due to inclement weather.

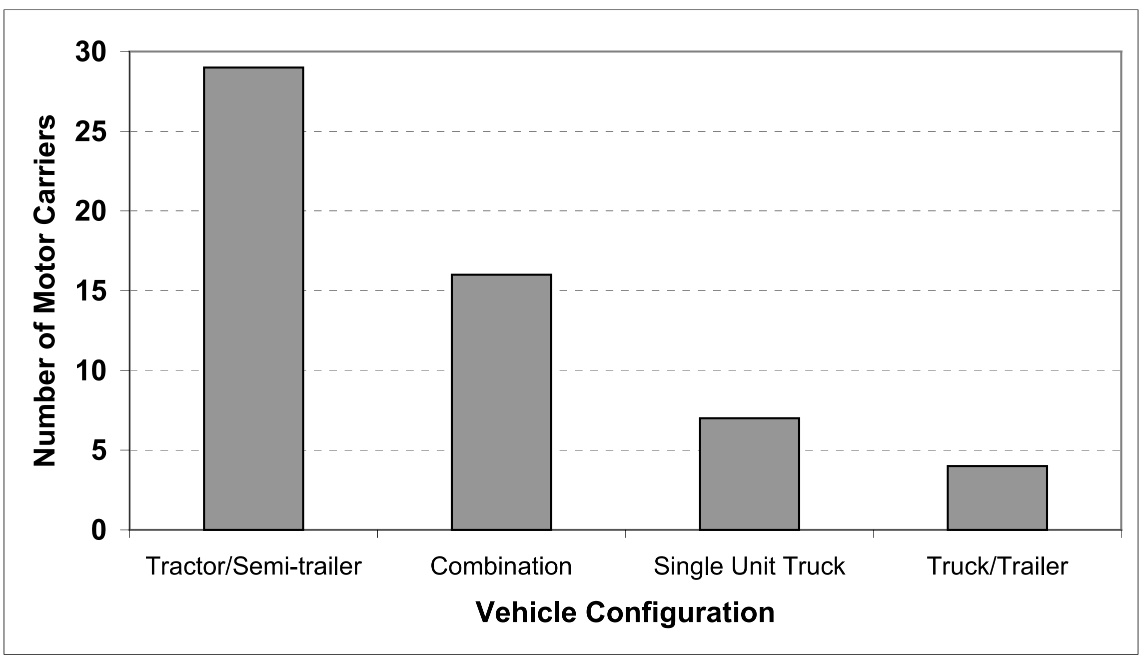


Figure 11. Numbers of carriers with various vehicle types.

Figure 12 shows the results of several interview questions relating to operations during hazardous driving conditions. Only four of the respondents indicated that weather or driving restrictions caused them to change the type of truck they used for a trip. Those who did change their vehicle configuration as needed based on weather conditions typically just eliminated the second trailer of a combination load. Twelve respondents indicated that they will change routes based on weather conditions if alternates exist; however, few identified viable alternate routes for their trips in the study corridors. This is inherent in rural mountainous regions where geography limits the availability of alternative routes and links to other roadways. Weather and roadway condition information, while helpful in preparing for a trip, is more limited in its utility for route selection in these environments.

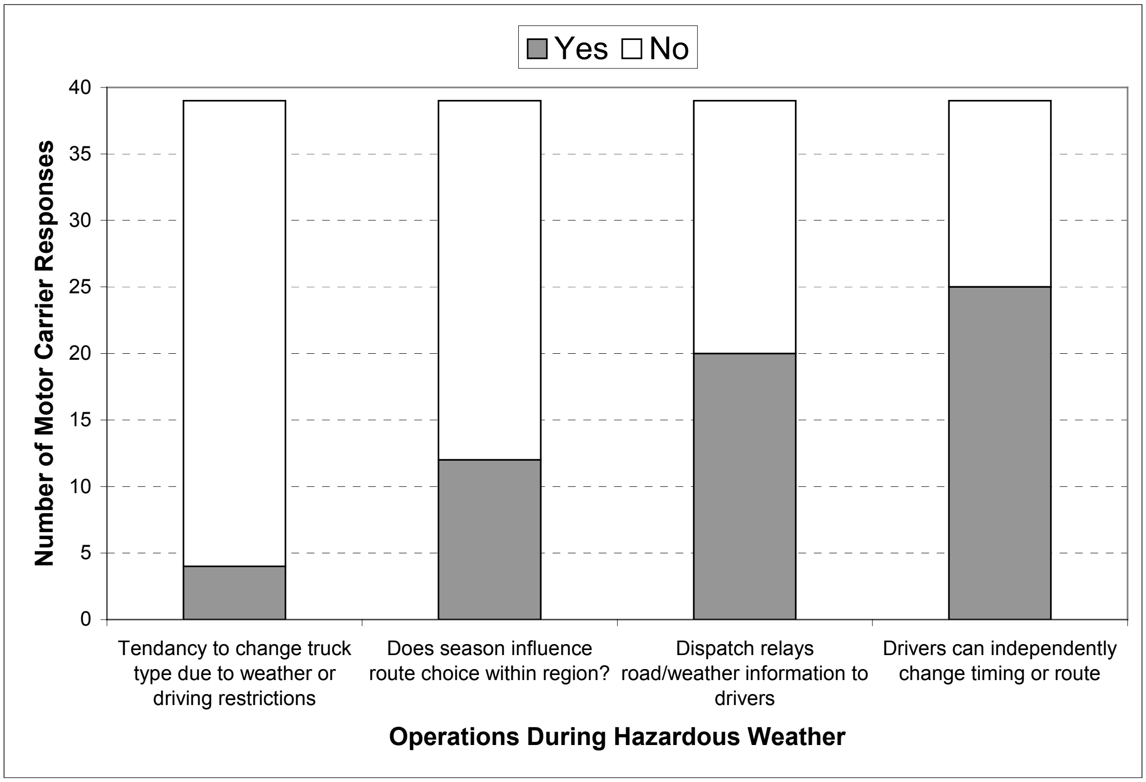


Figure 12. Hazardous weather operations trends.

Despite the apparent reluctance to change truck type or route for a trip based on weather, the motor carriers contacted were generally concerned about weather conditions. Twenty (51%) have an in-house dispatch function and use it to relay road and weather information to drivers. While their methods of obtaining the information varied, it was evident and is shown in Figure 13 that the new sources of information available as a result of the ITS deployments are being used by these commercial vehicle operators. Some respondents were uncertain as to the level of use of the WSDOT web site and HAR messages, and some companies did not have Internet access set up within their businesses.

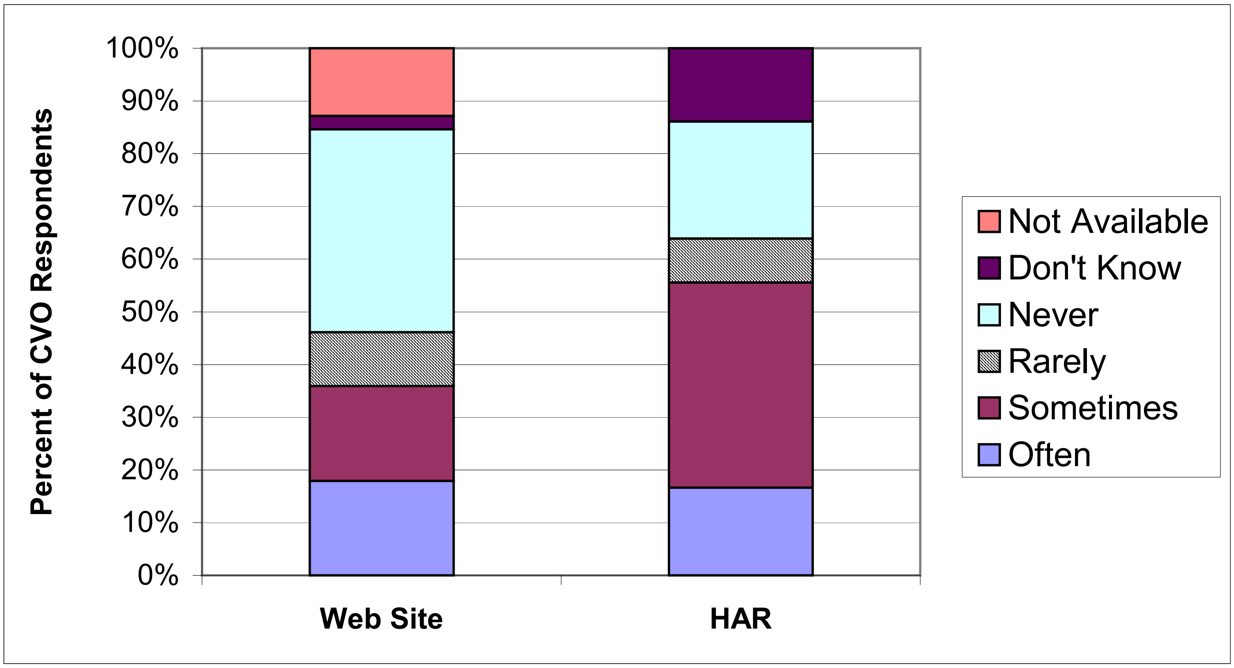


Figure 13. Reported post-deployment use of new WSDOT ITS road weather information sources.

Most that reported regular access to and use of road weather information indicated that the information helped them to be better prepared for conditions on their route. This was expressed in terms of ensuring that vehicles had adequate numbers of serviceable tire chains, knowing that a given trip may involve reducing speeds, and being able to alert customers of potential delays.

> "You can get a lot of information about what's happening from a picture." **[Comment by a truck driver on the value of the new cameras]**

In addition, interviewees were asked about the degree to which drivers reported that the HAR messages were useful. These results, that are shown in Figure 14, indicate that 20 (51%) find the HAR messages useful in assisting their travel. In fact, five (13%) find them "very useful" and 15 (38%) find them "somewhat useful."

4.3.2 Comparison to Baseline

The baseline interviews were aimed at determining 1) the level of commercial vehicle activity in the U.S. 395 and SR 20 corridors, 2) whether commercial vehicle operators and dispatchers actively sought out road and weather information, 3) the sources of information that they rely on most, and 4) how information regarding hazardous winter weather and road conditions impacts their decisions regarding operations. This information helped in understanding the potential effectiveness of information dissemination efforts by WSDOT. Additional unexpected insights gleaned from the baseline discussions played a role in formulating the questions used in the post-deployment interviews.

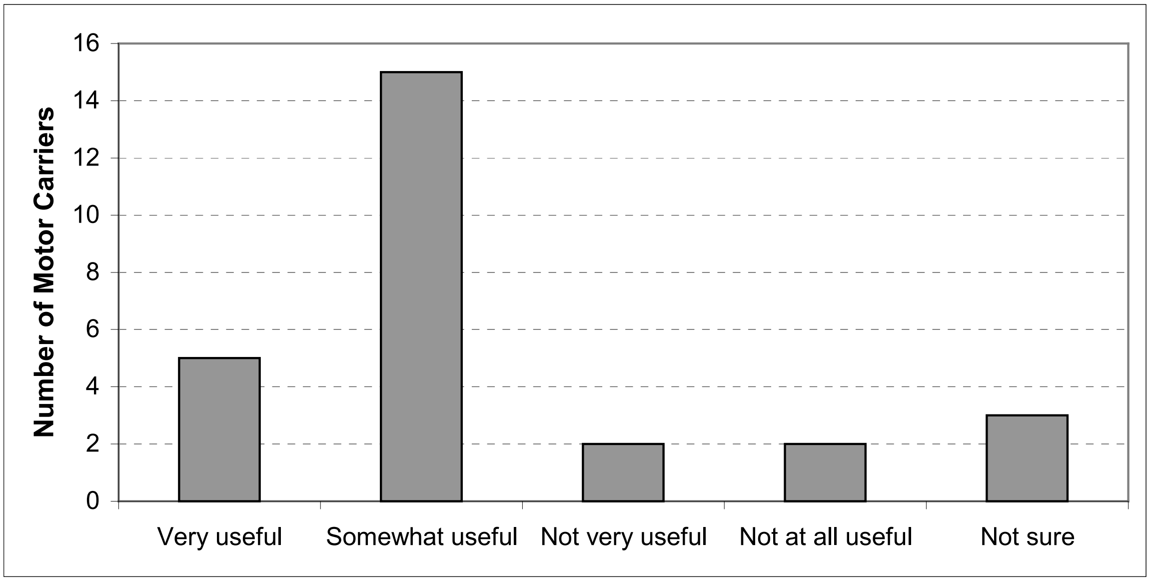


Figure 14. Reported usefulness of HAR messages by CVOs.

The post-deployment interviews were designed and conducted in an attempt to determine whether commercial vehicle operators were accessing and utilizing the road weather information being made available by WSDOT, if the use of the information had an impact on safety and operations, and how the CVOs perceived the benefits of the new services. The CVO evaluation design provided an opportunity to compare baseline and post-deployment data at an individual level; that is, because many of the same CVOs were re-interviewed two years after the baseline interviews, it is possible to track changes in the reported uses of and benefits from road weather information by each individual CVO.

Winter driving conditions in study region, 2003.

From the standpoint of basic operations there were several findings of interest. There appeared to be an increase in the use of the subject routes from early 2001 to early 2003 by the commercial vehicle operators interviewed. This is based on interview responses and not actual traffic counts and so is limited to the motor carriers interviewed. The patterns of use also varied substantially, with some CVOs reporting that they only use small segments of U.S. 395 for example. The increase in reported numbers of trips on these routes seems to be true in spite of the use of fewer vehicles owned by the companies.

A comparison of the baseline and post-deployment responses regarding use of dispatch to relay road/weather information indicates that fewer companies now use this strategy. However, during the post-deployment interviews a companion question asked if their use of this technique had changed in the past two years. Responses to this question reveal inconsistencies in reporting. Several companies reported use of dispatch to relay information in the post-deployment with no change in strategy in the past two years, but did not report the use of dispatch when interviewed during the baseline discussions. Also, several who reported the use of dispatch two years ago, indicated that they did not use this strategy in the post-deployment interview and that there had not been a change in operations in this regard. Some inconsistencies of this type are inevitable in interviews separated by two years and involving different respondents in different company positions trying to represent the activities of an entire company. While the instances of such reporting inconsistencies that we can identify are actually few, they add to the inherent uncertainty in data of this kind.

Twenty-five (64%) of companies interviewed allow their drivers to independently change their routing or trip timing in response to hazardous weather or roadway conditions. This was the same for both the baseline and the post-deployment interviews. It is interesting to note that companies with larger numbers of trucks and drivers in service are much less likely to allow drivers to change trip plans and they are more likely to have dispatchers that control company travel. Those companies with a dispatch service tend to restrict their drivers to tight schedules and routes. Log and lumber truck companies in the baseline were much more likely to be flexible in changing routes and timing and less likely to have a dispatch service than other CVOs. CVO drivers with greater flexibility might be expected to be more likely to benefit from road weather information and use that to alter trip plans. On the other hand, dispatchers also reported using and benefiting from road weather information. It may also be the case that the characteristic of being an independent owner/operator plays a key role in affecting the use and benefit from real-time road weather information more than other CVO types. In this sample, it happens that many of the logging companies are small, one-person operations. However, the available data from this sample do not allow for a more definitive interpretation.

Findings specific to basic winter operations were limited. Figure 15 below shows that the influence of season on trip route selection has diminished from the baseline information to the post-deployment interviews. This is interesting in light of the limited alternate routes available and implies that CVOs use the information less to change trip plans than to simply better prepare for the trips that they must make. One of the potential reasons for route change based on season is freezing and thawing of forest logging roads. When these roads are frozen, logging operations can be conducted without undo risk to the road surfaces; however, when they are thawing during the spring, these roads often have load restrictions placed on them because they are more vulnerable to road surface damage as the ground underneath is soft.

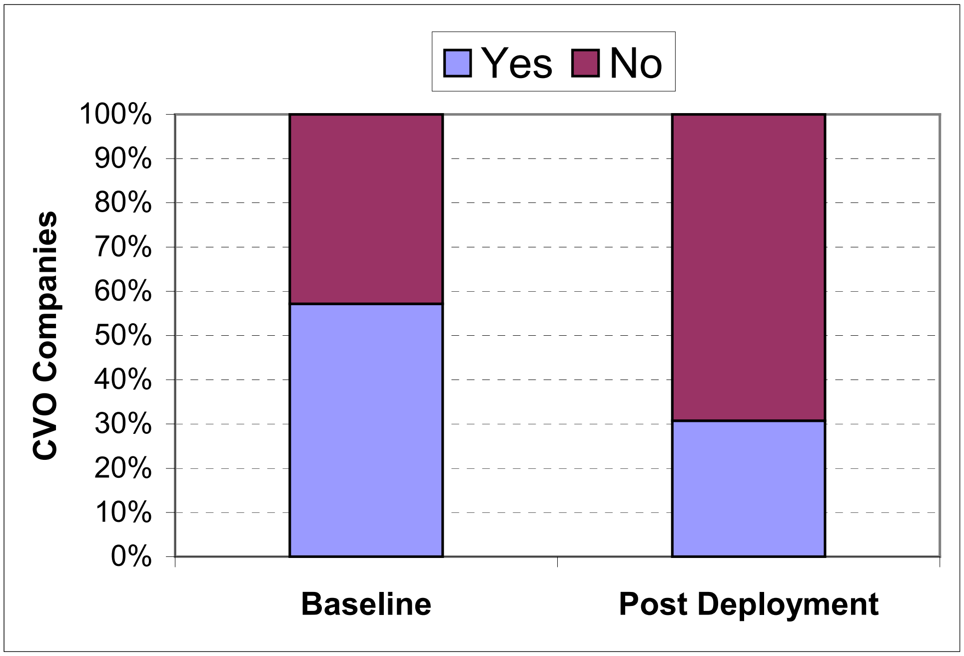


Figure 15. Responses to question, "Do the seasons (winter vs. summer) influence which routes you choose to use in the region?"

Figures 16 and 17 show the availability and frequency of use of various information sources, including both traditional and newer types that have been made available to travelers to aid in pre-trip planning and preparedness, as reported by the CVO survey respondents.

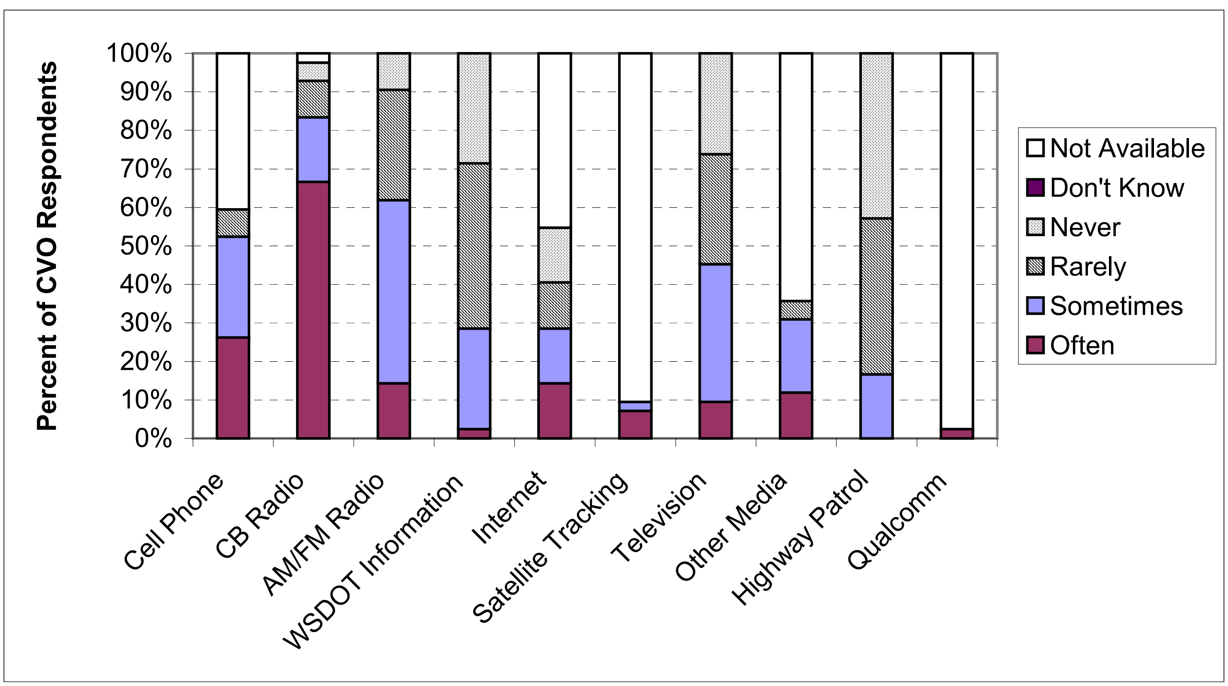


Figure 16. Reported baseline use of various information sources.

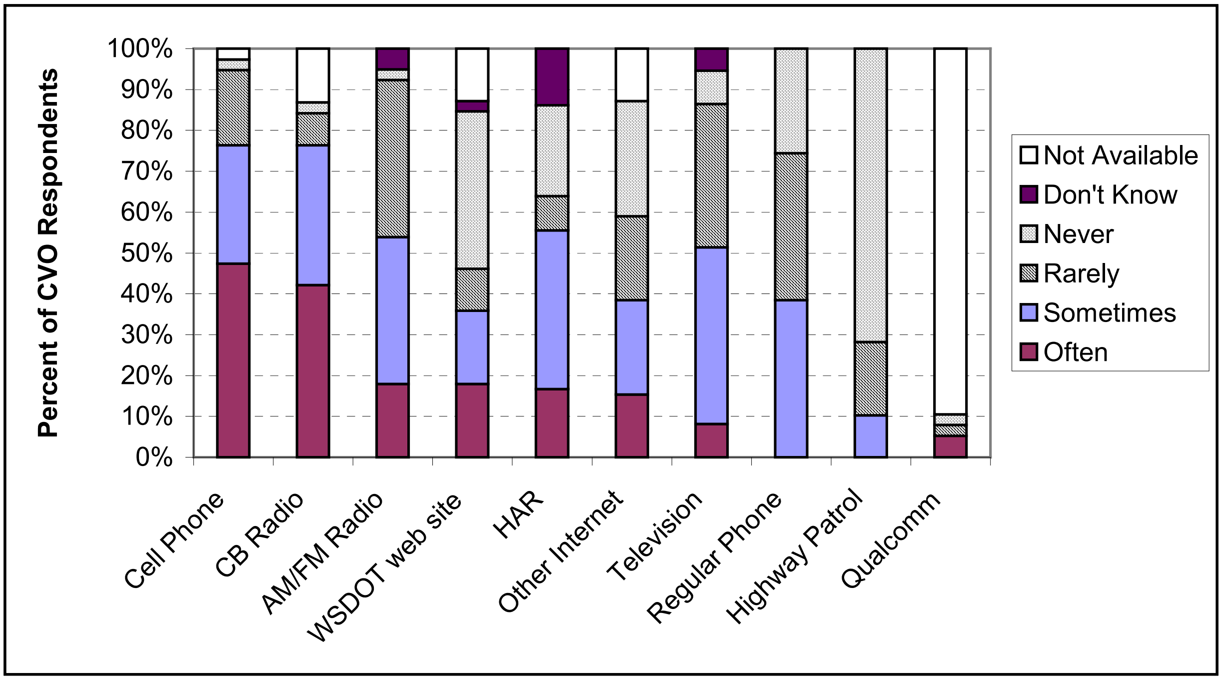


Figure 17. Reported post-deployment use of various information sources.

While there are reported increases in Internet use, and the new HAR broadcasts are being used extensively (22 or 56% of the CVOs report using HAR "sometimes" or "often"), it is evident from Figures 16, 17, and 18 that other sources, particularly those that make use of direct communications approaches, such as CB radios and cell phones, continue to be popular among commercial vehicle operators. In addition, the CVOs seem to rely heavily on the more traditional media broadcasts, particularly regarding more general weather and regional forecasts. The new ITS information sources therefore appear to be supplementing the traditional sources, not replacing them.

The earmark project resulted in enhancements to the information provided over the Internet, and CVOs reported increased availability and use of the Internet. Looking more closely at the changes between baseline and post-deployment in CVO use of the Internet, Figure 19 shows the marked increase in reported Internet availability. The increase in the percentage of companies that never use the Internet to access road weather information may be due to commercial operators who recently acquired Internet access and are therefore inexperienced Internet users. These users would still be learning the range of information available on the Internet and may not yet be aware of the road weather information available on the WSDOT site. In spite of this shift, it is clear from Figure 19 that overall use has increased over this period. Specifically, there is an increase in the percent of CVOs who report using the Internet "sometimes" or "often" from 11 (29%) to 18 (46%). It seems likely that the perceived value of WSDOT's road weather information on the Internet to CVOs may be increasing due to the addition of the new ITS information sources covering the rural areas where their travel is most impacted by adverse weather and where previously Internet-based road weather information was sparse.

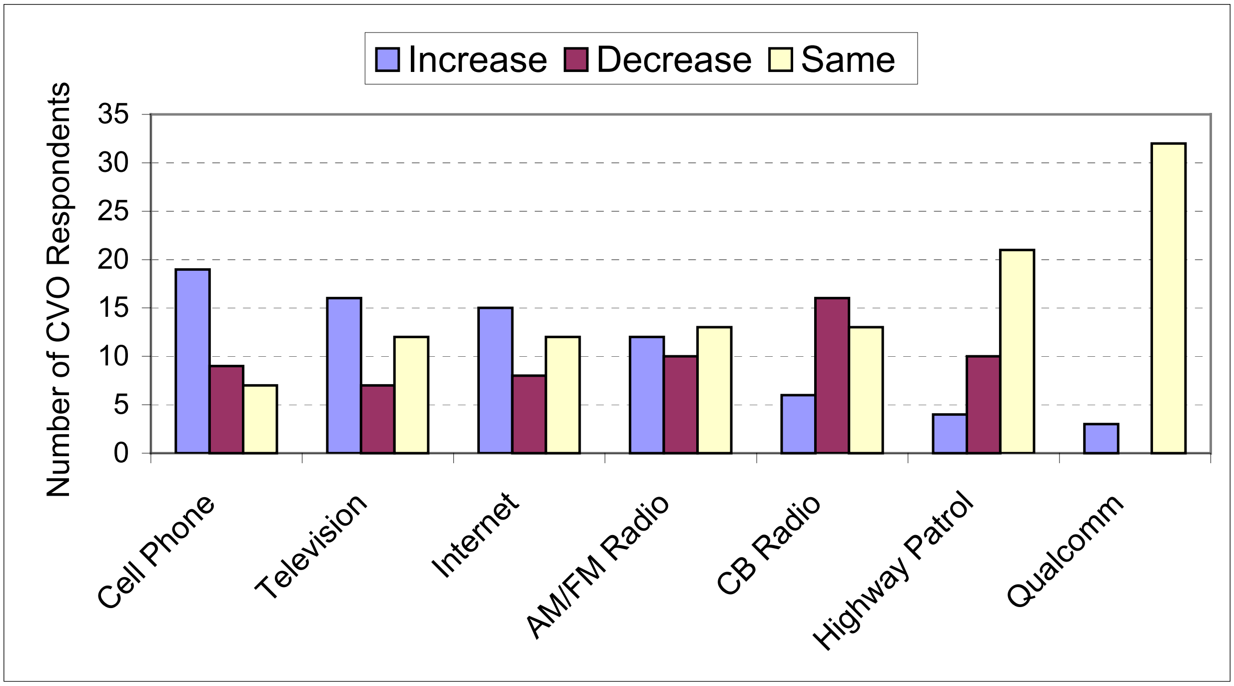


Figure 18. Reported changes in use of the various information sources by 35 individual CVOs between the baseline and post-deployment surveys.

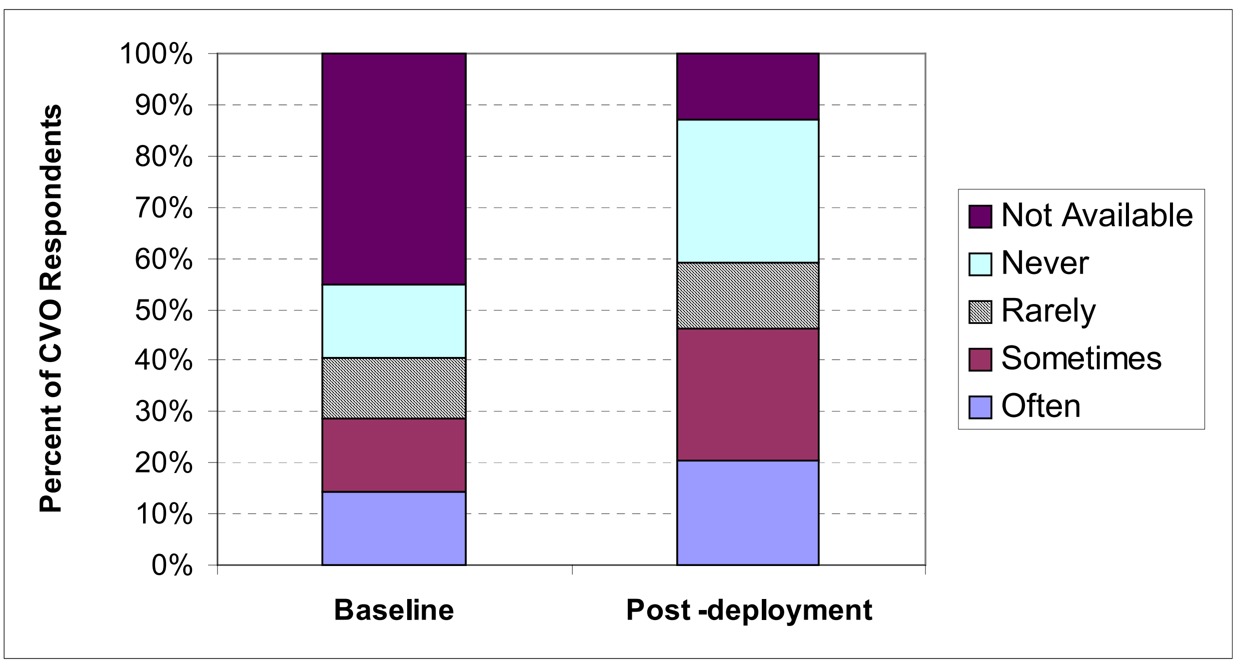


Figure 19. Reported Internet use for obtaining road weather information.

Finally, the use of information from all sources is greater in the post-deployment than in the baseline period. Also, there is a sense from the interview discussions with these commercial vehicle companies that they are more frequently getting the kind of information that they feel they need in the post-deployment phase than they were two years earlier during the baseline time frame. Respondents were generally more positive in the post-deployment survey when asked whether their drivers were getting the kind of information they need for travel in these corridors.

> "Drivers are better prepared and know whether or not they will have to chain up. They can tell customers that they might be late."
> **[Comment by a CVO dispatcher]**

While it was difficult to pinpoint specific safety benefits of the new and enhanced ITS elements through the analysis of the interview data collected, it was apparent from the conversations with the CVO representatives that some safety impacts can be attributed to the expanding availability of road weather information. An interview question asked CVOs to describe ways that the information from either the website or HARs helped them with their travel. Many respondents indicated that they were better prepared with the information at hand, particularly when they expected to encounter inclement conditions. They indicated that they were better prepared for the ensuing delays and able to either depart earlier or notify load recipients of delays. They commented that they were reminded to make certain that trucks were equipped with adequate sets of tire chains and that drivers knew when it was likely that they would need to stop and put them on. They also commented that the preparedness also helped them deal with the stress of driving under hazardous conditions.

> "If I tune in the [HAR] station, I get a good heads up about what's going on up there."
> **[Comment by a truck driver]**

4.3.3 Other Findings

Many of the interviewees commented on the HAR and WSDOT web site and the systems in place to help provide road weather information. Several said that they had not known about the WSDOT web site and camera images, but that from now on they would access and make use of these. This suggests the benefit of promoting the new ITS information services as a way to increase awareness and use, which was the point of one comment by an owner of a concrete business. Another recurring theme in comments during the post-deployment interviews was the appreciation of the camera images. This was accompanied by a desire for more cameras at a variety of additional locations. Often respondents identified specific routes other than U.S. 395 or SR 20 where they would like to have additional information. One comment suggested full motion video for the camera images, which is a capability that WSDOT is already using in their urban applications. Other suggestions included use of a public access television channel and a computer and Internet connection at weigh stations for access to the WSDOT information. One comment indicated that inaccurate information regarding road restrictions obtained via telephone had caused costly and inconvenient backtracking for one truck. Information accuracy is obviously important for building use and trust. Finally, several interviewees suggested establishing links for the WSDOT website to connect to other states' and counties' road restriction information.

> "Well, if there was a camera at Sherman Pass, we would sure use it because we can't ever be sure what's happening up there."
> **[Comment by a concrete business owner]**

5.0 Travel and Mobility for Public Travelers

5.1 Introduction

Motorists use the roadways in the study region for a variety of purposes, including commuting, sightseeing, personal business and recreation. U.S. 395 and SR 20 are also used by travelers entering and exiting the study area. Thus, public travelers may live and actively travel within the study region, may live outside the region and travel to or through the region, or may be seeking information about the region with future travel in mind. Benefits that may accrue to these general travelers are expected to be similar in some respects to the benefits expected for commercial users in this corridor, including:

- Safer travel by helping the driving public anticipate, prepare for, or avoid dangerous road and pass conditions, whether caused by snow, ice, rain, slides, construction, or other road hazards.
- More efficient travel experience by providing drivers with information that helps them make better trip timing and route selection choices.
- Increased comfort and reduced stress for travelers by providing them with more accurate and current information about conditions on the routes they (or friends or family members) plan to travel, or accurate forecasts for trips they are planning to take.

There was only limited road/weather information available to general travelers in this remote region of the state prior to the implementation of this earmark. Accessing that information was often difficult and time consuming, and it seldom resulted in reliable forecasts. The decision to post real-time images from the three new cameras on the WSDOT web site, to provide traveler information and warnings over the mobile HARs, and to enhance data about weather conditions, construction and maintenance activities, and road restriction updates offered traveler information of substantial value for this region essentially for the first time.

Given the paucity of available information of this sort prior to the earmark, baseline data were not collected from general travelers. Instead, after the ITS systems had been in place for a while, an Internet survey was posted on various locations on the WSDOT web site in order to learn how general travelers were responding to the information derived from the new ITS capabilities due to this earmark project.

5.2 Objectives and Approach

The approach to evaluating the response of general travelers to the new ITS-generated road/weather information was to conduct a web-based survey on WSDOT's relevant traveler information and road/weather web pages later in the winter travel season, after the new information sources had been available for several months. This strategy yielded responses from individuals who were aware of and used the Internet to consider and plan their travel in this region. While consideration was given to conducting a general population survey in order to yield a more representative sample of travelers in this study region, such an approach would have been very resource intensive and inconsistent with the scope of this evaluation study. The Internet survey approach was an efficient way to reach a significant number of general travelers who sought information of the sort this earmark was intended to provide.

The anticipated impacts, measures, and hypotheses that guided this component of the evaluation were described in the Evaluation Plan and Test Plan, and they are summarized in Table 6.

Table 6. Evaluation objectives and measures for public travelers.

Objectives and Anticipated Impacts	Evaluation Measures	Hypotheses
Increase safety	- Number of accidents - Perceived safety improvements	- The number of accidents and incidents due to weather and bad road conditions will go down - Drivers report improvements in safety due to ITS
Increase mobility	- Travel time - Travel decisions/behavior - Problems encountered on roads	- Better trip planning leads to more timely, reliable trips - Use of information alters trip decisions/behaviors, leading to enhanced mobility - Ability to avoid weather and hazard problems on roadway increases mobility
Increase satisfaction	- Awareness of information - Use of information - Reported satisfaction	- Drivers are more aware of information availability - Drivers make more use of available information - Drivers' comfort increases and stress associated with potentially dangerous driving situations decreases

A draft of the general traveler Internet survey was developed and reviewed by the WSDOT Project Manager and other WSDOT personnel responsible for traveler information on their web site. The survey (Appendix C) was modified based on comments, and links were placed on selected pages of the web site inviting visitors to those pages to complete the survey.

All of the ITS capabilities that offered information to general travelers, including the two mobile HARs, the three new RWIS-ESS and camera installations, and the web site upgrades, were installed and operational by the fall of 2002. WSDOT considered actively advertising these capabilities to the public, but actual promotional efforts were limited to information on the web site and in an occasional WSDOT newsletter. This decision was in part due to a desire to avoid in any way biasing public response to the on-line evaluation questions. There were at least three months of exposure to the new information prior to implementation of the web survey, and that was judged to be sufficient opportunity to build awareness among travelers in this region. During the evaluation interviews with the commercial vehicle operators, the CVO respondents were informed about the availability of the web survey and told they could respond to the survey if they wanted.

Before the survey was placed on the web, it was carefully reviewed with the project partners, compared with several other Internet-based traveler information surveys previously conducted by the study team, reviewed by in-house questionnaire experts, refined, and pre-tested among a few persons unfamiliar with this study. Survey review criteria included the reasonableness of the length of the survey, a balance between closed and open-ended question types, the order and wording of individual questions, clarity and understandability, and the survey focus in terms of relevance to the test hypotheses shown in Table 6. Once the individual questions were finalized, they were formatted for readability and conversational flow.

Respondents who agreed to fill out the survey are a self-selected sub-group of users, rather than a representative sample of visitors to these web sites. Furthermore, the group of respondents was composed only of those who accessed the Internet, and did not include representation of travelers who may travel in this region but do not have access to the Internet, for whatever reasons. Therefore, the results of this approach do not allow generalization of findings to all travelers in this region. However, the results provide useful feedback on how some users of traveler information use and value the kinds of new capabilities that are being introduced under this earmark program.

5.3 Data Collection Methods

The survey resided on the Battelle server in Columbus, Ohio. A link to the survey was activated transparently when a visitor to a location on the WSDOT web site where a survey banner had been placed clicked on the invitation to take the survey. The banner placement was closely coordinated with and implemented by WSDOT staff in Olympia, WA. The guiding principle was to display the banner only on web pages that provided road/weather information for the northeast sector of the state, north of Spokane, WA, that constituted the evaluation study area. We did not want to inconvenience web users who were not seeking such information in this part of the state. Therefore, banners were placed on the three camera image pages of interest to this study: Loon Lake Summit; Laurier; and Sherman Pass. In addition, the banner was inserted directly above the camera image itself as part of the JPG image. Also, banners were placed on the specific page locations that provided weather station data, travel alerts, and road temperatures for this Northeastern sector. Finally, because web users who accessed the three key camera images by going through the WSDOT Eastern Division homepage were connected to the relevant images in a different way from those entering from WSDOT's main road/weather pages, a separate banner was added for the camera images accessed from that division page.

Interested readers can view these pages by connecting through the URLs shown in Table 7.

Table 7. Web links to study area road/weather information on WSDOT web site.

Web Information Topic	URL Link to the Information
NE weather stations	www.wsdot.wa.gov/traffic/current/l2nebas.htm
NE travel alerts	www.wsdot.wa.gov/traffic/road/construction/l2nebas.cfm
NE road temperatures	www.wsdot.wa.gov/traffic/road/conditions/l2nebas.cfm
Sherman Pass camera	www.wsdot.wa.gov/traffic/camera/dotpages/sherman.htm
Loon Lake camera	www.wsdot.wa.gov/traffic/camera/dotpages/spokanescan.htm
Laurier camera	www.wsdot.wa.gov/traffic/camera/dotpages/laurier.htm

The banners were activated on March 7, 2003, and they were removed a month later on April 7, 2003. The banner link wording was: **Is this information helpful? Share your opinion. Click here.** It was presented as a hyperlink in red text, and when a person clicked on the banner, they were taken directly to the survey. When they completed the survey and submitted their responses, they were returned to the place on the WSDOT web site where they had clicked on the survey link. The data from each submitted survey were automatically logged into an Access database and stored for later analyses.

5.4 *Data Analysis and Findings*

5.4.1 Overall Web Survey Response Patterns

The first step in the data analysis was to check each of the data records and "clean" the data, though this required only a minimal amount of effort because the Internet survey design assured that all responses to the survey would be within specified ranges and other forms of possible response errors were prevented by the question input design. Incomplete surveys were included if they provided responses to the first two questions and most of the responses on the remaining questions. Out of the total of 237 respondents in the final database, 13 were incomplete to some degree, and most of those lacked responses only to questions #6 (opinions) and #7 (open-ended comments).

Approximately half of all the responses (117 out of 237) were received in the first week of the survey. Figure 20 shows the distribution of responses by day for the month-long survey period. The large number of responses early in the survey could be due to several factors. Most obviously, only a few of the individuals visiting these web pages will be inclined to respond to an on-line survey, and once they have responded, fewer are left who will do so later in the survey period. The most frequent visitors are likely to cluster at the front end and respond at the beginning of the survey when they first encounter the survey banner on one of the pages. Another factor influencing the response pattern will be the weather in the region of interest. We know that at the time of the start of this survey, a major winter storm was making its way across Puget Sound and heading east across the state. We subsequently learned from WSDOT that the number of individuals seeking traveler information on the WSDOT web site was so great beginning about March 5, 2003 that the site could not handle the volume and crashed.

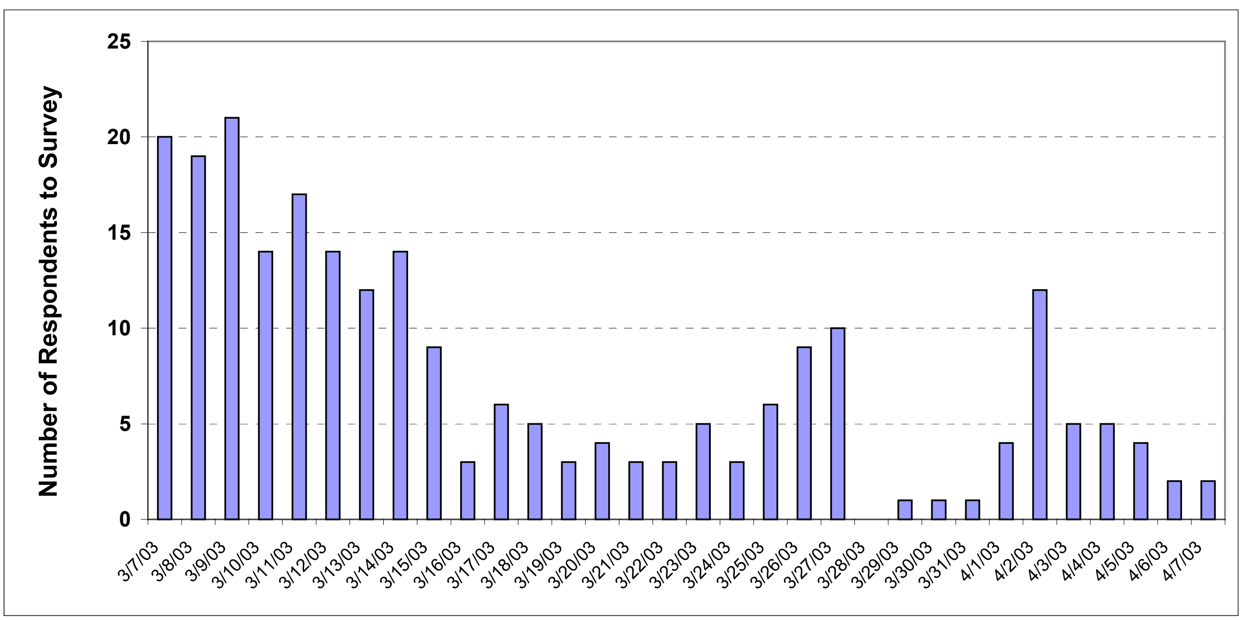


Figure 20. Number of persons completing web survey by day: March 7 to April 7, 2003.

Figure 21 illustrates the level of user activity on the WSDOT web site for pages that offer information about road/weather conditions in the Northeastern section of the State of

Washington. The figure overlays daily snowfall data with the number of page views for Sherman Pass accessed by web site visitors during the period of the evaluation survey.

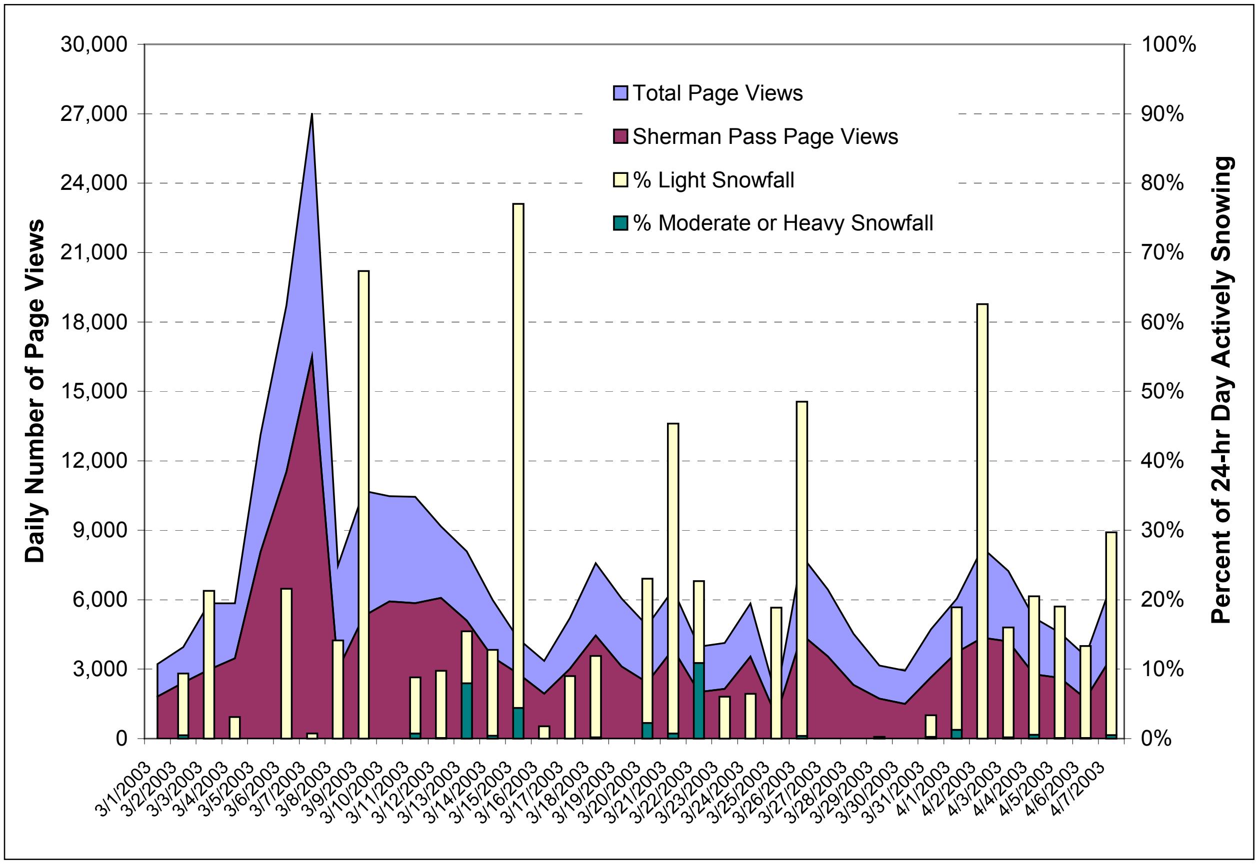


Figure 21. Number of page views accessed per day from March 1, 2003 to April 7, 2003 on WSDOT's web site to obtain road/weather information for Northeast Washington State, plus the extent of snow precipitation recorded for those days at Sherman Pass.

The period of time covered by the chart is from March 1, 2003 to April 7, 2003, six days longer than the actual survey period. Figure 21 shows daily snow precipitation, intensity of snow fall, on Sherman Pass during this period of time.[6] Eleven separate URLs were included in the calculation of number of page views per day accessed by users of the WSDOT web site for information in this region of the state. The period covered in Figure 21 essentially coincides with the on-line survey period shown in Figure 3, except that data for the six days prior to the start of the survey are provided to help interpret the large spike in user activity that occurred on March 7, 2003, the first day of the survey.

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[6] The precipitation data are derived from the new RWIS station located at the summit of Sherman Pass, as compiled by the Office of Information Technology, WA State DOT, Olympia, WA. In this instance the data reflect the portion of each 24 hour day that was recorded as light, moderate or heavy snow fall. Precipitation data were measured approximately every 2 to 10 minutes at the RWIS station, though there were gaps when no data were recorded. These data were converted to intervals (minutes since the last recording) and the type and intensity of precipitation were attributed to each corresponding interval. The large gaps were removed from the database. Then the intervals with snow were summed and the percent time snowing was calculated.

The page view data were analyzed using a special account provided by WSDOT to access their Internet activity database using the proprietary software called DigiMine.[7] The pages of interest included camera images from Sherman Pass, Loon Lake and Laurier, the NE weather stations, the NE travel alert page, the NE road temperatures page, and the actual jpg images from the camera shots. These data provide an informative background against which to interpret the survey responses.

As a general matter, it is evident from Figure 21 that the snowiest days (on Sherman Pass) tend to coincide with the peak page view activity on the WSDOT site, supporting the hypothesis that people will be motivated to access the web site for road/weather information when winter weather appears to present a driving hazard so they can better plan their trips, especially with regard to timing and routes. The interpretation of the large peak on March 7, 2003 is a matter of some speculation however. The winter storm that was moving across the state beginning on March 4, 2003 turned out to largely miss Sherman Pass in the northeast corner of the state, and relatively little snow fell on the pass due to that storm event. The heavy use of these NE road/weather pages on these days was likely by users who were concerned with their trip plans, even though heavy snow fall on Sherman Pass did not materialize. In addition to the snow-day effect is the higher web site usage on weekdays, presumably reflecting heavier business travel on those days.

5.4.2 Web Survey Results

The web survey began by asking the respondent to estimate how many times they had visited the WSDOT web site "to get road condition or weather information since December 1, 2002," which covered about a four month period during the 2002-2003 winter travel months. The responses are shown in Figure 22. About 93% of the respondents are relatively frequent users of information on this part of the web site. This is not surprising, as the respondents are a self-selected sample of all users of the site, and frequent users are more likely to have encountered the survey banner, as well as more likely to have opinions about the web site that they would like to share with WSDOT. In their

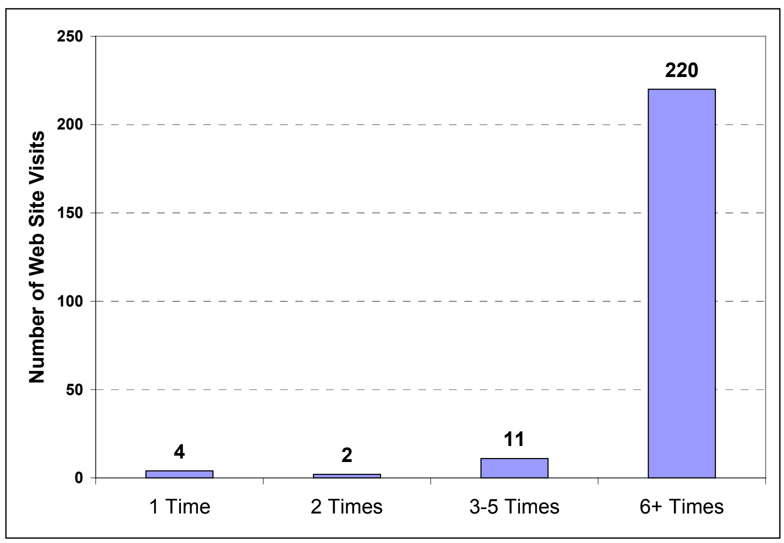

Figure 22. Number of times visited web site for road weather information since December 1, 2002.

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[7] One page view is recorded when a visitor to the web site clicks on one page. A single user may generate several page views in a single web site visit. It is difficult to accurately measure the number of visits (sometimes refered to as "user sessions"); nevertheless, the DigiMine software estimates both visits and unique visitors. The page view data shown in Figure 21 reflect a range of "visits" that average about 58% of the number of page views over this period, suggesting that each visitor viewed approximately 2 pages per visit, or a daily average of about 3,400 visits to these 11 web pages (not counting the unusual spike).

comments at the end of the survey, several respondents indicated they visit the site daily. An employee of the Colville WSP reported using the site more than *6 times a day*. Only four respondents indicated that this was their first visit to the web site. The strongly skewed data (i.e., most responses concentrated in the highest category) means that this variable will not be useful in helping to explain variation in the rest of the data about reasons for using the web site, types of trips taken, and benefits from information derived at the site. On the other hand, suggestions for changes in or improvements to the site will have particular value as they are coming from experienced users for whom this information is presumably important and needed frequently.

The next question asked respondents to estimate "How many road trips have you made using SR 395[8] or SR 20 in the North East portion of Washington State, in the area between Spokane and the Canadian border and east of Republic since December 1, 2002?" The presumption is that respondents who are making frequent trips will value the road/weather information more than those making fewer trips, or than those who are not traveling in the region. Figure 23 shows the distribution of respondents by their frequency of travel in the region. More than a third of the respondents (39%) report not having made any trips during this four-month period. These respondents were skipped ahead in the survey to the opinion questions.

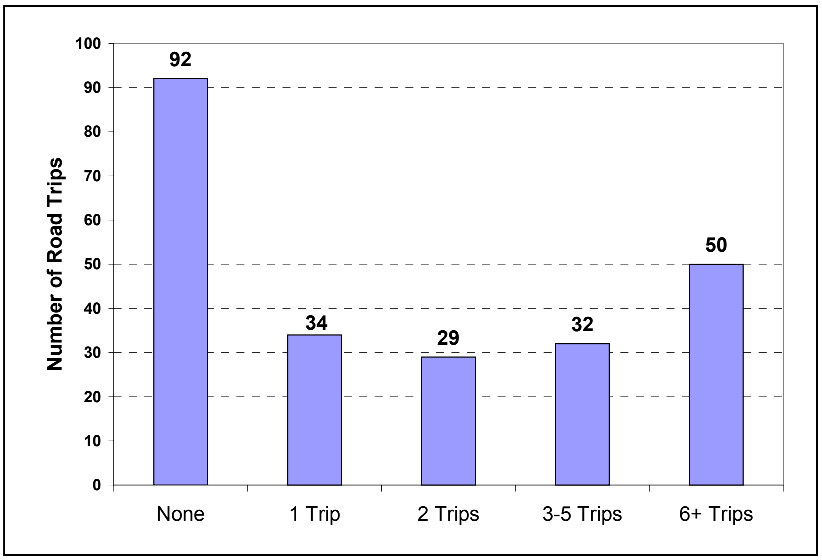


Figure 23. Number of road trips in study region since December 1, 2002.

It is of interest to note that there are a lot of people looking for road/weather information who are not currently traveling in the area. In fact, many of these non-travelers are from out of state and are presumably looking at these web pages out of curiosity, because they are interested in viewing the camera images, or because they have family or friends living or traveling in this region.

Respondents who said they made one or more trips in this winter season were next asked to indicate their primary and secondary reasons for using the web site for trips in this region of the state. Figure 24 shows the results in order from the most to the fewest number of respondents indicating their primary reason.

[8] This is how the question was worded. While SR 395 is not an incorrect usage, the more appropriate identification of the north-south route through the study region is U.S. 395, which is used as the reference throughout this report.

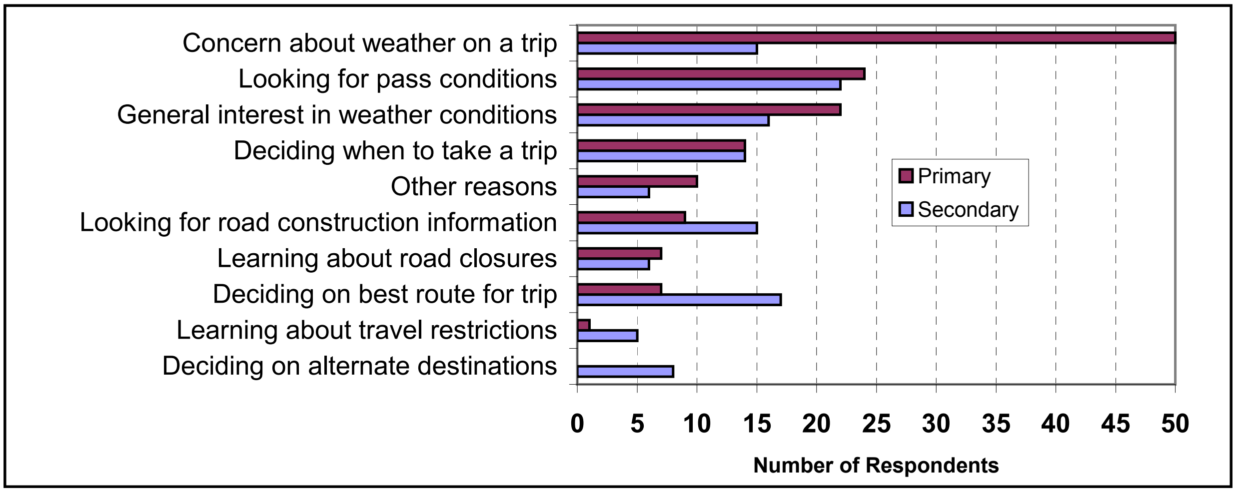


Figure 24. Primary and secondary reasons for using web site for trips in region.

Concern about weather conditions on trips that the respondent is planning to take is the number one reason for using the web site by a wide margin. The next two primary reasons are to look for mountain pass conditions and to satisfy general interest in weather conditions but not associated with any particular trip. Trip timing and route selection information are important benefits for many travelers using the web site, though twice as many said they use the site for trip timing than for selecting a route. Looking further into these data indicates that the frequent travelers (6+ trips) are more likely to use weather information for trip planning and much less likely to use the site for trip timing or due to general interest in weather information compared with infrequent travelers (those reporting only 1-2 trips).

As shown in Figure 25, respondents use the site for a variety of different reasons, including preparing for their own personal travel, managing commercial fleet trips in the region, tracking conditions for friends or relatives who live and travel in the region, or simply enjoying seeing what various parts of the state look like in the camera images. We asked all respondents to the web survey who said they had made one or more trips in the region in the winter of 2002-2003 (145 persons) to indicate all the different kinds of trips they had made, as well as the most frequent type of trip for which they use this web site.

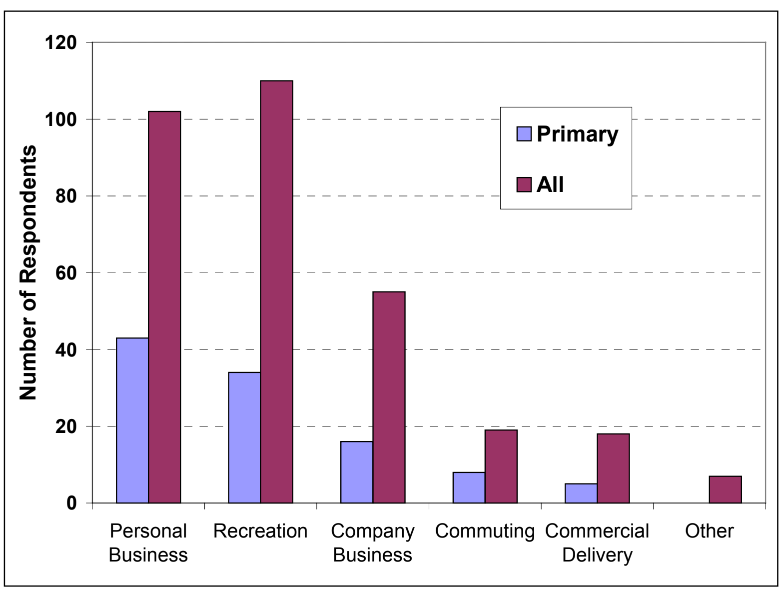


Figure 25. Types of trips: all that apply and most frequent type.

Overall, respondents said they used the web site most for planning recreational trips in the region. Personal business was also frequently cited, and it was the trip type that was the most frequent single reason for accessing road/weather information on the web site. There is very little commuting activity in this part of the state anyway. Also, with this web survey we were primarily interested in responses related to personal as opposed to commercial travel. Most of those who indicated commercial or company business as one of their trip types for which they accessed information on the web site also listed personal trip types (84%). As is evident from the data shown in Figure 25, most users of the web site use the information for more than one kind of trip; the average is 2.1 trip types per respondent. Thus, the road/weather information is benefiting many different travelers, and many others who are not actively traveling in the region at the time they are accessing the information, for a variety of trips.

> "This and other functions which you make available on the net are an invaluable source of information. Not just for my personal road trips around all of the state, but in my work as a dispatcher for a … courier company. Thank you for your service."
> **[Comment by a web user]**

The next question asked respondents to rate their use of the various road/weather information aspects of the web site in terms of each element's usefulness for those elements they reported using. If they said they had not used a particular element of the web site, they were asked to indicate whether or not they were aware of the availability of that capability on the web site.

Figure 26 shows the number of respondents who reported using each of seven different attributes, or information services, available on the site. Each of these services has been supplemented or enhanced by the ITS deployments that are the subject of this evaluation in the northeastern region of Washington State. They include pass reports, current weather conditions, camera images, road surface temperatures, weather warnings and weather forecasts, and construction updates.

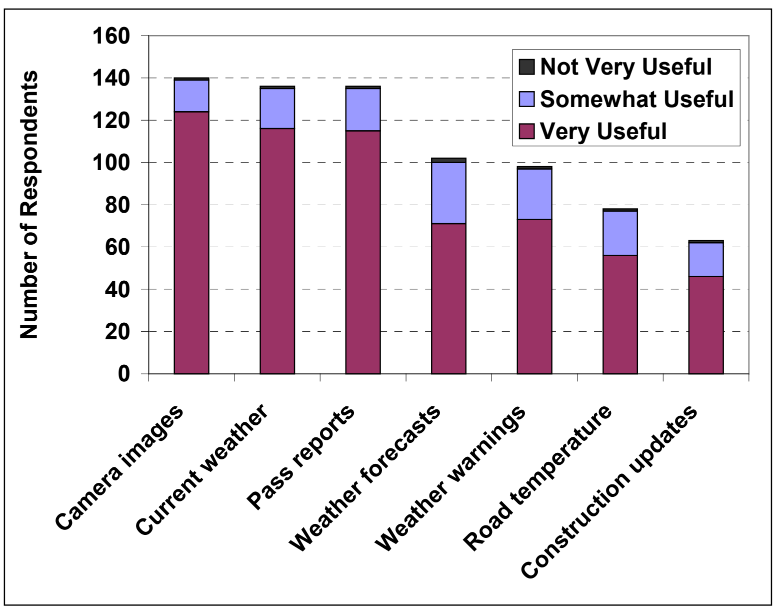


Figure 26. Use of various types of road weather information available on the WSDOT web site.

Figure 26 indicates that camera images, current weather information, and pass reports were used by the majority (between 94% and 99%) of these respondents. There was less reported use of weather forecasts (75%), weather warnings from the National Weather Service (70%), road surface temperature (56%), and road construction updates (46%).

For those who reported using each of these different information services on the web site, we asked them to rate the usefulness of each as "very useful", "somewhat useful", or "not very useful." Figure 26 also shows the split on rated usefulness for each of the seven web services. The majority of users of each of these web information service types found the information to be "very useful." Only a very few respondents rated any of these services as "not very useful."

Those respondents who said they didn't use one or more of these services were asked whether they were aware that the service was available on the WSDOT web site. Traveler awareness of the availability of road/weather information, and particularly the newer ITS capabilities, is a necessary precursor to use and benefit. While it is clear that this self-selected sample of web users implies a certain level of awareness to start with, we expect that all users will not be aware of all the road/weather information, because some are infrequent users, because some of the web site capabilities are relatively new, because individuals' needs are likely to be limited, and because all the information is not available at one location on the site. In this instance, we wanted to understand if lack of use was a reflection of lack of awareness, as opposed to a lack of need. Lack of awareness carries implications regarding steps the WSDOT might want to consider in terms of promoting the full range of road/weather information services.

> Use of a wider array of road/weather information could be increased by more actively promoting these kinds of information resources on the web. **[Survey finding]**

Figure 27 shows the number of respondents who reported that they don't use each of the web information services. This is the reciprocal of the numbers of users shown in Figure 26. The level of awareness of each service varies considerably among all the non-users of that service. For example, Figure 27 shows that road construction information is the least used (i.e., most non-users) of the seven services covered in this survey by the respondents, with 73 saying they had not used that information during the recent winter driving season in the study region. The most used information service is the camera images, with only 2 respondents saying they didn't access camera images, in this case most likely because both respondents said they were not aware of them. Overall, non use was highest for construction, road temperature, weather warnings and weather forecasts, in that order. Even though more than half of the respondents knew about the construction information, they didn't access or use it. But less than one-quarter of the respondents who said they didn't use road temperature, weather warnings or weather forecasts reported being aware of these information sources on the web. One conclusion is that use of a wider array of road/weather information could be increased by more actively promoting these kinds of information on the web, or making them easier to access.

> "I rely heavily on this web site for the information I need to have a safe trip. This site is extremely important to me, and I am very thankful my tax dollars support such a useful and informative tool." **[Comment by a web user]**

> "The weather changes 20 miles up the road from where the camera is placed at Loon Lake summit. Are there plans to have more cameras on U.S. 395?" **[Comment by a web user]**

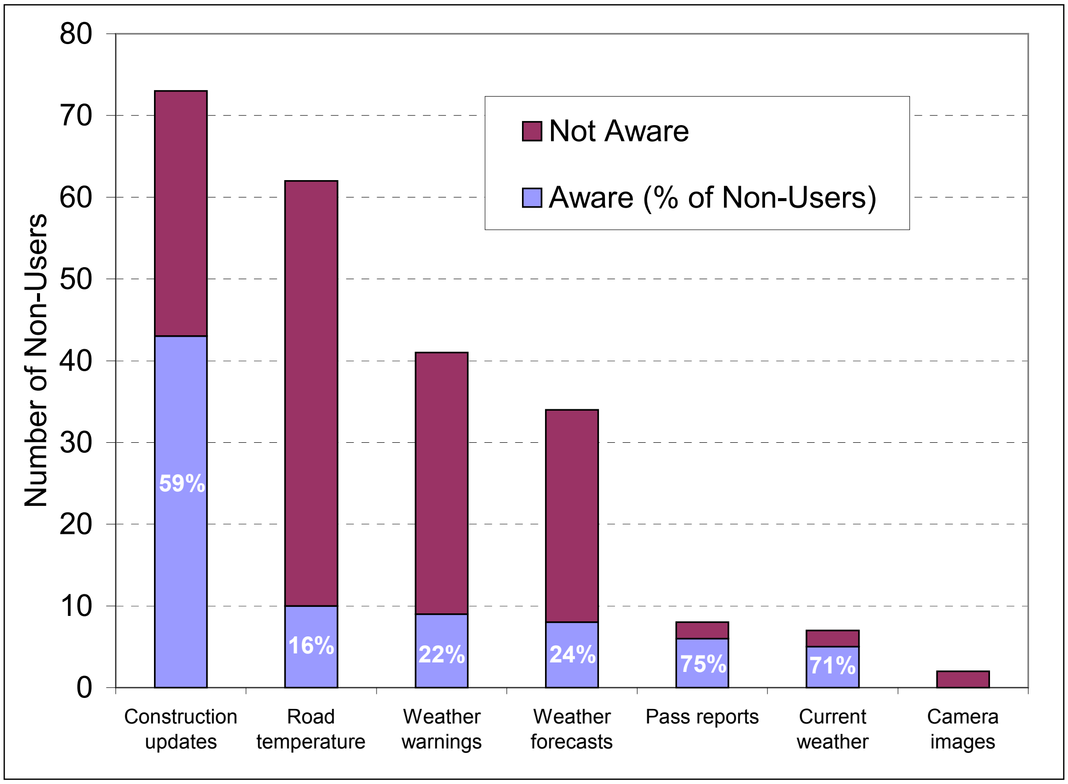
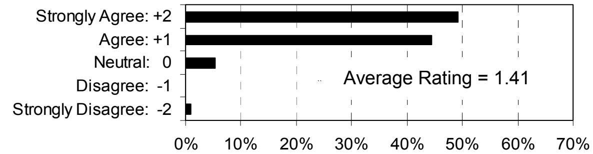


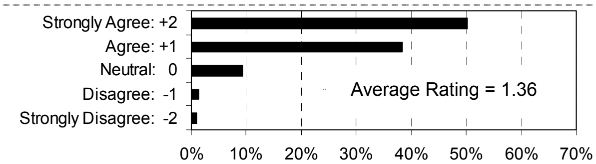
Figure 27. Number of respondents who report not using each web information service, numbers aware and not aware of the service, and percent of non-users who are aware of the service.

Respondents were next asked to report their level of agreement or disagreement with ten opinion questions in order to assess their perception of various benefits that they might derive from their use of the web site. Responses to these questions are shown in Figure 28. Respondent opinions were ranked on a five-point scale, ranging from Strongly Agree with a value of +2 to Strongly Disagree with a value of -2. Figure 28 presents the percent of responses in each agreement category and an average rating, which ranges from -2 to +2, reflecting the strength of agreement. The ten questions are ranked in Figure 28 in order from most to least agreement, based on the average rating across all respondents to each question.

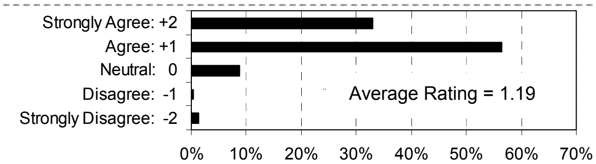
I feel that my use of this site makes me better prepared for weather conditions when I travel.



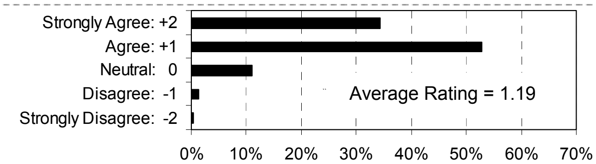
I feel that my use of this site makes my trips safer.



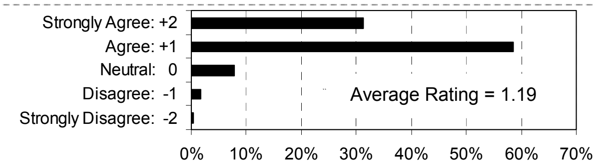
I feel confident about the accuracy of information on current conditions.



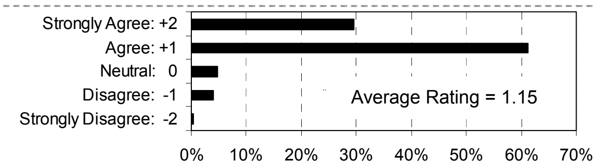
The information I get from this site makes me feel much more comfortable on my trips.



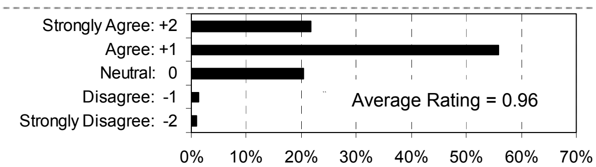
The site is well organized.



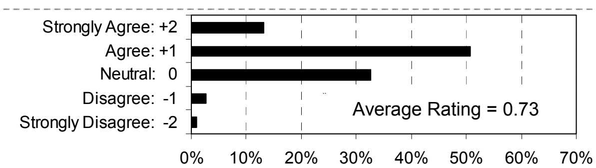
It is easy to find the information I am looking for.



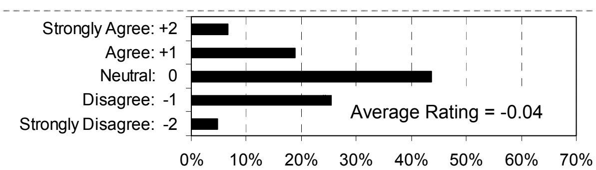
The information I get from this site helps me avoid travel delays.



I feel confident about the accuracy of the information on forecast conditions.



There is important information I need that I can't get at this site that I think should be made available here.



I tend not to use some of the information on this site because it takes too long to access.

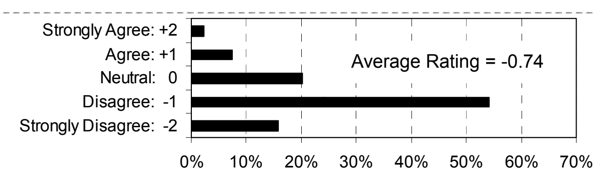


Figure 28. WSDOT web site respondents' attitudes and opinions.

Agreement was highest (94% agree or strongly agree) that the web site road weather information makes travelers better prepared for their trips. Respondents value the safety benefits, accuracy of current information, and the level of comfort afforded by the information. They also feel positively about the way the information is presented on the web site, in terms of its organization and ease of finding what they are looking for. Very few respondents agree or strongly agree (10% total) that the information takes them too long to access on the site to be useful. Over half the respondents (56%) agree that the information helps them avoid travel delays, but only 22% strongly agree with that and 20% are undecided. Confidence in the accuracy of information about *forecast* road/weather conditions is lower, as expected, compared with confidence in the accuracy of information about *current* conditions. There is greater disagreement among respondents about whether they can get the information they need at this site than with any of the other questions. Most are neutral (44%), while 26% agree and 31% disagree. An examination of their responses to the last question, asking them to indicate how the site could be improved, yields some insight into this diversity of responses. The data indicate that recreational travelers are more likely than any of the other types of travelers (commercial, personal business, commuting) to say they think information is missing from the site that they need or would like to have.

Loon Lake RWIS-ESS and camera on U.S. 395.

Finally, respondents were asked to "indicate, in your own words, how this web site could be improved to better meet your needs." Two-thirds of the respondents offered comments, some of which were general positive reactions without any specific suggestions to make. About 45% of the respondents (107 out of the 237 respondents) had specific suggestions for improvements, and one-third did not offer any comments. The overwhelmingly positive reaction to the improvements in the web site, which are due in large measure to the new ITS

"The camera on Sherman Pass has been out of order frequently. I think that a back up camera would be of help or another camera facing the opposite direction."
[Comment by a web user]

capabilities provided by this earmark project, document the high level of customer satisfaction among general travelers in the study region, as well as state wide.

Because most of the respondents were recruited to take the survey when they visited one or more of the three camera pages on the web site for this study region, there was substantial interest in the cameras and how they could be improved. Some respondents wanted to have access on the web site to additional kinds of road/weather information, and others offered suggestions for modifications to the web site design and presentation of information that they thought would be helpful to themselves and other travelers. Because respondents were viewing the web site from all across Washington State and even out of state, many suggestions were directed to improvements other than just to the road/weather information capabilities of the study region. Table 8 provides a brief summary of the range of suggestions for how the web site could be improved. Virtually every respondent who made a comment or suggestion prefaced the comment by saying how pleased they were with the efforts of WSDOT to provide such useful current road/weather condition information and how helpful that information was to them. Many were unable to think of any way the site could be improved because they said it served their needs well as is. Thus, the suggestions presented in Table 8 reflect satisfied customers who are trying to offer constructive ideas for making further marginal improvements to an already very good, useful web site. A few illustrative direct quotes from the set of comments are displayed in boxes in this report to give a more direct flavor of web site user reactions.

The WSDOT camera images are the most valued way of providing road/weather information on the WSDOT web site. **[Survey finding]**

Table 8. Respondent comments and suggestions for WSDOT road weather web site improvements.

Category of Comment/Suggestion	Number of Respondents
Cameras	
● Add additional cameras (10 requests for the SR 20/U.S. 395 area)	43
-- Keller (Hwy 21)	
-- Wauconda Pass (Hwy 20)	
-- Hwy 231)	
-- Boulder Pass	
-- SR20 from Tiger to Colville	
-- Pend Oreille river valley to Canadian border	
-- Frater Lake	
-- Chewelah	
-- Flowering Trail road	
● Decrease the “down time” on the camera images	17
● Aim or position cameras differently; indicate orientation	7
● Refresh camera images more often	5
● Provide lighting to allow night time viewing	4
● Provide mobile cameras for construction or problem sites	3
● Provide video clip in addition to snap shot images	3
● Add camera to existing location to show both directions (e.g. Sherman Pass	2
● Trim trees at Sherman Pass for better road views	2
● Other (show camera orientation; protect lens from weather)	2
Road Weather Information (other than camera images)	
● Indicate snow depth (measuring device visible from cameras)	8
● Indicate the elevation at various locations	4
● Indicate wind speed and direction	3
● Indicate sky conditions (clear, overcast, rain clouds)	2
● Other (black ice on road; river ferry service)	2
Web Site Design	
● Provide weather information along with the camera images	9
● Maintain currency of information (avoid old or inaccurate data)	3
● Provide larger maps or extra pages to avoid icon crowding and improve access	3
● Decrease image download times (not for this study area)	2
● Customize “my conditions” capability for frequent users	1
● Other (printable weather forecasts; access historical data; dynamic trip planner with estimated trip time at current conditions; better integrate information for long distance trip planning; access to “next” camera image)	5

6.0 System Performance

Another important aspect of the evaluation was how well the equipment performed, information was accessed, and integration issues were handled. This is important to document because if the systems had difficulties that prevented access or reduced the accuracy of the information being provided, this would severely impact the usefulness of the information. This chapter reports on what was learned regarding the performance of the equipment and related systems included in this project, including the RWIS stations, CCTV images, highway advisory radios, communication systems, information access issues, and TMC integration. The sources of this portion of the evaluation included TMC logs, RWIS data, and stakeholder interviews.

6.1 RWIS-ESS

The RWIS-ESS provided and commissioned by Surface Systems, Inc. included the tower, atmospheric and pavement sensors, computer processing equipment, and power supplies (excluding communications equipment and CCTV images discussed later). The Sherman and Laurier sites were completely new for the 2002-2003 winter, the Loon Lake site was upgraded with a camera during the deployment. The three RWIS-ESS located at Loon Lake, Sherman Pass, and Laurier performed well with no known system failures or outages occurring at the Loon Lake or Laurier sites. The pavement sensor cable at Sherman Pass was cut by a snowplow blade during the winter and was repaired quickly. It should be noted that the accuracy of the sensor readings were assumed to be within accepted tolerances and were not the focus of the evaluation.

A statistical analysis of the post-deployment evaluation period data from the Sherman Pass RWIS-ESS (December 1 through March 30) indicated that 598 (3%) of the total recorded observations occurred at greater intervals than 23 minutes. If the assumption is made of a twenty minute polling period, it appears on the surface that the majority of observations fall within what could be considered acceptable tolerances (96.8% reliable). However, the periods without observations reported accounted for 24% of the total observation time. Because of known communication problems using cellular phones, it is unknown whether the outages were due to the RWIS-ESS, communications, or failures of both. From an operational viewpoint, being blind to the conditions for nearly a quarter of the time is far below acceptable performance.

One of the questions on the Event Log specifically inquired of the maintenance crews whether the RWIS was working during the event in question. Expansion on this question during the follow-up interviews revealed problems with access to the RWIS information from the workstations at the maintenance sheds. The comments provided by the individual maintenance personnel during the interviews described slow Internet connections, troublesome security procedures (multiple log-in screens), and delay in computer support due to long distances separating the sheds from support staff in Spokane.

Installation of satellite Internet connectivity was expected to solve many of the access problems but instead proved troublesome. The complex path from the shed to the WSDOT server combined with poor dish orientation and size seemed to result in even slower connections especially during periods of storms. Once the dish at Orient was moved near the end of March 2003, access during clear weather was much faster. However, snow build-up, narrow horizon window, and heavy precipitation adversely impacted signal and system performance at the Republic Shed. Prior to the use of the satellite connection, dial-up accesses was direct to the WSDOT server, which is the only way to access the RWIS data in its entirety (pavement and weather data) through the SCANWEB interface. Initial setup of the satellite access gave the sheds access to only the public WSDOT Internet web site with only atmospheric information and no pavement information from the RWIS-ESS. Simple but numerous difficulties of this sort experienced by maintenance personnel generated frustration and reluctance to use the new technologies.

An incident worth noting was a tree that fell on the Sherman Pass site following the winter data collection period that damaged some of the environmental sensors (not the tower). The RWIS station was taken off line and powered down while repairs were made. No evaluation-related data were lost due to this incident, because it happened following the expected data collection time period.

6.2 CCTV Images

CCTV cameras were installed at all three RWIS stations. The Loon Lake camera faced north on U.S. 395 clearly showing all lanes of the roadway. The Laurier camera also faced north on U.S. 395 showing all lanes of traffic and the border crossing into Canada. The Sherman Pass camera faced east onto SR 20 from atop the summit. Depth of field is an issue for camera image usefulness as it relates to the distance from the road of the RWIS-ESS installation. The Sherman Pass camera could have used a higher magnification lens to view the roadway more clearly. One was investigated, but a workable solution was not found for this winter season.

The cameras all worked well and stayed clean and free of debris enough to provide images that were clear and useful to maintenance personnel and other users. A regular comment by maintenance forces was they would like some lighting at the sites so that nighttime images are useful. About half the time the winter maintenance operations are conducted in the dark of night.

6.3 Highway Advisory Radios (HAR)

There were two mobile HARs deployed under the project that provided road conditions and restrictions on Sherman Pass. This was the best way to get up-to-date information to travelers en-route regarding this often problematic mountainous corridor. The HARs experienced several performance issues that prevented them from working as envisioned. Each of these problems have been addressed by the WSDOT personnel and it is expected that they will perform as originally designed this coming winter.

The primary cause of the problems was characterized as trying to use the HARs in a way that was not originally envisioned. It was thought that the HARs would only be used periodically during the winter season when a severe condition existed. Instead, they were used continuously to provide pass conditions to motorists. This caused problems with the operation of the HAR that resulted in significant amount of downtime. It was estimated by the crews that were assigned to maintain them, that the HARs and their supporting signs and flashers were up and running only approximately 50% of the winter season (about a third of the time during the early winter period and 95% of the time after the problems were resolved by mid-January). The primary reasons for this, and the resolutions instituted, are as follows:

Solar Power Approach. Because the HARs were only planned to be used periodically, they were designed to run on solar power. Because they were used essentially continuously, and due to the large percentage of winter months with cloud cover in this region, the solar panels originally designed were not able to power the units. It was determined that a solar panel large enough to provide for the power need would be too large to be practical. It was decided that permanent power would be required and has been installed at both HAR sites. The HARs were used successfully during the summer prior in nearly continuous operation however fair weather and long days masked the problem that developed during the winter deployment.

Battery Power. The systems used batteries and the solar power charged the batteries. When the solar power source could not keep up with the demand, the batteries were drained below their ability to be recharged and needed to be replaced. Batteries were replaced and with permanent power, the system is now working properly.

Flashers. One of the primary problems with the system were the flashers on the permanent HAR advisory signs located near the Kettle Falls HAR. The flashers were supposed to be on when there was a message. Due to the power supply issues described above, the flashers were not working for much of the winter season. Although there were messages on the HAR, travelers may or may not have tuned in because their was no indication to do so (through the use of the flashers and signs). Again, these issues have been resolved with permanent power. A key issue is the fact there is no feedback mechanism to allow for confirmation of the flasher operation.

Mechanical Issues. The DCP2000 controller (Kettle Falls) was damaged by water entering the conduit in the system. Pager units that turned on the flashers were returned to the manufacturer to be reinitialized when the communication signal was lost. A relay failure and loose electrical connections proved problematic until they were addressed. Each of these system failures were dealt with as quickly as possible during the winter and resolved accordingly. The HAR systems are operating properly now.

Communications. The cell and pager communications in the area was not reliable resulting in operators having to make several attempts to activate or change messages/signs. The HARs are still going to be operated with this method, however they are considering other solutions such as hard-wire phone connections. There is also no feedback mechanism on the HARs allowing for confirmation of proper operation. This is addressed in newer models of HARs.

These system failures and other problems resulted in approximately 10 trips from Spokane to either Kettle Falls or Republic, numerous labor hours, and some equipment costs to perform the necessary maintenance on the HARs units. Exact and total costs are not known.

WSDOT personnel are committed to using the HARs this coming winter and believe they have addressed the issues that plagued the system this past winter. New locations for the HARs will ensure reliable commercial power and two new signs are going in place near Kettle Falls to help notify travelers of the HAR messages. The lessons learned through the system operation this past winter will help to improve the up-time of the system in future years. The HARs are being used by WSDOT this summer in other locations in the Eastern Region to support other traffic control and traveler information around problem areas or construction projects.

6.4 Communication Systems

Communication is an essential component of ITS. In general, the communications performed well (see HAR discussion above). However, there were some communication problems with the RWIS station atop Sherman Pass. Cell phones were used to convey the RWIS-ESS data and CCTV images. Because of the cost of connect time, the frequency of information downloads was less than the other sites that had the advantage of hard-wire phone connections.

As a result of infrequent and sometimes inconsistent communication with the Sherman Pass RWIS-ESS, associated web information and camera image were often either not current or indicated that the camera was out of service. The camera actually was operating properly; however since the image was not current, the Internet page was set not to display the image. For future winters, WSDOT is considering changing the system defaults to display an image at Sherman Pass more often, taking into account the communication issues.

6.5 Information Access Issues

Access to the information in a timely manner is critical to achieving the goal of more informed decision-making. The project data was accessible through the Internet only and good, consistent Internet access was essential to retrieving desired information. Our user group (for the purposes of this evaluation) included the WSDOT Eastern Region Maintenance personnel in the study area, commercial vehicle operators, and the general motorist. The evaluation only collected data related to information access from the maintenance personnel. We are not aware of any significant information access problems with the other groups.

The maintenance personnel suffered from lack of consistent and meaningful Internet access at the maintenance sheds. WSDOT was in the process of changing their access from RAS dial up of the WSDOT server to satellite Internet connection during the evaluation period. Because of firewall and configuration issues, the maintenance personnel lost access to the RWIS specific software (ScanWeb) and valuable other information. Many other problems were experienced with the satellite connection; lack of adequate horizon clearance, poor signal on bad weather days, and snow accumulation during weather events. Enhancements to the communications approach that were expected to improve Internet access, particularly the switch to satellite communications, initially resulted in slow, intermittent, and inconsistent access. We believe this had a significant impact on the use of the RWIS data by some maintenance personnel during critical winter events. These issues have now been addressed, and future access should be improved for the upcoming winter.

6.6 TMC Integration

The Spokane Regional Traffic Management Center was used to collect and disseminate the information. Their staff also controlled the messages on the HARs and monitored data being provided by the RWIS-ESS and cameras. They were responsible for logging the operations and identifying any maintenance issues. The logs received from the TMC were extremely helpful to the evaluators to better understand the day-to-day operations of the systems and identify any problems that arose.

In general, this approach worked well, and future operations of the U.S. 395 winter weather and road condition information will continue to be handled by the Spokane TMC. The TMC has installed a T1 high speed communication line, and beginning in the fall of 2003, they will be operating 24 hours a day, 7 days a week. This will enhance the overall traffic and road condition information in the region.

As might be expected within an organization implementing any new technology, communication breakdowns occurred between the WSDOT maintenance personnel and TMC operators regarding use of the HAR and corresponding messages on some occasions early in the winter. These were largely institutional as opposed to technical problems that were smoothed out as more experience was gained with the equipment and procedures over the course of the winter.

7.0 Safety

7.1 Introduction

According to a recent report from The National Oceanic and Atmospheric Administration, "adverse weather is estimated to play a role, directly or indirectly, in 800,000 injuries and 7,000 fatalities annually resulting from vehicle crashes. This represents about 28 percent of all highway crashes and 19 percent of all fatalities."[9] Safety is an important goal area for this earmark evaluation, but one for which solid data and evaluation measures are difficult to obtain. The evaluation seeks to identify whether or not improvements in driving safety are occurring since the deployment of the new ITS road weather information services. For the purposes of this evaluation, safety benefits may be measurable in several different ways, including:

- A reduction in crashes, accidents, and road incidents, particularly those related to weather events;
- A reduction in traveler exposure to unsafe road conditions in the region;
- Changes in traveler awareness, preparedness, and behavior that lead to safer travel experiences; and,
- A perception on the part of travelers, maintenance crews, and emergency service providers that travel safety is improving and that better information is contributing to that improvement.

It is not possible to derive valid statistical inferences from only a few months worth of post-deployment accident data. In spite of that, this evaluation examined accident records for the study corridors to gain perspective on the risks associated with winter road travel and maintenance in this region and to lay the groundwork for a more complete understanding of safety benefits in conjunction with the qualitative safety data that were collected.

7.2 Objectives and Approach

Using a variety of quantitative and qualitative data, this evaluation sought to assess the effects of the mobile HARs, RWIS-ESS, CCTV cameras, and information on the Internet on travelers' safety in the corridor region. Table 9 outlines the evaluation objectives, anticipated impacts, measures, and hypotheses that were used to guide the evaluation.

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[9] U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of the Federal Coordinator for Meteorological Services and Supporting Research. 2002. *Weather Information for Surface Transportation: National Needs Assessment Report.* FCM-R18-2002. Washington, DC (December). P. ES-2.

Table 9. Anticipated Impacts and Measures for Safety

Objectives and Anticipated Impacts	Evaluation Measures	Hypotheses
Reduce number and severity of crashes and road incidents	- Number of vehicle crashes, accidents, incidents - Perceived changes in travel safety in the region	- The number of crashes, accidents and incidents due to weather and bad road conditions will go down - Drivers and WSDOT/WSP report improvements in safety due to ITS
Reduce traveler exposure to unsafe road conditions	- Changes in awareness and use of traveler information - Changes in travel decisions before and after project	- Traveler diversion around hazardous road conditions will be more timely and effective - Travelers will become more aware of road weather information after the project than before - Travelers will use the new information to enhance their preparedness and adjust their travel plans to increase travel safety

7.3 Data collection Methods

To assess the various pathways to safety improvement in the study region, baseline accident data have been collected from WSDOT records for the U.S. 395 and SR 20 corridor segments covering 1992 to 2002 (with two years of missing data from 1997 to 1998), plus the 2002-2003 post-deployment winter period (December 2002 through March 2003). Commercial vehicle operators and public travelers were asked about their uses of the new information as a way to enhance travel safety and their perception of the benefits associated with that information. The WSDOT maintenance crews who maintain the roads in the region were interviewed to better understand how they used the information to improve the condition of the roads in the winter, and a State Patrol officer was interviewed to gain his perspective on how emergency service providers use road weather information and how travelers appear to be responding to improvements in the amount, content and timeliness of road weather information.

Accident/incident data reports were obtained from WSDOT's Transportation Data Office (safety databases) in Olympia, WA. These reports were organized and analyzed to document the recent history and current road safety conditions in the region. The data were obtained for the baseline period from 1992 through 2002 and the first quarter of 2003 (the post-deployment period), though the records for 1997 and 1998 are incomplete. The State of Washington has been transitioning to a new computer and database system, and has not been able to complete data entry for every year. While they are current as of 2003, they do not plan at this time to go back and reconstruct the accident data for 1997 and 1998.

The information gathered in the WSDOT accident reports were evaluated in terms of the following indicators:

- Number of crashes in the project area
- Severity of the crashes
- The type and cause of crashes or incidents
- How many and what kind of vehicles were involved in the incidents
- What time of day the incidents occurred
- Road surface and weather conditions at the scene of the incident

- Specific milepost locations where the incidents occurred along the two main study corridors to determine where any patterns may exist.

Based on observations of weather-related accidents during a portion of the baseline period, as well as the clear challenges presented by winter travel over Sherman Pass, particular attention has been placed on selected "hot spots" where 5 or more accidents were recorded, and on a 20 mile stretch across Sherman Pass.

It is known that vehicles operating at speeds excessive for the conditions contribute to many of the incidents in the baseline period, and weather and road conditions are important contributing factors.

7.4 Data Analysis and Findings

7.4.1 WSDOT Accident Data

This section presents the results of the analysis of WSDOT accident records for this region. The safety data were provided for selected segments of U.S. 395 and SR 20, following the formats outlined in Appendix E. The accident data were organized by milepost for each of the roadway segments.

As shown in Table 10, there were a total of 504 accidents in the U.S. 395 corridor during the years from 1992 to 2003. SR 20, a less traveled corridor, had a total of 245 recorded accidents for the same time period. Taking account of the missing data periods, the average number of accidents per month on U.S. 395 was 4.5 and the average per month on SR 20 was 2.1.

Table 10. Total and weather-related annual accidents for 1992-2003.

US 395	1992	1993	1994	1995	1996	1999	2000	2001	2002	2003[a]	Total
Total Accidents	56	44	53	61	68	48	50	59	59	6	504
Weather Related	27	27	17	29	37	18	19	25	21	3	223
% Weather Related	48%	61%	32%	48%	54%	38%	38%	42%	36%	50%	44%

SR 20	1992	1993	1994	1995	1996	1999	2000	2001	2002	2003[b]	Total
Total Accidents	38	20	27	31	29	19	29	24	18	10	245
Weather Related	22	11	15	16	18	13	13	16	8	3	135
% Weather Related	58%	55%	56%	52%	62%	68%	45%	67%	44%	30%	55%

[a]Data from Jan-Mar, 2003 only
[b]Data from Jan-Aug, 2003 only

A high percentage of the annual accidents, as reported in the records by the State Patrol, involved bad weather or dangerous weather-related road conditions, as shown in Table 10. A weather-related accident was one that occurred in the presence of wet, snowy or icy pavement, and/or rainy, snowy or foggy weather conditions. Overall, 44% of all accidents that occurred in the U.S. 395 corridor for this period were weather-related accidents, and 55% of the accidents that occurred on SR 20 were weather-related. This level of weather-related accidents in this region is notably higher than the national average cited earlier. As a first overall sense of whether the post-deployment period may have differed from the baseline, Table 10 shows that the percentage of weather-related accidents for the first three months of 2003 on U.S. 395 were somewhat higher than average (50% versus 44%), and the percentage of weather-related accidents for the first eight months of 2003 on SR 20 were below average (30% versus 55%).

Table 11 looks at the same accident data for the four main winter driving months of December through March for each of the baseline winters and the single post-deployment winter. For every one of these winters, there was a higher percentage of weather-related accidents than for the year as a whole. While the new ITS services are intended to provide benefits throughout the year, the focus of this evaluation has been on the use of better road weather information during the winter period. As for the year as a whole, the percent of weather-related accidents for the four month post-deployment winter is not significantly different from the average experience for those same four month periods in the baseline.

Table 11. Total and weather-related winter accidents (4 month Dec.—March), 1992-2003.

US 395	1991-92[a]	1992-93	1993-94	1994-95	1995-96	1-3/1999	1999-00	2000-01	2001-02	2002-03	Total
Winter Accidents	19	25	17	22	12	12	18	13	32	15	185
Weather Related	13	18	10	14	8	10	13	10	22	10	128
% Weather Related	68%	72%	59%	64%	67%	83%	72%	77%	69%	67%	69%

SR 20	1991-92[a]	1992-93	1993-94	1994-95	1995-96	1-3/1999	1999-00	2000-01	2001-02	2002-03	Total
Winter Accidents	19	8	6	8	6	1	6	5	6	5	70
Weather Related	14	6	5	8	4	1	5	4	6	3	56
% Weather Related	74%	75%	83%	100%	67%	100%	83%	80%	100%	60%	80%

[a] 12/91 data not available

All of the accident data are organized by milepost location along U.S. 395 and SR 20 in the study region. This allows a closer look at those locations where accidents appear to be more prevalent, or the proportion of more severe accidents is higher, or a higher proportion of accidents are weather-related. This is important because safety benefits that could be derived from the ITS equipment may be particularly beneficial for these situations.

Some of the road segments along these two main corridors experienced higher accident rates than others. One location of particular interest is the Sherman Pass corridor that ranges roughly between the chain-up areas on each side of the pass. The top of the pass is 5,575 feet at milepost 319.50, and the segments on either side of the pass range from MP 309.02 on the Republic side to MP 331.25 on the Colville side, a distance of just over 22 miles. Sherman Pass is the highest pass maintained year round by WSDOT in the state. Accidents associated with Sherman Pass occur on both sides of the mountain pass, and the number of accidents that were recorded along this stretch of road between January 1992 and December 2002 (not including the two missing years of 1997 and 1998) totaled 154 accidents. Because the RWIS-ESS and camera systems have been installed at Sherman Pass, they are expected to be particularly beneficial from a safety enhancement standpoint, given the winter weather-related accident risks across this pass.

Table 12 below shows all the high accident locations on U.S. 395 and SR 20, as well as the 22 mile stretch on both sides of Sherman Pass. For the purposes of this analysis, a high accident location was defined as one experiencing 5 or more recorded accidents during the baseline period. There were 13 such locations identified, 12 of which were along U.S. 395 and one of which was along SR 20. Every one of these locations was at an intersection. These high accident locations accounted for about 17% of all the recorded accidents along U.S. 395 and

SR 20 during this period. Just under one-third of them (29.1%) could be considered weather-related, given that road conditions were recorded as other than dry. A total of 144 injuries were associated with the high accident locations, but these injuries were no more likely to be weather-related than the accidents. In fact, comparing these results with the data on all accidents in these corridors (Table 10) suggests that weather was less of a factor than the traffic risks associated with the location itself, involving an intersection.

The annual accident data for the 22 mile corridor crossing Sherman Pass shows that two-thirds of all the accidents recorded during the baseline period along SR 20 occurred in this stretch of road crossing the pass, though throughout the year only a slightly higher than average number of those accidents were weather-related, compared with all accidents recorded on SR 20 (62% on the pass versus 56% over all of SR 20). The proportion of injuries that could be said to be from weather-related accidents was quite a bit higher for the Sherman Pass corridor than for all the other high accident locations along U.S. 395 and SR 20 examined in this evaluation (61% injury accidents on Sherman Pass versus about 27% for all the other high accident locations shown in Table 11).

With only 8 months of post-deployment data for 2003, there were 10 recorded accidents on SR 20 (see Table 10) and 3 of these were weather-related. Of the 10 accidents for that period, 6 of them occurred on this 22 mile stretch of road across Sherman Pass, and only one of those occurred during the January to March winter driving period. Of the 5 winter accidents identified in Table 11 for 2002-2003, four of them occurred on this stretch of SR 20 over Sherman Pass and three of those were weather-related. Overall, the numbers are too small, and with only one post-deployment period to examine, it is not possible to identify an effect, one way or the other, for the ITS facilities on accident propensity or severity. More data will need to be collected to sort this out. The data are suggestive however, given that the lowest percentage of weather-related accidents for winter driving over Sherman Pass was recorded for the post-deployment period (Table 11).

The comparable data for only the first three months of 2003 for U.S. 395 show 6 accidents, three of which are weather-related (Table 10). None of these occurred at the high accident locations identified in Table 12. Three of the accidents experienced one injury each. Considering the post-deployment driving period (December 2002 through March 2003), most of the accidents occurred in December 2002 (9 out of 15, Table 11). But as with SR 20, the overall accident experience for this post-deployment period for U.S. 395 is not significantly different from the average baseline experience.

The details of the accident cause data overall indicate that intersections, curves, steep grades, and high speeds are major contributing factors, along with adverse weather conditions and slippery road surfaces. It is the expectation of this project that providing drivers with better road weather information will help them become more aware of and prepared for these hazards and hopefully more attentive. Over the longer run, better preparedness should translate into increased safety.

The severity of each reported accident is listed in the accident database and summarized in Table 13. The severity codes as established by WSDOT are as follows, and also are shown in Appendix E:

1 = Property damage only
2 = Fatal
5 = Disabling injury
6 = Evident injury
7 = Possible injury

Table 12. High Accident Locations on U.S. 395 and SR 20, 1992–2002[a]

MP Location	Location Description	No. of Accidents	Weather Related Accidents	Percent Weather Related	No. of Injuries	No. of Weather Related Injuries
180.46	Intersection U.S. 395 and Monroe Road	31	11	35.5%	37	15
181.06	Intersection U.S. 395 and Dahl Road	8	2	25.0%	11	1
182.82	Intersection U.S. 395 and Spotted Road	7	2	28.6%	14	6
183.94	Intersection U.S. 395 and Wallbridge Road	9	2	22.2%	7	0
184.54	Intersection U.S. 395 and Railroad Road	5	3	60.0%	3	1
185.23	Intersection U.S. 395 and Swenson Road	6	1	16.7%	8	0
185.60	Intersection U.S. 395 and Williams Valley Road	7	2	28.6%	9	7
186.09	Intersection U.S. 395 and Railroad Road	5	1	20.0%	7	2
187.30	Intersection U.S. 395 and Grote Road	7	3	42.9%	5	2
189.54	Intersection U.S. 395 and Sunset Bay Road	6	2	33.3%	5	0
190.58	Intersection U.S. 395 and SR292 and Garden Spot Road	21	5	23.8%	31	5
202.43	Intersection U.S. 395 and SR231	7	1	14.3%	6	0
305.24	Intersection SR 20 and SR21	8	2	25.0%	1	0
	Sub-Total:	127	37	29.1%	144	39
309.02 to 331.25	Western Chain-up area to Eastern Chain-up Area, SR 20, Sherman Pass	154	96	62.3%	74	45

[a] A high accident location is defined for this table as a milepost location with 5 or more accidents recorded during the baseline period between January 1992 and December 2002, not including the years 1997 and 1998.

The data shown in Table 13 do not suggest a clear relationship between accident severity and weather. Each type of accident, as defined by the severity code, is associated with weather causes to about the same extent as the average over all types of accidents (as shown in Table 10)[10]. These data cover the baseline period, and there is insufficient data for the post-deployment winter months to directly determine the effect of the ITS installations on the numbers of accidents, accident severity, or the proportion of weather-related accidents.[11]

Table 13. Accident Severity by Route and Weather: 1992 - 2002

Severity Code	U.S. 395		SR 20	
	Weather Related Accidents	Other Accidents	Weather Related Accidents	Other Accidents
1	117 (46%)	139	93 (60%)	63
2	5 (38%)	8	0 (0%)	2
5	16 (38%)	26	4 (31%)	9
6	40 (35%)	75	18 (49%)	19
7	30 (43%)	40	16 (62%)	10
Total:	208 (42%)	288	131 (56%)	103

Finally, we examined the types of vehicles that were involved in accidents, as recorded in the safety database. The vehicle type codes are listed in Appendix E. The data only cover the period 1992 through 1996 because vehicle type information was not recorded on the data sheets for the 1999 through 2003 period. All vehicles were classified into three categories, namely cars, trucks, and other, and whether or not they were involved in a weather-related accident. Of the weather-related accidents in the U.S. 395 corridor, 95% involved cars, 4% involved trucks, and the remaining were considered other vehicle types as shown in Figure 29. Comparable data for SR 20 are shown in Figure 30, where 80% of all weather-related accidents involved cars, 18% involved trucks, and the remaining 2% were "other" vehicle types.

[10] There are minor differences in the totals between Table 9 and Table 12 due to missing accident severity data.
[11] No accident severity codes were provided by WSDOT for the 10 accidents in the first eight months of 2003 on U.S. 396. Three of the six accidents for the first three months of 2003 on SR 20 were coded severity level 7.

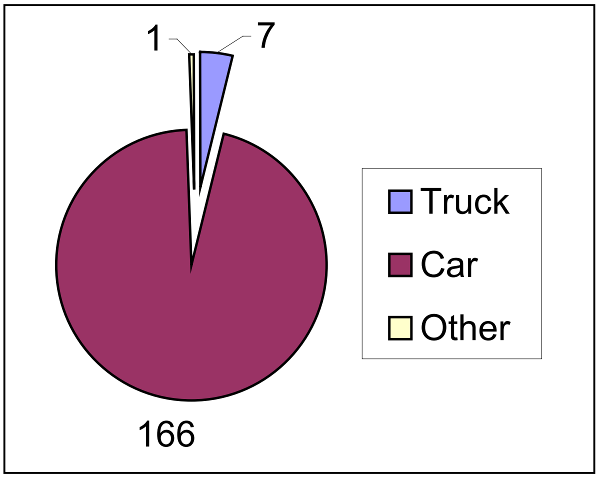

Figure 29. Weather-Related Accidents by Vehicle Type on U.S. 395

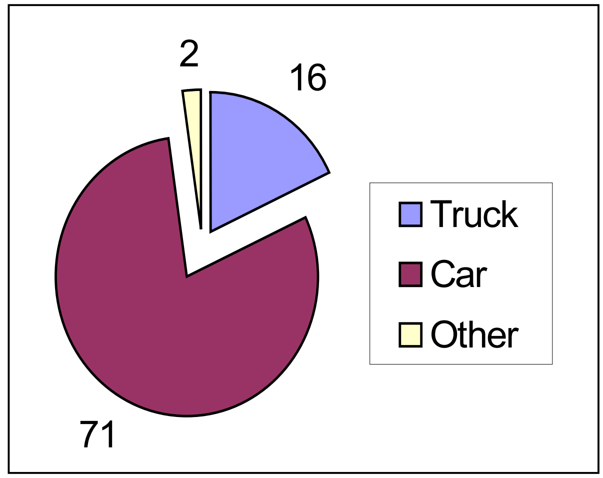

Figure 30. Weather-Related Accidents by Vehicle Type on SR 20

Based on the data examined for the period 1992 through 2003, some general observations include the following:

- A high percentage of the accidents that occurred in this region were weather-related;
- The proportion of weather-related accidents is highest during the winter months;
- Truck involvement in the accidents that occurred in the corridor was low;
- Fatal crashes also were low;
- Causes of these accidents were primarily poor weather and road conditions, along with steep grades, curvy roads and driver unfamiliarity, inattentiveness and excessive speeds; and,
- There are some particular "hot spots" where the number of accidents is higher than most other areas, particularly at intersections on U.S. 395 and across Sherman Pass on SR 20.

Because of the large number of weather-related events in this region, the ITS system improvements in road weather information are expected to help reduce the number and severity of accidents over the longer term. It is also instructive to note that several of the key new RWIS-ESS facilities are located close to some of the worst road segments from a winter safety perspective.

7.4.2 Qualitative Safety Data

As has been noted, safety benefits are difficult to measure quantitatively because of the many factors that affect safety other than ITS that are difficult to control in a field evaluation, such as road geometry, weather variability, road conditions, and driver characteristics. In addition, the fact that accidents are rare events makes it especially difficult to identify significant safety benefits with only one year of post-deployment data in hand (actually in this case only four winter driving months). This evaluation supplemented the quantitative evaluation component with a qualitative set of interviews and surveys. This provides additional perspective on the safety benefits of the new ITS facilities from the point of view of travelers, WSDOT road crews, and the State Patrol. The qualitative insights regarding safety benefits are summarized in

Table 14. Taken together, the quantitative and qualitative data offer a more complete picture of the overall safety benefits of the ITS deployments evaluated in this study.

General Travelers. The general public is very aware of the risks associated with driving in rural and mountainous areas during the winter. Users of the WSDOT road weather information web site said that their primary concern and main reason for using this web site was to learn about the weather conditions they would face on trips they planned to take in this region in the winter. In responding to questions about the benefits they received from using the weather information web site, the highest levels of agreement had to do with aspects of safety and preparedness. Ninety-four percent of the respondents said that the web site road weather information makes them better prepared for their trips and 88 percent agreed with the statement: "I feel that my use of this site makes my trips safer." As one respondent stated in a comment at the end of the survey, "I rely heavily on this web site for the information I need to have a safe trip."

Commercial Vehicle Operators. The 39 commercial operators in the post-deployment interviews were asked, "Has the availability of HARs, camera images of key roadway segments, and enhanced Internet information affected driving safety for you in this region compared with last year?" Eleven of the respondents said they didn't know whether their drivers used these information sources, or they themselves didn't use them. Of the remaining 28 CVOs, 16 (57%) said the availability of the new information made them "somewhat" or "a lot" safer. The remainder (12 CVOS, 43%) said the safety benefit to them was "about the same as before." No one reported a reduction in safety benefit. Furthermore, 19 of the CVO respondents said that the new information provided through the WSDOT web site and HAR messages made them and their drivers better prepared for road conditions in the region, and hence presumably safer. Finally, the general trend shown in CVO responses that indicates increased use of information due to the new ITS technologies provided under this earmark is expected to translate into a positive safety value for all travelers.

Maintenance and Operations Staff. No data were obtained from the maintenance and operations activities that directly measure the safety benefits of the new ITS information. However, maintenance field staff commented on their sense that fewer truck accidents were likely associated with the availability of advanced road weather information from the Sherman Pass RWIS-ESS, real-time condition announcements on the HARs, and the opportunity to more effectively pursue WSDOT's anti-icing program to make the roads safer for travel. It also seems reasonable to assume that the road crews were able to be more efficient in their assignment of limited resources, given that they could now rely on camera images and RWIS-ESS road condition readings to assess where the worst problems were located, thereby resulting in safer roads, both for travelers and maintenance crews.

Washington State Patrol (WSP). An interview was conducted with the Sergeant in charge of the WSP unit based in Colville, WA. He has 9 patrol officers covering all roads in his jurisdiction that includes Stevens and Ferry counties, plus some portions of adjacent counties. His office works closely and well with WSDOT, calling in hazardous road conditions, requesting sand or plow trucks in the winter, closing dangerous sections of road, responding to citizen and official inquiries about current conditions, and monitoring CVOs and chain regulations. Most of the WSP's winter road safety concerns relate to unpredictable microclimate conditions, such as icy road patches, that lead to jack-knifed truck trailers and run-off-the-road accidents. The WSP feels that the new ITS information offers a valuable resource both to the WSP and to travelers, but their concern is that awareness of this information is still low. The HARs offer good real-time safety enhancing information but some travelers are likely to miss the information altogether due to limited broadcast range and sign placements. The ideal would be a 511-type phone system with region-wide coverage and location-specific information. The WSP did not see any reduction in the average number of calls they received from the public this past winter inquiring about conditions, even though good information is now available over the Internet. They also said that the real value of the information depends a lot on how quickly the word gets out to travelers, and the ITS equipment helps speed up that process of information collection and dissemination. The WSP has also gained efficiency benefits from the RWIS and camera equipment because they can access information over the Internet about road conditions for which they used to have to send out a vehicle to check in person.

Table 14. Summary of perceived safety benefits by users.

General Travelers	Commercial Operators	WSDOT M&O Staff	Washington State Patrol
• High concern for safety • 94% say web weather info makes them better prepared • 88% say use of web makes trips safer	• 72% of CVOs use HAR, cameras or Internet • 41% report they have experienced increased driving safety in the region • 57% of users say new information makes them feel safer than before • 68% of users felt better prepared	• In interviews staff said new ITS systems seem to have reduced truck accidents • Better information allows more effective road pre-treatment, more efficient clearing, and therefore safer roads	• Better information is offered by ITS facilities but public awareness is low • Difficult to say whether there are measurable safety benefits in just one winter • Travelers who do access the new information are better prepared

8.0 Conclusions

The ITS equipment installed in the rural corridor north of Spokane, Washington to the Canadian border in support of enhanced traveler information has resulted in benefits for operations and maintenance, commercial vehicle operations, and public travel in the region. The ITS deployments included two RWIS-ESS facilities placed in key locations, three new CCTV cameras mounted on the RWIS-ESS towers, and two mobile HAR. Even though this constitutes a limited preliminary deployment in a large geographic area, the positive impacts have already been quite substantial. The deployment has served to demonstrate the value of improved road weather information to WSDOT's winter maintenance program, the ability of the operations and maintenance crews to adapt their procedures to better take advantage of the new systems, and the value to both commercial and public travelers in the region to being better prepared for difficult winter driving conditions. Overall, the perceived safety benefits of these facilities have been noted by many of the affected travelers and operators in the region.

The primary benefits of the ITS facilities (summarized in Table 15) include:

- Improvements in winter road maintenance efficiency due to increased availability of relevant and geographically significant RWIS data and camera images. WSDOT road crews are able to allocate their scarce and costly equipment more efficiently, make proactive treatment decisions, and clear pavement of snow and ice to quickly restore the normal level-of-service.
- Better prepared travelers in the region with improved knowledge of weather and road conditions that will be faced during planned trips (commercial and general travel). Being better prepared translates into higher levels of driving satisfaction and safer driving.
- Perception by most users that the improvements in traveler information timeliness and accuracy improves safety in the project corridors.
- Safer, more confident travel decisions (when and where to travel) by commercial and general travelers after obtaining the new weather and road condition information.
- Comments from all users indicate a heightened interest in this type of information, suggesting increased use in the future to improve efficiency, safety, and comfort in traveling in this region.
- While benefits are substantial and measurable, concerns remain that public awareness of the enhanced information, especially for use in pre-trip planning, is low, and more attention needs to be paid to promoting the information services.

The evaluation team feels this was a productive and meaningful evaluation of ITS-based environmental sensing and traveler information dissemination in a rural area. The evaluation concludes that even limited ITS road weather information systems can offer substantial benefits both to state DOT operations and to commercial and private travelers in these rural areas. Although system bugs need to be worked out, and in spite of a noticeable learning and trust-building curve in the short run, in the long run both operators and travelers adjust their behaviors to access and use quality real-time information when it becomes available to them. The local project team believes that additional ITS capabilities deployed more widely in this rural environment will add additional benefits at relatively modest costs, allowing the WSDOT to rely even more on the improved road weather information in better managing their assets. The findings in this report also can be used by DOTs in other rural areas to effectively deploy similar ITS to enhance travel in their rural areas.

As a result of this earmark projects, and based on findings from the evaluation, WSDOT plans to expand and enhance the use of RWIS, including camera images, in more locations in the project corridors to further extend the coverage throughout their maintenance jurisdiction. Based on their experience deploying these initial systems, they anticipate that the costs of adding additional equipment will be reduced and that the lessons they have learned along the way will lead to greater efficiencies in the operation and maintenance of these systems. They also believe that the overall benefits to be derived from such systems will be much greater once the capabilities are more widely disbursed in the region and more routinely used by both travelers and WSDOT operators.

Table 15. U.S 395 Spokane FY99 Earmark evaluation summary results.

Evaluation Category	Key Benefit Findings from the Use of ITS Equipment
Infrastructure Operations and Maintenance	• WSDOT experienced time and resource savings that were applied more productively elsewhere in their service area. • WSDOT office at Colville experienced a reduction in public requests for road condition information compared with the baseline period, freeing up staff for more important tasks. • WSDOT maintenance crews used the information extensively to determine how when and how much to deploy liquid anti-icing chemicals, reduce the amount of sand applied (25% reduction estimated), reduce the number of unnecessary trips, and generally increase the efficiency of maintenance activities. • WSDOT has developed plans to expand the use of ITS equip. in the project corridor to cover other critical road sections.
Travel and Mobility for Commercial Vehicles	• CVOs are able to make better informed travel decisions and report that they are better prepared for their trips. • CVOs reported using the Internet to obtain weather and road condition information more during the post-deployment period than in the baseline period (46% vs 29%, respectively). • 56% of CVOs reported that they tuned to one or both of the HAR stations while traveling in the area. The majority found the HAR messages to be “somewhat” or “very” useful.
Travel and Mobility for Public Travelers	• The website that contains weather and road condition information in this area was used extensively by the those responding to the web survey (93% of responders were frequent WSDOT website users). • Camera images, current weather information, and pass reports were used by the vast majority of respondents (>94%). • 94% of respondents agree that this information makes them better prepared for their trips.
System Performance	• Overall, the systems performed well. However, issues included HAR power requirements, communication breakdowns at Sherman Pass, and Internet access problems at maintenance sheds. • These issues have been addressed and negative impacts to overall system operation should be reduced in the future.
Safety	• Post-deployment data (only a partial 1-year) suggest the safety experience was not particularly out of the baseline range, and accidents are too few to ascribe statistical significance. • 88% of general travelers responded with “strongly agree” or “agree” with the statement: ”I feel that my use of the website makes my trips safer.” • 41% of CVOs report they have experienced increased driving safety in the region. • WSDOT maintenance personnel reported fewer jack-knifed trucks and other crashes during the post-deployment period.

Appendix A

Event Log Sample

Maintenance & Operations Event Log - Colville

FY99 ITS Earmark Evaluation

Observer ______________________________ Log Date ____________________

This event log is to record information about major events in support of an evaluation of Intelligent Transportation System (ITS) technologies that have been deployed along the project corridor. Events may include snowstorms, major accidents, flooding, any amount of freezing rain, icing, drifting snow, or fog that disrupts traffic or causes a safety hazard. A snow event can be regarded as any storm that deposits an inch or more of snow.

	Colville			
	Route	395	20E	25
EVENT	Event Type	S MX R BS FG FR FI FD TI	S MX R BS FG FR FI FD TI	S MX R BS FG FR FI FD TI
	Snow MiXed Rain Blowing or DriftingSnow FoG FreezingRain Frost or Ice FlooD TrafficIncident			
TIMING	Begin Date / Time	/	/	/
	End Date / Time	/	/	/
WEATHER	Event Snow Total Inches			
	Event Start Temperature			
	Temperature Trend			
	Precipitation Description	SC AA OC CN Lt Mod Hvy	SC AA OC CN Lt Mod Hvy	SC AA OC CN Lt Mod Hvy
	SCattered (<50% of area) AllArea OCcassional CoNtinuous Light (Visibility > 1/2 mile) Moderate (1/4 mile < Visibility < 1/2 mile) Heavy (Visibility < 1/4 mile)			
Pre Event All Liquid Treatment		Y N	Y N	Y N
EQUIP	# Trucks			
	# Shifts			
TRAFFIC	Restrictions	N OP >10K AVXA C	N OP >10K AVXA C	N OP >10K AVXA C
	None OversizeProhibited ChainsReq >10Kgvw ChainsReq AllVehicles eXceptAwd Closed			
	Crash Activity or Types			
How did You learn of the Event? (forecast, callout, etc)				

Were the RWIS sites functioning adequately during the event?	Y N
Did you base, support, or confirm a plan or decision during the event on RWIS site data or camera image?	Y N
Did you redistribute your truck coverage and focus on selected areas during this event based on the RWIS?..	Y N
Did you forego a regular patrol based on or partially due to use of RWIS or camera image?	Y N
Did you self-dispatch or were dispatched at any time due to RWIS information or camera image?	Y N
Were there any weather surprises during this event?	Y N
Did camera images or RWIS data assist you in knowing how well you were meeting the designated LOS?	Y N
Did weather or incidents keep you from meeting the desired LOS for any road segments during the event?	Y N
Were the HAR utilized during this event? (skip next 4 questions if no)	Y N
Were the HAR messages activated quickly enough to reach the majority of drivers affected?	Y N
Were they taken down quickly enough when conditions returned to normal?	Y N
Did the message or messages adequately convey the best suggestible actions to drivers?	Y N
Did the drivers respond appropriately?	Y N

Comments:

Please fax to Keith Walker, Colville, WA at (509) 684-7316 upon completion.
For questions, or assistance contact Steve Conger, Meyer Mohaddes Associates, at 208-435-4630 or sconger@mmausa.com

Appendix B

Sherman Pass HAR Log Scripts

Sherman Pass HAR Script

This is the Washington State Department of Transportation highway advisory radio.

The current conditions on State Route 20, Sherman Pass, are:

________________, ______________________________
(temperature) (visibility/precipitation)

____
(road conditions)

☐ There are no restrictions.

☐ Traction advisory: Oversize loads prohibited, no passenger tire restrictions.

☐ Vehicles over ten-thousand pounds chains required. Passenger vehicles, all season tires required.

☐ Chains required on all vehicles except all-wheel drive.

WNVA-814.

Sherman Pass HAR End of Shift Script

This is the Washington State Department of Transportation highway advisory radio.

The latest conditions reported at ___________ for State Route 20, Sherman Pass, are:

________________, ______________________________
(temperature) (visibility/precipitation)

____
(road conditions)

☐ There are no restrictions.

☐ Traction advisory: Oversize loads prohibited, no passenger tire restrictions.

☐ Vehicles over ten-thousand pounds chains required. Passenger vehicles, all season tires required.

☐ Chains required on all vehicles except all-wheel drive.

The National Weather Service forecast for tonight:

____

____

Weather conditions can change rapidly. Motorists should be prepared for hazardous winter driving conditions. The current road conditions for Sherman Pass will be updated by 8:00 AM.

WNVA-814.

Abbreviations Used in the TMC Log Entry Forms

Abbreviation	Definition
ADV or AVD	Advise
B	Bare
BCSIIP	Bare with Compact Snow and Ice In Places
BD	Bare and Dry
BFIIP	Bare with Frost and Ice In Places
BFIP	Bare with Frost In Places
BKN or BKC	Broken Clouds
BLO	Blowing
BLSN	Blowing Snow
BSIP	Bare with Snow In Places
BW	Bare and Wet
CFS	Closed For the Season
CHR	Chains Required
CLDY	Cloudy
CLR	Clear
CS	Compact Snow
CSI	Compact Snow and Ice
CSIIP	Compact Snow and Ice In Places
CSOR	Compact Snow On Road
CSSL	Compact Snow and Slush
CW	Central Washington
DEG	Degree
EB	East Bound
FGP	Fog Patches
HAR	Highway Advisory Radio
IIP	Ice In Places
LT	Light
LTSN	Light Snow
MBW	Mostly Bare and Wet
NN	No New
OC	Overcast
SCT	Scattered
SLOR	Slush On the Road
SN	Snow
SNFLR	Snow Flurries
SNGLT	Snowing Lightly
SNIIP	Snow and Ice In Places
TA	Traction Advisory
TMC	Traffic Management Center
TNEW	Trace New
TOT	Total Snow
WB	West Bound
WC	Watch & Carry (chains)
WSP	Washington State Patrol

Appendix C

CVO Telephone Interview Questionnaire

Commercial Vehicle Operations
U.S. 395 Earmark Evaluation -- Phase III

Introduction for discussion with CVOs:

A) Prior Participant Organizations:
- Ask for ____________________ (the department and respondent to the earlier interview)
- My name is __________________, and I am with Meyer Mohaddes, Assoc. in Boise, ID.
- In cooperation with the Washington State DOT, we are conducting an evaluation of new road/weather information technologies…
- This interview is the second in our two and a half year evaluation process. Your organization participated in the first interview providing beneficial input for establishing baseline conditions.

B) New Contacts:
- My name is __________________, and I am with Meyer Mohaddes, Assoc. in Boise, ID.
- In cooperation with the Washington State DOT, we are conducting an evaluation of new road/weather information technologies…
- Your name and number was supplied to us by WSDOT, the WTA, or other states' trucking associations.
- Our evaluation study is focusing on the Northeast part of Washington in the region between Spokane and the Canadian border and between Republic and Colville. Does your company operate trucks in that region? If not, record basic contact info and terminate the interview.
- This interview is the second and final in our two and a half year evaluation process.
- The interview should take only about 10-15 minutes. (Schedule an alternative interview time if this won't work for the respondent or if you need to speak with someone who is not available.)

The following questions are best answered by someone familiar with your company's operations, such as a dispatcher or someone who can answer from a driver's perspective. The focus will be on information relevant to travel in the corridor region north of Spokane.

Be assured that your company and individual information will be kept strictly confidential. We will not mention names and will only present group statistics in our evaluation reports.

Name: ______________________________ Title: ______________________________

Organization: ______________________________ Location: ______________________________

Number of Years Organization has been Operating: ______________________________

Date: ______________________________ Time of interview: ______________________________

1. About how many one-way truck trips do your drivers make per month on each of the following road segments?

Corridor road segments	No. of One-Way Trips/Time Frame
SR 395 between Spokane and Laurier or any alternate north-south segment	___________ / ___________
Route 20 between Republic and Colville (over Sherman Pass) or any alternative east-west segment.	___________ / ___________

(NOTE: If 0 for both of the above, then terminate the interview at this point.)

2. What percentage of your trips are on routes other than SR 395 or SR 20 in this region?

3. How does the frequency of trips you are making now in this region compare with two years ago?

☐ More trips now ☐ Fewer trips now ☐ The same # of trips

4. How many trucks do you have in your company that operate in this corridor region?

☐ 1 - 2 ☐ 3 - 5 ☐ 6 - 10 ☐ 11 - 25 ☐ 26 or more

5. How many drivers do you have operating in this corridor? _________________

   (As time and discussion allow, ask about driver experience level. Do the same drivers tend to drive these routes/trucks?)

   ____

   ____

   ____

6. How does the number of trucks in your company that operate in this region now compare with two years ago?

☐ More trucks now ☐ Fewer trucks now ☐ About the same # of trucks

7. Type of truck/cargo shipped in this region now (estimate percent distribution if more than one type):

☐ Poles or Logs ☐ Food or Ag ☐ Construction ☐ Other __________
☐ Lumber ☐ Livestock ☐ Home Office Prod __________________
☐ Wood Byproducts ☐ HAZMAT ☐ General Freight __________________

8. What types of vehicles do you operate in this corridor region? Check all that apply:

☐ Single Unit Truck ☐ Truck / Trailer
☐ Tractor / Semi-Trailer ☐ Combination

9. Do weather or driving restrictions cause you to change the type of truck you use?

____

10. Do the seasons (winter vs. summer) influence which routes you choose to use in this region?

☐ Yes ☐ No

If yes, how?____

11. Does your organization/operation use a dispatch service to relay road, weather or other travel information or to request changes in trip route/timing to truck drivers?

☐ Yes ☐ No

12. Is this different than two years ago?

☐ Yes ☐ No

13. Are your drivers free to independently change the timing or routes they use on their trips?

☐ Yes ☐ No

14. If you are not a driver operating in the 395 corridor from Spokane north, please answer assuming you are. I am going to read a list of different kinds of traveler information sources and ask you to first say whether each is available to you (either before or during your trip), and for those that are to indicate whether and how often you use them, and whether you use them before your trip, during your trip, or both. Such information could include winter weather, flooding, major incidents, road construction, road conditions, and other delay information:

Source of Information	Not Avail to Driver	Frequency of Use				Type of Use	
		Often	Sometimes	Rarely	Never	Pre-trip	En-route
AM/FM Radio	☐	☐	☐	☐	☐	☐	☐
TV	☐	☐	☐	☐	☐	☐	☐
CB Radio	☐	☐	☐	☐	☐	☐	☐
Cell Phone	☐	☐	☐	☐	☐	☐	☐
Regular Phone	☐	☐	☐	☐	☐	☐	☐
Highway Patrol	☐	☐	☐	☐	☐	☐	☐
WSDOT Web	☐	☐	☐	☐	☐	☐	☐
Other Internet	☐	☐	☐	☐	☐	☐	☐
HAR	☐	☐	☐	☐	☐	☐	☐
Qualcomm	☐	☐	☐	☐	☐	☐	☐
Word-of-mouth	☐	☐	☐	☐	☐	☐	☐
Other (List)	☐	☐	☐	☐	☐	☐	☐
Other (List)	☐	☐	☐	☐	☐	☐	☐

WSDOT Web Survey – Are you aware of the online survey? ☐ Yes ☐ No

(Completed survey? Willing to complete survey? <http://www.sdas.battelle.org/wsdot/wsdot.asp>)

---

15. Please describe the conditions under which drivers use available travel information to change trip timing, routing or destination. That is, when might they do this and why?

Change Trip Timing?

Weather	
Closure	
Construction	
Crash	
Congestion	
Restrictions	

Change Routing?

Weather	
Closure	
Construction	
Crash	
Congestion	
Restrictions	

Change Destination?

Weather	
Closure	
Construction	
Crash	
Congestion	
Restrictions	

16. What are your options to re-route?

____

____

____

17. How often did you or any of your drivers access the Washington State DOT Traffic and Weather Website for travel during this winter season in this region?

☐ For all trips ☐ For most, but not all, trips ☐ For a few trips ☐ Not at all

18. Do you, or your other drivers, typically tune in to listen to the HAR message when you see the flashing sign?

☐ Yes ☐ No (skip to #20)

19. How useful do you and your drivers find the HAR messages?

☐ Very useful ☐ Somewhat useful ☐ Not very useful ☐ Not at all useful

20. Please describe some of the ways the information from either the website or HARs helped you with your traveling in the corridor.

____

____

____

____

____

____

21. Has the availability of HARs, camera images of key roadway segments, and enhanced Internet information affected driving safety for you in this region compared with last year?

☐ A lot safer ☐ Somewhat safer ☐ About the same as before ☐ Somewhat less safe ☐ A lot less safe

22. Do your drivers feel that they are getting the kind of information they need for travel in the SR 395 and SR 20 corridor region? Briefly comment on information access and quality, and any other information that is currently unavailable but that drivers wish they had so they could make better driving choices:

23. What changes to the information sources or content could be made to provide greater benefit or usability by truck drivers?

24. Does your business need to apply for oversize, overweight, or other permitting on these routes?

Thank you for taking the time to answer my questions.

Notes (plus any additional comments or suggestions by respondent):

Appendix D

General Traveler Web Survey Questionnaire

WSDOT Internet User Survey

Thank you for your interest in rating the features of this Web site. The Washington State Department of Transportation wants to provide you with timely and reliable road and weather information to help you travel safely. If you travel in the Northeast region of the State of Washington, this is your opportunity to give WSDOT your feedback on the information about road and weather conditions on this web site. The survey is funded by a federal grant from the Federal Highway Administration.

- This survey has seven (7) main questions, several of which have multiple sub-questions.
- The survey should take about 5 to 10 minutes to complete.
- You will be able to offer comments at the end of the survey.
- You will be able to review all of your answers at the end of the survey.
- Please respond only once to this survey.

---

1. Since December 1, 2002, approximately how many times have you visited this WSDOT web site to get road condition or weather information (*including* this visit)? *(check one box)*
   - ☐ One time (this visit)
   - ☐ 2 times
   - ☐ 3-5 time
   - ☐ 6 or more times

2. Since December 1, 2002, approximately how many road trips have you made using SR395 or SR20 in the North East portion of Washington State, in the area between Spokane and the Canadian border and east of Republic? *(check one box)*
   - ☐ None since 12/1/02 *[Skip to Question 6]*
   - ☐ 1 trip
   - ☐ 2 trips
   - ☐ 3-5 trips
   - ☐ 6 or more trips

3. Indicate your #1 and #2 reasons for using this web site for trips in the North East part of Washington State. *(put a "1" next to your main reason, and a "2" next to your second reason)*
   - ☐ Concerned about weather conditions on trips I plan to take
   - ☐ Generally interested in weather conditions but not associated with any particular trip plan.
   - ☐ Gathering information so I can decide when to take my trip
   - ☐ Trying to decide which is the best route to take
   - ☐ Trying to decide on alternate destinations for my trip
   - ☐ Looking for mountain pass conditions
   - ☐ Learning about travel restrictions
   - ☐ Learning about any road closures
   - ☐ Looking for current road construction information
   - ☐ Other reasons. (Please specify: ____)

4. What kinds of trips in the North East region of Washington State do you use this web site for? First check off **each** trip purpose that you have ever used this site for. Then check **one** trip type that you primarily, or most frequently, use this web site for.

	Ever Used For This (check all that apply)	Primary/Most Frequent Use (check one)
a. Business (e.g., company business; commercial travel)	☐	☐
b. Commuting to/from work	☐	☐
c. Personal business (e.g., family visits)	☐	☐
d. Recreation	☐	☐
e. Commercial (e.g., freight hauling, delivery)	☐	☐
f. Other (Please specify: ___________________)	☐	☐

5. Next, we would like you to rate your use of various road/weather information aspects of this web site. [**Note:** For "a" through "k" respondents were asked: "Have you used the web site to get *[pass reports]* information at least once since 12/1/02?" Yes/No. If "Yes", respondent was asked to rate usefulness, per below. If "No", respondent was asked: "Were you aware that *[pass reports]* information is available on this web site?" Yes/No. Go to next item.]

	Very Useful	Somewhat Useful	Not Very Useful
a. Pass reports	1	2	3
b. Current weather conditions (e.g., temperature, precipitation)	1	2	3
c. Camera images	1	2	3
d. Road surface temperature	1	2	3
e. Weather warnings (National Weather Service)	1	2	3
f. Weather forecasts	1	2	3
g. Construction updates	1	2	3

6. Based on your experience using this web site, please evaluate the site in terms of the following aspects. In answering these questions, consider your use of the web site for information only on the North East sector of the state. Indicate your level of agreement with each of these aspects of the web site:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
a. It is easy to find the information I am looking for.	1	2	3	4	5
b. The site is well organized.	1	2	3	4	5
c. I feel confident about the accuracy of the information on <u>current</u> conditions.	1	2	3	4	5
d. I feel confident about the accuracy of the information on <u>forecast</u> conditions.	1	2	3	4	5
e. I feel that my use of this site makes my trips safer.	1	2	3	4	5
f. There is important information I need that I can't get at this site that I think should be made available here.	1	2	3	4	5
g. The information I get from this site helps me avoid travel delays.	1	2	3	4	5
h. I feel that my use of this site makes me better prepared for weather conditions when I travel.					
h. I tend not to use some of the information on this site because it takes too long to access	1	2	3	4	5
i. The information I get from this site makes me feel much more comfortable on my trips.	1	2	3	4	5

7. Finally, please indicate, in your own words, how this web site could be improved to better meet your needs. Consider information content, ease of use of the site, ability to understand what is presented, and anything else that could make this site better. Be as specific as you can.

____

____

____

____

____

____

____

Thank you for taking the time to complete this survey.

Appendix E

Safety Database Contents

Accident Data Report Headings	Details
State Route Number	U.S. 395 and SR20
Mile Post Number (s)	
WSP Accident Report Number	
Diagram Analysis Data	
Accident Severity	1 = Property damage only 2 = Fatal 5 = Disabling injury 6 = Evident injury 7 = Possible injury 0 = Not stated
Number of Injuries	
Number of Fatalities	
Date	
Time	
Intersection Relationship	
Roadway Surface	
Weather	
Light	
Diagram Data Collision Type	
WSP Object Struck	
Severity	
Number of Injuries	
Number of Deaths	
Number of Vehicles	
Vehicle 1 Type	0 = Not stated or not applicable 1 – Passenger car 2 = Pickup truck 3 = Flatbed truck or van 4 = Truck and trailer 5 = Truck tractor 6 = Truck tractor and semi-trailer 7 = Other truck combinations 8 = Farm tractor and/or equipment 9 = Taxi 10 = Bus 11 = School bus 12 = Motorcycle 13 = Scooter bike 14 = Other 15 = Moped
Vehicle 2 Type	
Was Alcohol Involved?	
Driver 1 Contributing Circumstances	
Driver 2 Contributing Circumstances	
WSP Collision Type	