COMPARATIVE EVALUATION OF AUTOMATED WIND WARNING SYSTEMS

Showcase Evaluation #15

Technical Memorandum 2: Operational Benefits

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GLOSSARY OF ABBREVIATIONS

AADT	Annual Average Daily Traffic
ATR	Automatic Traffic Recorder
AWWS	Automated Wind Warning Systems
Caltrans	California Department of Transportation
CMS	Changeable Message Sign
COATS	California/Oregon Advanced Transportation Systems
FHWA	Federal Highway Administration
ITS	Intelligent Transportation Systems
MOE	Measure of Effectiveness
MP	Mile Post
NB	North Bound
ODOT	Oregon Department of Transportation
RWIS	Road Weather Information Systems
SB	South Bound
SRRA	Safety Roadside Rest Area
TripCheck	ODOT Traveler Information Website
VMS	Variable Message Sign

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1. INTRODUCTION

One challenge facing rural travelers is weather hazards that produce adverse driving conditions at isolated locations. One such hazard is sustained high winds that can cause high-profile vehicles such as recreational or commercial vehicles to overturn, and lower-profile vehicles to leave their lanes, jeopardizing motorist safety. Since wind conditions and patterns are defined significantly by local topography, there is limited ability to mitigate the impacts of wind through improved roadway design. Warning the drivers of impending cross winds well in advance and measures to reduce operational speeds are other options explored by transportation professionals.

To address localized high cross wind challenges, the Oregon and California Departments of Transportation (ODOT and Caltrans, respectively) have used intelligent transportation systems (ITS) installations to alert motorists of dangerously windy conditions automatically. The warning messages are displayed to drivers at locations where they can stop and wait until the winds die down or where they can decide to take a longer alternate route. Three systems have been deployed in the rural California/Oregon Advanced Transportation Systems study area, at the following locations:

- Between Port Orford and Gold Beach, Oregon on US Route 101 between mileposts (MP) 300.10 and 327.51 ("South Coast System")
- On the Yaquina Bay Bridge (US Route 101) between mileposts 141.27 (SB) and 142.08 (NB) in Oregon
- On Interstate 5 in Siskiyou County, California between postmiles 13.2 (Weed) to 45.3 (Yreka)

As these systems represent innovative applications of ITS in a rural environment, a project through COATS Showcase was initiated to evaluate their effectiveness. The evaluation focused on the two Oregon systems, because these two systems were fully automated and operational prior to the high wind season of 2003-04 (i.e. November 2003 – March 2004). The AWWS on Interstate 5 in California is not expected to be fully automated before December 2005. The goals of the automated wind warning systems (AWWS) deployed in Oregon are threefold:

- Improve the safety and security of the region's rural transportation system
- Provide sustainable advanced traveler information systems that collect and disseminate credible, accurate "real-time" information
- Increase operational efficiency and productivity focusing on system providers

It is also important to identify other benefits such as personnel time savings due to automation of some of the processes. In this COATS Showcase research project, the automated wind warning systems in Oregon are being evaluated against the measures of effectiveness (MOE) shown in Table 1-1. The ones that are being evaluated in this project include:

1. Reduction in wind induced accident frequency and severity
2. Traveler awareness of these systems
3. Traveler perception of the usefulness of these systems
4. Traveler perception of the reliability of the system

5. System accuracy
6. Other operational cost savings

The purpose of this technical memorandum is to assess the systems' operational cost savings (MOE 6). Chapter 2 provides further background on these systems, Chapter 3 reviews their operational concepts, Chapter 4 derives estimates for operational benefits, and Chapter 5 presents benefit-cost ratios.

Table 1-1: Goals, Objectives and Measures of Effectiveness

Goal	Objective	Potential Measures of Effectiveness	Data Source
Improve the safety and security of the region's rural transportation system	Improve the safety of high profile vehicles	▪ Crash frequency for high profile vehicles ▪ Crash severity for high profile vehicles	Crash Data
	Improve safety of lower profile vehicles	▪ Crash frequency for all vehicles ▪ Crash severity for all vehicles	Crash Data
Provide sustainable traveler information systems that collect and disseminate credible, accurate "real-time" information	Improve the motorist information on severe weather conditions	▪ System usage by motorists ▪ Awareness of system among motorists	Motorist Survey
	Improve motorist acceptance and perception	▪ Sign clarity ▪ Message credibility and reliability	Motorist Survey
Increase operational efficiency and productivity focusing on system providers	Improve staff operations efficiency	▪ Savings in personnel time ▪ Reduction in the time to post a message	Maintenance Logs
	System reliability	▪ Number of full system outages ▪ Number of partial system outages	Maintenance Logs
	Improving emergency response	▪ Information sharing	Kick Off

2. SYSTEM DESCRIPTION

This chapter provides more detail on the wind warning systems that are being evaluated in this project along with – for completeness – the system under development in northern California.

2.1. South Coast System

This part of U.S. Highway 101 from Port Orford to Gold Beach has been identified as a high wind area. The ODOT ITS Unit designed a system that uses a local wind gauge (anemometer) to monitor wind speeds in the critical wind speed location (i.e. near Humbug Mountain).

Prior to implementation of the system, when high winds were detected, maintenance staff drove to Gold Beach (MP 330) and Port Orford (MP 300) to flip up folded signs that read "CAUTION HIGH WINDS NEXT 27 MILES WHEN FLASHING" and turn on a flashing beacon to warn traffic about windy conditions. The employee would patrol the highway until the winds subsided, and then manually turn off each sign. This system had a high maintenance cost, required a 60-mile round trip to Gold Beach, and was not timely enough. One of these signs is shown in Figure 2-1.

Figure 2-1: Static Sign with Flashing Beacon at Gold Beach

This process has now been automated. Currently, this system consists of an anemometer that provides continuous input to the controller connected to a flashing beacon on static warning signs located at either end of the corridor. Communication to the two warning signs is automated and is provided using dial-up telephone links. Motorists are informed when average winds of speeds higher than 35 mph are recorded over a given time interval (e.g. 2 minutes). This enhancement has also enabled an automated creation of an instance of severity 0 (zero) incident (for wind speeds between 35 and 80 mph) or a severity two incident (for wind speeds greater than 80 mph) in Oregon's Highway Travel Conditions Reporting System (HTCRS). This incident in HTCRS is then verified by the Traffic Operations Center (TOC) staff. When verified by the TOC staff, the HTCRS warning is posted on ODOT's TripCheck web site.

Project implementation was motivated by the many potential benefits, including equipment cost savings, elimination of unnecessary and possibly unsafe travel by ODOT personnel, and more rapid detection and notification of high-wind conditions, which would improve safety in the corridor.

2.2. Yaquina Bay Bridge System

The second AWWS in Oregon was installed on Yaquina Bay Bridge (US Route 101) between mileposts 141.27 (SB) and 142.08 (NB). ODOT has had a manual process for measuring gusts in the vicinity of the bridge and providing warnings to the public. When gusts or sustained high winds were present, an employee went to the site with a portable anemometer and, if windy conditions were verified, unfolded static warning signs on either end of the bridge. Crossing the bridge to reach the other sign (and then coming back) presented a safety risk for the employee charged with this task.

To avoid the safety risks and to improve operations, ODOT has automated the posting of high-wind warnings. The proposed system originally consisted of a local wind gauge connected to small variable message signs (VMS) located at either end of the corridor with different levels of warning. Due to lack of available funding, the current system uses a static sign that reads “Caution High Winds on Bridge When Flashing” and flashing beacons installed on top of the signs. The signs are located to provide sufficient warning for drivers to be able to turn around on existing roads under either end of the bridge. Although the current signs display a fixed message, the system records two different warning levels. Proposed warnings for each range of sustained wind speeds are shown in Table 2-1. This system also defines the severity of the incident. This severity is automatically recorded in HTCRS, and is then verified by the Traffic Operations Center (TOC) staff. When verified and accepted by TOC staff, a warning message is automatically posted on ODOT’s TripCheck Web site. Faxes are also sent manually to other agencies, and maintenance staff are also notified automatically via pager and / or email. The sign is deactivated when the average wind speed goes below 25 mph. This system will archive data including wind speed, and date and time of warning postings.

Table 2-1: Warning Messages for Yaquina Bay System

Average Wind Speed Range	Warning Message	HTCRS Severity Level
35 to 80 mph	Pending Closure	1
Over 80 mph	Closure	2

2.3. Interstate 5 System

Caltrans has installed a set of changeable message signs (CMS) on Interstate 5 in Siskiyou County between postmiles 13.2 (Weed) to 45.3 (Yreka). Currently there are static signs with no flashing beacons at both the locations indicated above. The static signs are not responsive to real-time weather conditions and they make less of an impression on the drivers, because they display a message of caution irrespective of wind speeds.

Caltrans has been providing high wind warning messages through two CMS: one just south of the Yreka interchange (PM 45.3) and the other at the Abrams Lake over-crossing (PM 13.2) for the southbound and northbound traffic, respectively. There is a weather station installed at the northbound Weed Safety Roadside Rest Area at PM 25.7 to make the system responsive to conditions on a real-time basis. Caltrans is in the process of automating the activation of warning messages through these CMS signs. The CMS also allow greater flexibility in message sets, including the ability to report specific levels of warning, or the actual wind speed.

Table 2-2 summarizes the different characteristics of these three systems. All three systems are currently active. The two systems on US 101 in Oregon are automated, while the system on Interstate 5 in California is operational but not fully automated.

Table 2-2: Summary of Wind Warning System Characteristics.

Charactersitics of the System	AWWS at Yaquina Bay Bridge, OR	AWWS at South Coast, OR	5, Siskiyou County, CA
Flashing/Non-Flashing	Flashing	Flashing	CMS
Static/Dynamic	Static (to be upgraded to CMS)	Static	Dynamic (CMS)
Message sent to sign (manual / automated)	Automated	Automated	Manual (To Be Automated in 2005)
Message posted on Web (manual / automated)	Semi - Automated	Semi - Automated	N/A
Archiving of the Wind Data	Yes	Yes	No
TOC notification of sign activation (manual / automated)	Automated	Automated	To be Automated
TOC notification of wind data (manual / automated)	Automated	Automated	Automated
Location of signage	US Route 101, MP 141.27 (SB) and 142.08 (NB)	US Route 101, MP 300.10 to 327.51	Interstate 5, PM 13.2 to 45.3, Siskiyou County

3. OPERATIONAL CONCEPTS

To expedite the process of activating the warning signs to alert highway users of the high wind hazard, ODOT implemented new systems that automatically activate flashing beacons whenever high winds are detected. These signs are advisory in nature, and the roads are not closed during high wind conditions since drivers have been adequately warned of high winds with the help of an active warning system (not a static sign as shown in Figure 3-1 that warns drivers irrespective of the wind conditions).

Figure 3-1: Typical Static Wind Warning Sign in Oregon

This chapter reviews operations with respect to high wind conditions at both locations, prior to and after implementation of the automated wind warning systems (AWWS). These are important pieces to evaluate the economic savings resulting from these systems. The operational cost savings include *direct cost savings* from not having to use a maintenance crew and highway patrol officers outside of normal hours, and *indirect cost savings* by not having to close the roadway totally but still warning the drivers of impending high winds adequately.

3.1. Operations before AWWS (Base Case)

To assess the cost savings resulting from automating the wind warning process, it is important to define the base case – i.e. how high winds events were handled before the advent of the AWWS.

3.1.1. South Coast System

When maintenance personnel learned of high wind conditions along this corridor – either from the public through telephone calls or through observation of wind speeds during their regular field maintenance activities – a maintenance crew would take a vehicle mounted with an anemometer to the field to measure the wind speeds. If the wind speeds were measured to be higher than 40 mph for a sustained time period, the maintenance crew would call the highway patrol and coordinate a road closure. The road closure was necessary as the 27-mile stretch does not have any rest areas, parking areas, hotels, motels or turn-arounds. Two maintenance personnel (one for each side) were required to be on-site, along with highway patrol officers, to help stop traffic.

Maintenance personnel would monitor high winds until they subsided to a level where the road could be safely opened. Typically, these high winds events last from four to eight hours.

3.1.2. Yaquina Bay Bridge System

The base case for the Yaquina Bay Bridge is identical to that of the South Coast System. Road closures were also used here, as any alternative routes to taking the bridge are at least 20 miles longer, and the bridge acts as a critical link for commuters in the area.

3.2. Operations after AWWS

This section summarizes the operation of each system as implemented. More details on these operations will be provided as Theory of Operations (TOO) diagrams as part of the final evaluation report.

3.2.1. South Coast System

When a high wind event (wind speeds > 35 mph) is detected automatically via anemometer readings, the controller at the Humbug Mountain RWIS dials the controllers at the Port Orford and Gold Beach (Wedderburn) locations. These controllers at the sign locations turn the beacons on. Maintenance personnel are therefore not directly involved, unless a road closure is necessary because of exceptionally severe weather, a crash blocking the roadway, or other factors. Wind speeds are monitored continuously and the signs are deactivated when the average wind speeds over a two-minute time period fall below 25 mph.

3.2.2. Yaquina Bay Bridge System

When a high wind event (wind speeds > 35 mph) is detected, the controller at the bridge dials the controllers at the signs on both ends of the bridge. These controllers at the signs turn the beacons on. The controller attached to the anemometer then notifies the Traffic Operations Center in Salem that the signs are activated. Maintenance personnel are only sent out to close the roads when the wind speeds reach higher than 80 mph. Wind speeds are monitored continuously at regular intervals and the signs are deactivated when the average wind speeds over a two-minute time period fall below 25 mph.

3.3. Motivation for the New Automated Systems

Maintenance personnel responsible for both these systems and the ODOT personnel who developed these systems were interviewed regarding the motivation for automating these systems. (More details are provided in Appendix A.) Maintenance personnel at both locations said that the system was installed to protect their personnel from working outside of their vehicles when high winds are present.

The 27-mile stretch of US Route 101 between Port Orford and Gold Beach experiences high cross winds frequently between November and May. There are no major diversion routes or rest areas available on this stretch of highway. This makes it necessary to warn drivers of a high cross winds hazard before they enter this stretch of highway, so that they can choose to stay in one of the nearby towns until the winds subside or to decide to proceed with caution. A crash in this stretch of highway will effectively close down the road for extended periods of time.

Maintenance personnel stated that the typical road closures due to high cross winds lasted between four and eight hours before the AWWS was installed. Thus, this automated system helps to warn drivers promptly before they get to a high wind hazard situation and potentially avoid crashes, leading to reduction in road closure delays.

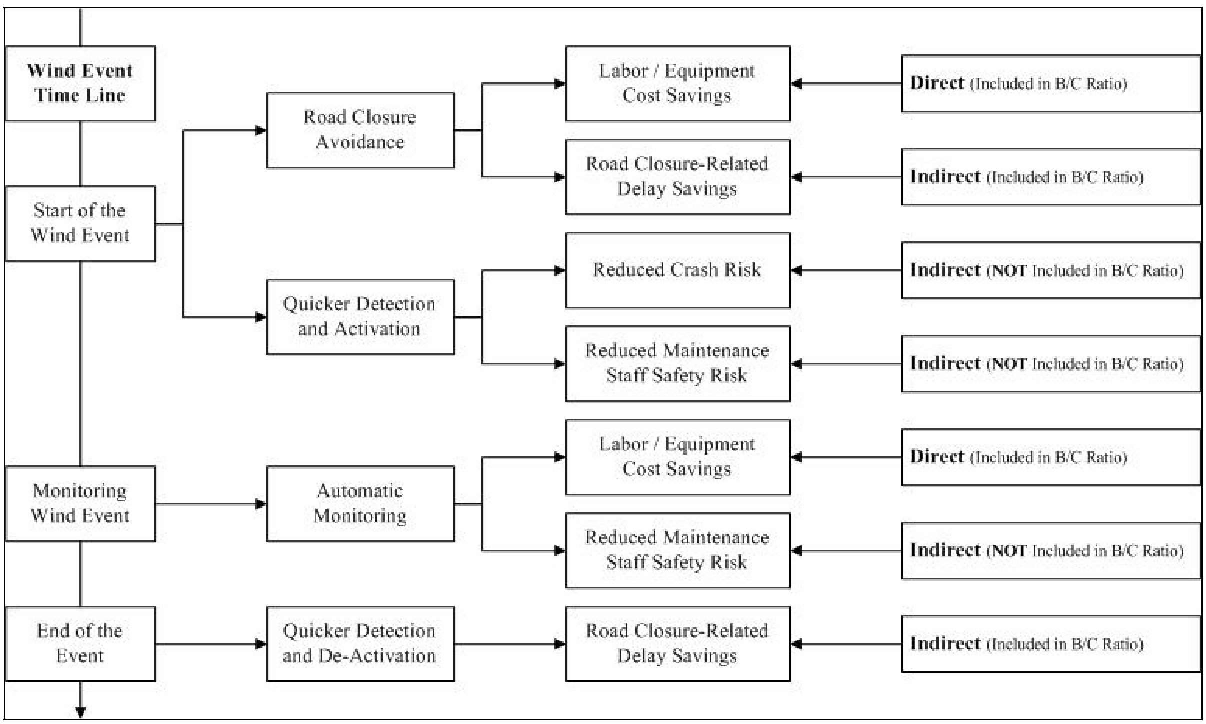
It was noted by maintenance personnel that the Yaquina Bay Bridge on US Route 101 provides a vital link for traffic in and through Oregon along the Pacific coast. When the bridge is closed, vehicles must take an alternate route that is about 20 miles longer and is not designed to handle the additional traffic. This situation makes it important for the bridge to stay open as well as safe for traffic. Crashes that occur on the bridge can lead to bridge closures between four and eight hours, thus leading to numerous hours of delay. This automated system was expected not only to eliminate the need for maintenance personnel to travel to and on the bridge to switch on the signs, but to expedite wind warnings to high-profile vehicles. This would prompt drivers of high-profile vehicles to wait out high-speed winds and gusts, rather than getting caught in a potentially dangerous situation.

4. OPERATIONAL BENEFITS

As mentioned earlier, the operational benefits of the AWWS are both direct and indirect. The direct benefits include the labor and equipment cost savings realized by not having maintenance personnel and state police on-site during wind events to enact road closures. Delay reductions due to automation of activation and deactivation and reduced safety risk for the driving public and maintenance staff are considered indirect benefits for the purpose of this study.

Figure 4-1 shows how the different benefits from using an AWWS – in comparison to the base case – correspond to different points in a high wind event. This breakdown will be used to calculate the benefits of the system. As can be seen, some potential benefits of the system are not included in the benefit-cost calculation because of the high number of assumptions that would need to be made.

Figure 4-1: Schematic Diagram of Direct and Indirect Benefits of AWWS



4.1. Direct Benefits

As was shown in Figure 4-1, the direct benefits of the AWWS result from labor and equipment cost savings realized through avoiding road closures and the need to manually monitor conditions (on-site) during high-wind events at regular intervals. In both cases, the annual savings are a function of the number of high-wind events observed at each site.

Activation records of the AWWS between Port Orford and Gold Beach (South Coast system) show five instances of activation for an average duration of 14 hours and 47 minutes between February and May of 2002 (see Appendix A for more details). It should be noted that these five activations were recorded only over half of a typical high winds season. Maintenance personnel estimate that they would normally have had to close down this section of highway between five and ten times per year because of high winds prior to installation of the AWWS at South Coast. The records of actual activations of the AWWS seem to corroborate these estimates. Since sign activation records were archived only starting June 2005, maintenance personnel's estimate of average road closure duration – between four and eight hours – is used.

For the Yaquina Bay Bridge, maintenance personnel estimated that the bridge would be closed due to high winds about thirty (30) times per year prior to installation of the AWWS. The average duration of sign activation between December 2004 and June 2005 for the Yaquina Bay Bridge system is about 2.5 hours. The activation records are shown in Appendix A. The average duration was calculated after combining events within 30 minutes of each other (i.e. the start time of an event is within 30 minutes of the end time of the next event). More recent records of the sign activations show that the longest events were 16 hours and 2½ hours long for the Yaquina Bay Bridge and South Coast systems, respectively.

Based on the average durations of road closures – four hours for the South Coast system and two and half hours for the Yaquina Bay Bridge system – and the average distances between the maintenance yards and the system locations, the average labor and vehicle costs per closure were calculated as shown in Table 4-1 and Table 4-2 for the two systems. The labor rates were calculated from prevailing wage rates published by the Oregon Bureau of Labor and Industries. To be conservative in the overall estimation of savings, the rates used here are base rates, not overtime rates. Wind-related road closures that occur during overtime periods such as nights or weekends would therefore have higher labor costs (perhaps 50 percent higher). The number of work hours as shown in Table 4-1 and Table 4-2 are estimated by adding the driving time to the average road closure time.

Table 4-1: Labor and Equipment Cost per Road Closure (South Coast)

	Savings on Vehicle Operations		Savings on Labor		Total
Maintenance Crew Savings Per Road Closure	Average Vehicle Rate/Mile	$0.50	Average Wage Rate (Overtime)	$33.47	$635
	Number of Vehicle	2	Number of Crew Members	3	
	Number of Miles Driven	4	Number of Work Hours	6	
	Total	$32.00	Total	$602.51	
Highway Patrol Savings Per Road Closure	Average Vehicle Rate	$0.50	Average Wage Rate	$32.01	$392
	Number of Vehicle	2	Number of Crew Members	2	
	Number of Miles Driven	4	Number of Work Hours	6	
	Total	$8.00	Total	$384.12	
				TOTAL	**$1,027**

Table 4-2: Labor and Equipment Cost per Road Closure (Yaquina Bay Bridge)

	Savings on Vehicle Operations		Savings on Labor		Total
Maintenance Crew Savings Per Road Closure	Average Vehicle Rate/Mile	$0.50	Average Wage Rate (Overtime)	$33.47	$369
	Number of Vehicle	2	Number of Crew Members	3	
	Number of Miles Driven	3	Number of Work Hours	3.5	
	Total	$18.00	Total	$351.47	
Highway Patrol Savings Per Road Closure	Average Vehicle Rate	$0.50	Average Wage Rate	$32.01	$228
	Number of Vehicle	2	Number of Crew Members	2	
	Number of Miles Driven	2	Number of Work Hours	3.5	
	Total	$4.00	Total	$224.07	
				TOTAL	**$597**

Based on the estimated number of road closures, Table 4-3 provides an estimation of direct savings from reduction in road closures per year. It should be noted that the number of times the crews are called in is typically higher than the number of times the road is actually closed.

Table 4-3: Annual Labor and Equipment Cost Savings

	Number of Road Closures per Year	Number of Time a Crew is Called	Total per Year
South Coast System	5 to 10	10	$10,270
Yaquina Bay System	upto 30	30	$17,910

The estimation of the direct cost savings from labor and equipment did not include any special equipment other than the vehicles that may be needed by the maintenance staff to transport road blocks and such. The low totals shown in Table 4-3 are used in the calculation of benefit-to-cost ratio.

4.2. Indirect Benefits

Of the indirect benefits identified in Figure 4-1, only those associated with delay savings related to road closures are included in this analysis.

4.2.1. Traffic Characteristics

Estimated delay associated with road closures is based on traffic characteristics associated with each location. Average daily traffic (ADT) volumes recorded at the nearest automatic traffic recorders (ATR) to the systems were obtained from the ODOT Traffic Counting Program. It is possible that a certain percentage of motorists choose to take an alternate route during high-wind events. An estimation of the percentage of drivers that may choose to take an alternate route was performed based on the responses to the motorist survey conducted for the two locations in Oregon (1). The responses to these questions revealed the following stated preferences for taking alternate routes. Based on Table 4-4, the reduction in traffic at these locations during high wind events may be between 10 and 12 percent for South Coast system and between 5 and 10 percent for Yaquina Bay Bridge system.

Table 4-4: Motorist Survey Responses on Likelihood to Use Alternate Routes

	6b) How likely are you to take another route?			8d) How likely are you to take an alternate route?		
System Location	Very Likely	Somewhat Likely	Total	Very Likely	Somewhat Likely	Total
South Coast	4.5%	7.4%	11.9%	4.5%	5.6%	10.1%
Yaquina Bay	4.1%	2.9%	7.0%	5.8%	5.0%	10.8%

<u>South Coast</u>

The lowest and highest ADTs during the months of high winds season, recorded at an ATR 0.3 miles south of Port Orford, were 2,052 and 2,736 respectively in 2002. The ATR station located 1.1 miles north of the California state line is the nearest ATR station that classifies the vehicles. The percentage of heavy vehicles at this station is approximately 8.7 percent of total traffic. Since there are no major highway junctions on US Route 101 between the state line and Port Orford, the same percentage of heavy vehicle traffic can be assumed for Port Orford. It should be noted that the variation between the maximum hour volume and the 30^{th} hour volume is about two percent of ADT (less than 60 vehicles per hour). The maximum hourly volume for this location is calculated to be 547 vehicles per hour based on Table 4-5 while the average hourly volume is 123 vehicles per hour. This shows that the traffic volume for a typical six-hour wind event can vary significantly if one or two of the peak hours are included. However, the maximum hourly volume may not occur during the high wind season at all.

For a typical six-hour road closure, which includes four hours of wind event duration and one hour of set-up and one hour of removal time, the number of vehicles affected would be one-fourth (i.e. 6 hours / 24 hours) of the seasonal ADT (average volume scenario). A high volume scenario is also presented to document the possible highest indirect benefits. The high volume scenario is calculated by adding the five-hour average traffic volume with the maximum hourly volume. It should be noted that only the benefits based on the average volume scenario are used for estimating the benefit-to-cost ratio. The ADT for the months between November and March ranged between 85 and 98 percent of annual average daily traffic (AADT). The ADT for the high wind season was estimated at 79.4 percent of AADT. . A factor of 0.794 for seasonal variation is used to estimate the number of vehicles delayed. The average and high traffic volumes are estimated to be 584 and 1,033 vehicles, respectively, for a typical six-hour wind-related road closure. A factor of 0.739 to account for passengers who choose to take an alternate route or wait out the wind storm is included. A factor of 0.913 is also applied to calculate the number of passenger cars alone because the percentage of heavy vehicles as indicated earlier is about 8.7 percent of the traffic.

Table 4-5: Estimated Average Daily Traffic through South Coast System Location

YEAR	ADT	Max. Day Volume	Max. Hour Volume	10th Hour Volume	20th Hour Volume	30th Hour Volume
		Percentage of ADT				
2001	2,822	174	17.3	15.7	15.2	15
2002	2,903	204	20.1			
2003	2,867	***	***	***	***	***
2004	2,941	173	18.6	***	***	***
2005	*2,265**	*125*	*13*	***	***	***

* Average of Jan and Feb 2005 *** Not Available

<u>Yaquina Bay Bridge</u>

ADTs for the ATR just north of the Yaquina Bay Bridge at the intersection of US Route 101 and 25th Street in Newport, approximately 2.5 miles north of the Yaquina Bay Bridge, are shown in Table 4-6.

Table 4-6: Estimated Average Daily Traffic (ADT) through Yaquina Bay Bridge

Year	ADT (veh / day)	Max. Day Volume	Max. Hour Volume	10th Hour Volume	20th Hour Volume	30th Hour Volume
		as percentage of ADT				
1997	17,061	152%	12.9%	12.4%	12.2%	12.1%
1998	18,541	190%	18.5%	12.7%	12.0%	11.8%
1999	18,146	135%	11.9%	11.3%	11.1%	11.0%
2000	17,951	141%	12.4%	11.7%	11.5%	11.3%
2001	18,375	***	***	***	***	***
2002	18,598	149%	12.9%	11.9%	11.6^	11.5%
2003	18,900	141%	12.1%	11.6%	11.4%	11.3%
2004	19,295	142%	12.1%	***	***	***
2005	*16,835 **	*104%*	*10.0%*	***	***	***

* Average of Jan and Feb 2005 *** Not Available

The lowest and highest monthly ADTs in 2002 at the Newport ATR during the November to March high wind season were 16,011 and 18,443 respectively. The heavy vehicle percentage recorded at Newport is 5.1 percent. It should be noted that the variation between the maximum hour volume and the 30th hour volume is within one percent (about 150 vehicles per hour). The maximum hourly volume for this location is calculated to be 2,335 vehicles per hour based on Table 4-6 while the average hourly volume is only 804 vehicles per hour. This shows that the average traffic volume for a two and half hour duration (i.e. 2,010 for two and half hours) can vary significantly if one or more of the peak hours are part of the two and half hour duration.

For an average road closure, the number of vehicles affected will be about one tenth (i.e. 2.5 hours / 24 hours) of the seasonal ADT (average volume scenario). A high volume scenario is also presented here to provide an understanding of the maximum possible indirect benefits from the system. The high volume is calculated by adding one twenty-fourth of the seasonal ADT to the maximum hourly volume. The monthly average traffic volume for the months of high wind season ranges between 77 and 97 percent of the AADT. The average traffic volume for the high wind season is 88.2 percent of the AADT. A factor of 0.882 for seasonal variations is used to calculate the number of delayed vehicles. The traffic volume for a two and half-hour duration is estimated to range between 1,773 and 3,399 vehicles over the two and half-hour duration. A factor of 0.716 to reflect passengers who choose to wait for winds to subside or take an alternate route is used to estimate the number of vehicles delayed. A factor of 0.949 is also applied to calculate the number of passenger cars alone because the percentage of heavy vehicles as indicated earlier is about 5.1 percent of the traffic.

4.2.2. Indirect Operational Benefits of South Coast System

For an average six-hour road closure between Port Orford and Gold Beach, it is estimated that 26.1 percent of the motorists and 28.3 percent of high profile vehicles will take an alternate route or wait for the winds to subside when the AWWS is activated. Table 4-7 shows the average delay and cost associated with the delay due to a road closure. The estimation takes into consideration that the high wind events can occur at any time of the day. A low volume scenario and a high volume scenario are presented here to provide an understanding of the possible variations in the benefits. The low volume scenario is the one that is used for the benefit-to-cost ratios presented in the following sections. The value of time is a critical parameter for estimation of benefits and costs, and there is significant variability in the estimated value of time across different studies. For example, an evaluation of Oregon's Operation GreenLight program estimated the value of time for commercial vehicles to be about $1.24 per minute (i.e. $74.40 per hour) (2). The estimation based on the Federal Highway Administration's (FHWA) HERS model was found to be more applicable for this analysis, and so it was used. The value of truck travel per hour using the HERS model is estimated to be $27.83 in 2003 U.S. dollars. The value of time for all employees is estimated to be $18.56 per hour, based on the average wage rate from National Income and Product Accounts (NIPA) of the United States, for 2000 (3).

Table 4-7: Average Delay Costs per Road Closure (South Coast)

Average Delay per Closure	Average Volume Scenario	High Volume Scenario
Passenger Vehicles		
Vehicles Delayed per Closure	394	697
Average Value of Time per Hour	$18.56	$18.56
Average Cost	$7,313	$12,936
Heavy Trucks		
Trucks Delayed per Closure	37	65
Average Value of Time per Hour	$27.83	$27.83
Average Cost	$1,030	$1,809
Average Cost of Delay Per Closure	**$8,343**	**$14,745**

As indicated earlier, it is estimated that there could be up to 10 closures per year. Records of actual activations of the wind warning system between January and April 2002 (half of the high wind season in one year) indicate five activations, averaging 14 hours duration. Without the AWWS, ODOT would have to close the roadway when the high winds reach speeds of 80 mph. If the roads are still closed during these high wind events, there are not any delay savings. To account for this, the number of road closures avoided by the implementation of AWWS is estimated to be five. These road closures would have resulted in estimated delays averaging between $8,343 and $14,745 per closure. For the five avoided road closures, the average annual cost savings due to road closures between Port Orford and Gold Beach would be between $41,715 and $73,725 per year. It should be noted that only the average volume scenario (i.e. $41,715) is used for calculating benefit-to-cost ratio.

Apart from the benefits discussed above, there are also savings from informing the truckers of high wind conditions more promptly. Motorists who choose to wait out the winds when the AWWS is activated (26.1 percent) would start waiting earlier as they are notified earlier through the automated systems compared to a manually operated warning. At the same time, the waiting motorists will be notified of the cessation of high wind conditions earlier through the automated system compared to manually operated warning, because the maintenance personnel only measure the wind speeds at regular intervals (e.g. one- or two-hour intervals). This quicker notification will lead to a reduction in the safety risk of the motorists and may also lead to a reduction in their wait time. Table 4-8 shows the average delay savings from the system for the trucks that choose to wait out the high winds (28.3 percent of the truckers from the motorist survey). Estimated savings are calculated based on various possible levels of effectiveness. These savings are the net savings in delay (i.e. the time saved by deactivating the sign more promptly accounting for the possible earlier start time for waiting motorists).

Table 4-8: Average Delay Savings for Stopped or Diverted Traffic per Wind Event (South Coast)

	Average Volume Scenario	High Volume Scenario
Stopped or Diverted Passenger Vehicles	139	246
Average Cost of Delay for Drivers per Closure	$2,582	$4,567
Estimated Savings from		
10% Reduction in Waiting Delay (36 min)	$258	$457
20% Reduction in Road Closure (72 min)	$516	$913
30% Reduction in Road Closure (98 min)	$775	$1,370
40% Reduction in Road Closure (134 min)	$1,033	$1,827
Stopped or Diverted Truckers	14	26
Average Cost of Delay for Truckers per Closure	$401	$710
Estimated Savings from		
10% Reduction in Waiting Delay (36 min)	$40	$71
20% Reduction in Road Closure (62 min)	$80	$142
30% Reduction in Road Closure (98 min)	$120	$213
40% Reduction in Road Closure (134 min)	$161	$284

As estimated earlier, the number of activations of the signs for extended periods of time is about five times per year during the high winds season (i.e. not including the road closure events). The savings for the drivers that choose to wait out the high winds or take an alternate route is between $2580 and $4565 per year. The savings from the automation of the signs attributable to reducing delays for truckers over one year could range between $400 and $710 per year.

4.2.3. Indirect Operational Benefits of Yaquina Bay Bridge System

Table 4-9 shows the average delay and cost associated with the delay due to the average two and half-hour closure at Yaquina Bay Bridge. It was estimated that 28.4 percent of the motorists and 24.3 percent of the truckers will choose to pullover and wait or take an alternate route when the AWWS is activated from the motorist survey results for Yaquina Bay Bridge system.

Table 4-9: Average Delay Costs per Road Closure (Yaquina Bay Bridge)

Average Delay per Year	Average Volume Scenario	High Volume Scenario
Passenger Vehicles		
Average Number Delayed per Closure	1,205	2,310
Average Value of Time per Hour	$18.56	$18.56
Average Annual Cost	$22,365	$42,874
Heavy Trucks		
Average Number Delayed per Closure	68	131
Average Value of Time per Hour	$27.83	$27.83
Average Annual Cost	$1,892	$3,646
Average Cost of Delay Per Closure	**$24,257**	**$46,520**

As indicated by maintenance personnel when they were interviewed, there were up to 30 bridge closures per year before the installation of AWWS.

Based on the recollection of maintenance personnel during interviews and available weather data, it is estimated that sustained high winds of speeds more than 80 mph for extended time periods occur about 20 times a year. Without the AWWS, ODOT would close the bridge when high winds reach speeds of 35 mph. Even with the AWWS, ODOT still closes the roadways when the wind speeds exceed 80 mph. Based on this information, it can be assumed that the difference in the number of bridge closures since installation of AWWS (i.e. the wind speeds being between 35 mph and 80 mph) is about 10 instances per year. Based on these assumptions, the total annual average costs due to the bridge closures would have been between $242,570 and $465,200 per year (i.e. for 10 bridge closures per year). In the more recent interview of the maintenance personnel, it was indicated that there may be about one road closure in two years due to wind speeds above 80 mph.

Table 4-10 shows the average delay savings from automation of the system for the vehicles, including high profile vehicles that choose to wait out the high winds. Estimated savings are calculated based on various possible levels of effectiveness.

Table 4-10: Average Delay Savings for Stopped or Diverted Traffic per Wind Event (Yaquina Bay Bridge)

	Average Volume Scenario	High Volume Scenario
Stopped or Diverted Passenger Cars per Event	478	916
Average Cost of Delay for Drivers per Closure	$8,869	$17,003
Estimated Savings from		
10% Reduction in Waiting Delay (15 min)	$887	$1,700
20% Reduction in Road Closure (30 min)	$1,774	$3,401
30% Reduction in Road Closure (45 min)	$2,661	$5,101
40% Reduction in Road Closure (60 min)	$3,548	$6,801
Stopped or Diverted Truckers per Event	22	42
Average Cost of Delay for Truckers per Closure	$612	$1,172
Estimated Savings from		
10% Reduction in Waiting Delay (15 min)	$61	$117
20% Reduction in Road Closure (30 min)	$122	$234
30% Reduction in Road Closure (45 min)	$183	$352
40% Reduction in Road Closure (60 min)	$245	$469

As estimated earlier, the number of activations of the signs for extended periods of time is about 10 times per year during the high winds season excluding road closures due to wind speeds of 80 mph or more. The savings for the drivers that choose to wait out the high winds is between $17,740 and $34,010 per year. The savings from the automation of the signs imputable to reducing delays for truckers over one year could range between $1220 and $2,340 per year.

4.2.4. Other Indirect Benefits

For completeness, it is important to note the other potential indirect benefits of the AWWS. While these benefits are not quantified in the benefit-cost analysis, they should be acknowledged as a part of the overall system effectiveness.

Safety Benefit

With a more reliable and prompt wind warning, fewer vehicles will be exposed to high wind events, which consequently should decrease crash risk. Crashes at either location could result in a road closure, causing significant delay. The relatively infrequent number of wind-influenced crashes at each location would require a significant number of assumptions in order to estimate potential safety benefits attributable to AWWS. The Oregon crash report form does not have high winds listed as a contributing factor. This makes it even more difficult to measure the safety benefits of AWWS at these two locations. An analysis of wind influenced crashes in California and Minnesota to determine the typical characteristics of wind influenced crashes is presented in Technical Memorandum 3 (4).

With some basic assumptions, the safety benefits associated with reducing crashes appear small, because of the relative infrequency of wind-related crashes. The average crash rates over the wind season (i.e. November to March) are estimated to be 0.67 and 1.27 crashes per million vehicle miles of travel (VMT) for the South Coast and Yaquina Bay Bridge systems, respectively, based on crash data for years between 1997 and 2003. The annual average crash rates are estimated to be between 0.57 and 0.75 per million VMT for the South Coast and Yaquina Bay Bridge locations, respectively, averaged over the same time period. Using these crash rates, it was determined that the reduction in crash exposure for the driving public from one less hour of exposure to high winds because of more prompt sign activation would be 0.0017 crashes per hour and 0.00037 crashes per hour for South Coast system and Yaquina Bay Bridge system, respectively. In other words, it would take hundreds or thousands of high-wind events for the earlier system activation to reduce the expected number of crashes by even one at either location. In both locations, however, a crash will not only affect the safety of people directly involved in the crash, but will also likely close the road, causing potentially significant delays. These benefits are real, but are not quantified because of the numerous assumptions required.

Reduced Risk for Maintenance Personnel

Maintenance personnel could be susceptible to a greater risk of injury when exposed to high-wind events. The relatively infrequent number of injuries to maintenance personnel would make it difficult to precisely estimate the potential benefits in this area.

Reliability and Customer Satisfaction

Automation of the systems has led to better customer satisfaction and also a better perception of the reliability of the warning system. A higher perception of reliability leads to better adherence to the advisory warning message that can potentially result in safer driving conditions and reduced overall delay for everyone.

5. BENEFIT-COST RATIO

The direct and indirect benefits were estimated as shown in previous sections of this report. Some of the direct and indirect benefits of the two systems in Oregon could not be estimated and are not included in the benefit cost ratio calculations in this section.

5.1. System Costs

The implementation costs of these systems were estimated to be approximately $90,000 for both the systems and the annual maintenance costs of the South Coast system and Yaquina Bay System are expected to be $3,000 and $3,500 per year respectively. These costs were estimated, because the systems were designed, built and installed by ODOT, and numerous state resources were used in the processes that were not readily traceable. Estimation of maintenance costs are based on another COATS Showcase study regarding maintenance costs of field elements in rural areas.

Table 5-1: System Implementation and Maintenance Costs

	Implementation Costs	Annual Costs (Recurring)		
		Maintenance	Operational	**Total**
South Coast System	$90,000	$1,500	$1,500	$3,000
Yaquina Bay System	$90,000	$1,500	$2,000	$3,500

5.2. Methodology

The identified costs and benefits in the previous sections of this document were used to calculate the benefit-to-cost ratio presented in this section. The following assumptions were made for this estimation.

1. A ten year analysis period was used for the calculation of benefit-to-cost ratio.
2. A traffic growth rate of 2 percent per year and a rate of return (ROR) of 7 percent are assumed.
3. 3 percent inflation is assumed to calculate the benefits in 2004 US dollars.

5.3. South Coast System

The benefit-cost ratio for the South Coast AWWS was estimated as shown in Table 5-2.

Table 5-2: Benefit-Cost Table (South Coast)

Annual Savings From Non-Closures (Direct)	
Wage and Equipment Cost Savings from Non-Closure	$5,135 to $10,270
Annual Savings from Non –Closure (Indirect)	
Savings from Non-Closure through delay reductions	$41,715 to $73,725
Annual Savings from Automation (Indirect)	
Savings from Automation for Truckers and Drivers (for 20 % delay reduction)	$2980 to $5275
Annual Operations and Maintenance Costs (Recurring)	
Power, Communication and Maintenance Costs	$3000
Installation Costs (Non-Recurring)	
Initial Installation Costs	$90,000
B/C Ratio (Over 10 Years)	
Direct Benefits Alone	0.87
Direct and Indirect Benefits Included	4.13
Number of Years Before Benefits Exceed Costs	
Direct Benefits Alone	12 Years
Direct and Indirect Benefits Included	3 Years

5.4. Yaquina Bay Bridge System

The benefit-cost ratio for the Yaquina Bay Bridge AWWS is derived in Table 5-3.

Table 5-3: Benefit-Cost Table (Yaquina Bay Bridge)

Annual Savings From Non-Closures (Direct)	
Wage and Equipment Cost Savings from Non-Closure	$11,940 to $17,910
Annual Savings from Non –Closure (Indirect)	
Savings from Non-Closure through delay reductions	$242,570 to $465,200
Annual Savings from Automation (Indirect)	
Savings from Automation for Truckers and Drivers (for 20 % delay reduction)	$18,960 to $36,350
Annual Operations and Maintenance Costs (Recurring)	
Power, Communication and Maintenance Costs	$3500
Installation Costs (Non-Recurring)	
Initial Installation Costs	$90,000
B/C Ratio (10 Yrs. Life)	
Direct Benefits Alone	1.46
Direct and Indirect Benefits Included	22.8
Number of Years Before Benefits Exceed Costs	
Direct Benefits Alone	7 years
Direct and Indirect Benefits Included	1 Year

5.5. Summary

The estimated benefit-cost (B/C) ratios indicate that both AWWS in Oregon will result in direct returns equal to their installation and recurring maintenance and operations costs to ODOT equal to the cost of installation and annual maintenance within 12 years for the South Coast system and 7 years for the Yaquina Bay Bridge system. If delay reductions to the motorists are considered, the benefits of the system pay for the system installation and maintenance costs within two years for the South Coast system and one year for the Yaquina Bay Bridge system. As was stated earlier, these B/C estimates did not include any indirect benefits such as improved safety for maintenance personnel and improved safety for the motorists during high wind events. Higher benefits from Yaquina Bay bridge system can be attributed to the facts that Yaquina Bay Bridge experiences high cross winds more frequently than the South Coast system location and also that the traffic through the Yaquina Bay bridge is much higher than the traffic through the South Coast system location.

It can be concluded that these AWWS deployments offer significant cost savings to drivers as well as ODOT. These systems also allow more prompt high wind notifications to the drivers thus reducing exposure of the driving public to high cross winds along US Route 101.

APPENDIX A

Activation Records for Warning Signs at Port Orford and Gold Beach

LOCATION	TIMES		DURATION
(Hwy 101)	DATE / HOUR ON	DATE / HOUR OFF	
MP 300	2/17/02 23:18	2/18/02 7:24	8:06:00
MP 327	2/17/02 23:20	2/18/02 8:30	9:10:00
MP 300	2/23/02 23:18	2/24/02 7:24	8:06:00
MP 327	2/23/02 23:20	2/24/02 8:30	9:10:00
MP 300	2/25/02 7:00	2/26/02 10:05	27:05:00
MP 327	2/25/02 7:00	2/26/02 10:05	27:05:00
MP 300	3/1/02 0:15	3/1/02 8:28	8:13:00
MP 327	3/1/02 0:15	3/1/02 8:28	8:13:00
MP 300	4/19/02 12:09	4/20/02 8:30	20:21:00
MP 327	4/19/02 12:57	4/20/02 8:13	19:16:00
		Avg. Duration	14:47:48

Activation Records for Warning Signs at Yaquina Bay Bridge

Event #	Date / Hr On	Date / Hr Off	Duration
1	12/13/04 15:51	12/13/04 17:01	1:10
2	12/25/04 7:43	12/25/04 16:23	8:40
3	2/28/05 11:31	2/28/05 12:41	1:10
4	3/16/05 11:13	3/16/05 15:37	4:24
5	3/19/05 14:15	3/20/05 7:05	16:50
6	3/20/05 7:55	3/20/05 8:25	0:30
7	3/20/05 17:15	3/20/05 20:05	2:50
8	3/20/05 20:55	3/20/05 21:05	0:10
9	3/26/05 3:46	3/26/05 5:42	1:56
10	3/26/05 9:24	3/26/05 9:34	0:10
11	3/26/05 9:44	3/26/05 10:04	0:20
12	3/26/05 10:34	3/26/05 11:44	1:10
13	3/26/05 11:54	3/26/05 13:19	1:25
14	3/26/05 13:34	3/26/05 19:54	6:20
10-14			10:30
15	3/26/05 21:55	3/26/05 22:25	0:30
16	3/26/05 22:35	3/26/05 23:25	0:50
17	3/26/05 23:35	3/26/05 23:55	0:20
18	3/27/05 0:05	3/27/05 3:05	3:00
15-18			5:10
19	3/27/05 3:25	3/27/05 9:59	6:34
20	3/28/05 8:41	3/28/05 11:12	2:31
21	3/28/05 23:02	3/29/05 1:10	2:08
22	3/29/05 4:24	3/29/05 4:52	0:28
23	4/12/05 7:19	4/12/05 7:29	0:10
24	4/12/05 9:40	4/12/05 10:20	0:40
25	4/12/05 17:30	4/12/05 17:50	0:20
26	4/16/05 1:23	4/16/05 3:13	1:50
27	4/16/05 5:24	4/16/05 5:34	0:10
28	4/16/05 6:54	4/16/05 7:04	0:10
29	4/23/05 3:22	4/23/05 4:12	0:50
30	5/18/05 11:22	5/18/05 12:42	1:20
31	5/18/05 14:42	5/18/05 15:02	0:20
32	5/18/05 15:22	5/18/05 15:52	0:30
31-32			1:10
33	5/19/05 2:13	5/19/05 3:33	1:20
34	5/21/05 16:25	5/21/05 16:35	0:10
35	5/21/05 18:15	5/21/05 19:35	1:20
36	6/5/05 10:36	6/5/05 10:46	0:10
		Average	2:40

APPENDIX B

ODOT and Caltrans maintenance personnel responsible for operating and maintaining the wind warning systems were asked the following questions so that the operations and maintenance could be documented.

1. What are the reasons for the deployment of the system? What is the specific problem that the system was deployed for?
2. Architecture:
    a. Who is responsible for the maintenance of specific components (Anemometer/RWIS, Controller, Static sign with flashing beacon/CMS)?
    b. What are the communication devices and medium?
3. Are archived data in terms of wind speed, direction and activation time periods available? If available who would be responsible contact point?
4. What is the wind speed thresholds used in these systems? Did the maintenance staff provide them? If so, how did you arrive at them?
5. Why and how were these locations selected for the deployment of these projects?
6. What do the maintenance staffs think that are the mileposts of influence?
7. What are the typical characteristics of the travel in these corridors? Check the proposed motorist survey method for the site.
8. Does the maintenance staff possess any records on the activation of signs before these signs were automated?
9. Have they had any liability issues with these systems?
10. Could we get a copy of the design drawings?
11. How/ why did the agency decide to deploy the particular instrument/ technology that they chose?
12. What are the pre implementation and post implementation operations procedure?

Personnel who were contacted include:

- Robert Fynn, Oregon Department of Transportation Region 2
- Jerry Gregory, Oregon Department of Transportation Region 3
- Dave Kubishta, Oregon Department of Transportation Region 2
- Galen McGill, Oregon Department of Transportation Traffic Management Section
- Phill Pitts, California Department of Transportation District 2
- Stacy Shetler, Oregon Department of Transportation Traffic Management Section
- Doug Spencer, Oregon Department of Transportation Traffic Management Section
- Ian Turnbull, California Department of Transportation District 2

1. What are the reasons for the deployment of the system? What is the specific problem that the system was deployed for?

South Coast System

Galen/Doug/Stacy

Safety and operational Benefits; to warn motorists of high cross winds well in advance and prevent users from being in the middle of high crosswinds.

Jerry Gregory:

The initial motivation for this system was derived from motorist staff safety concerns. While the primary reason was safety, personnel time savings by automation of turning the warning signs on, was the secondary motivation.

Yaquina Bay Bridge System:

Galen/Doug/Stacy

The motivation for deploying this system over the bridge is to warn the high profile vehicles before they attempt to cross the bridge so that they can take the turn around routes below the bridge to get to a rest area near by and wait. High cross-winds typically exist for an average duration of 2- 3 hours. There are no alternates to get across the bay and the motorists would have to travel an additional 30 miles to get around the bay.

Dave Kubishta and Robert Fynn

The major reason for this deployment is the presence of a long history of wrecks on the bridge due to high crosswinds. Since this two-lane bridge is a key to the traffic across the bay, the bridge needs to be open. This system necessitates preventive measures to avoid crashes on the bridge.

Interstate 5 System (Yreka):

Phill Pitt

The primary motivation for the deployment of these systems is the operational savings.

2. System Architecture:

a. Who is responsible for the maintenance of specific components (Anemometer/RWIS, Controller, Static sign with flashing beacon/CMS)?

b. What are the communication devices and medium?

South Coast System

Galen/Doug/Stacy

The interface (controller) is being maintained by Doug while Bill Roberts (ODOT Region 3) is maintaining the other field components (i.e. the anemometer and controller). The communication between the interface and the signs and the communication between signs and TOC are all voice modem based dial-up communication.

The anemometer is placed in Humbug Mountain. This component does not measure temperature or pressure. The Atek interface that is part of the system placed at Humbug Mountain receives wind speed and direction data and determines whether the winds are higher than 35 mph and turns on the sign at Port Orford. The sign calls up the regional TOC and reports its activation. The interface then calls up the sign at Gold Beach and activates the sign. This sign also reports to the TOC that it is activated. The same procedure is followed for deactivation of these signs. Activation and deactivation takes up to seven telephone calls. The phone line is desired to be transformed to SCR frame release network.

Jerry Gregory

Originally, the system was planned such that the signs would be turned on if there are high cross winds recorded either by the anemometer at Humbug Mountain or at the RWIS at Port Orford. The RWIS station at Port Orford is not measuring the true wind speed because it is sheltered. Now the system is planned such that the system would be turned on when the anemometer at Humbug Mountain records high cross winds.

<u>Yaquina Bay Bridge System</u>:

Galen/Doug/Stacy

There are three warning levels at this site. When wind speeds are 30-35 mph, a warning message is displayed. A caution message is issued when the wind speeds are above 60 mph and less than 85 mph. The bridge is closed for high profile traffic when the wind speeds are above 85 mph. With the current system the motorists are warned of high crosswinds when the wind speeds are above 35 mph and the maintenance staff would have to go out to close down the bridge.

Dave Kubishta and Robert Fynn:

The controller attached to the anemometer would determine whether there are hazardous conditions due to cross winds and activate the flashing beacons on the sign. The controller will also send a message to the Region 2 TOC. TOC will alert the dispatch that will send a crew to close the roads to high profile vehicles if the winds of higher speed than 80 mph.

When the system is in place, there would be two levels of warning that would be given. Level 1 (> 35 mph and < 60 mph) involves activating the signs (flashing beacons on the signs), notifying the Region 2 TOC and automatically informing the field offices, dispatch and the press by fax. Level 2 (> 60 mph) activities include all of the Level 1 activities plus sending out a crew is to close the roads for high-profile vehicles. A closure message would be posted when the signs are upgraded to a VMS.

<u>Interstate 5 System (Yreka)</u>:

No information provided.

3. Are archived data in terms of wind speed, direction and activation time periods available? If available who would be responsible contact point?

South Coast System

The wind speed and direction data are not archived. (Jerry Gregory might have recorded some of the wind speeds sporadically in a sheet of paper Ref: Sue from the kick off meeting)

Yaquina Bay Bridge System

A NTCIP- and NWS-compliant interface that works better than the Atek interface (used in the South Coast system) is being used for wind data archiving in the Yaquina Bay Bridge system. Wind speed is defined as the average of instantaneously measured speeds over two minutes, whereas gust speed is the average of instantaneously measured speeds over 10 minutes. The contact point for archived wind data is Doug Spencer.

Interstate 5 System (Yreka):

Phill Pitts:

Dino Johnson at Redding (Caltrans Dist. 2) would be contact point for any archived data. Ian mentioned that he would be able to provide the archived wind data from the RWIS server.

4. What are the wind speed thresholds used in these systems? Did the maintenance staff provide them? If so, how did you arrive at them?

South Coast System

Galen/Doug/Stacy:

The wind speed thresholds were got from the maintenance staff from their experience. The threshold is 35 mph. When the wind speed gets higher than 35 mph, the system provides motorists the advisory message by turning the flashing beacons on.

Yaquina Bay Bridge System

Galen/Doug/Stacy:

There are three warning levels at this site. When the wind speeds are 30-35 mph, a warning message is displayed. A caution message is issued when the wind speeds are above 60 mph and less than 85 mph. The bridge is closed for high profile traffic when the wind speeds are above 85 mph. With the current system the motorists are warned of high crosswinds when the wind speeds are above 35 mph and the maintenance staff would have to go out to close down the bridge.

Dave Kubishta and Robb Fynn:

When the system is in place, there would be two levels of warning that would be given. Activities for each level are described earlier.

Interstate 5 System (Yreka):

No Information provided.

5. Why and how were these locations selected for the deployment of these projects?

South Coast System

The local commuters may wait for the winds to subside while tourists may decide to proceed and find themselves in the middle of high winds. There has been a history of overturned trailers, semi trucks and single vehicle accidents caused by high crosswinds along this corridor

Yaquina Bay Bridge

Galen/Doug/Stacy

There is a good amount of truck traffic through this bridge and this bridge is the key facility to get across the bay.

Dave/Robert

The major reason for this deployment is the presence of a long history of wrecks on the bridge due to high crosswinds. Since this two-lane bridge is a key to the traffic across the bay, the bridge needs to be open. This necessitates preventive measures to avoid crashes on the bridge.

Interstate 5 System (Yreka):

Phill Pitts:

The worst wind area, influenced by Mount Shasta, is between Weed and Grenada.

6. What do the maintenance staffs think that are the mileposts of influence?

South Coast System

The milepost of influence is the corridor between the locations of static signs at Port Orford and Gold Beach.

Yaquina Bay Bridge

The milepost of influence is the length of the bridge both ways.

Interstate 5 System (Yreka)

Ian indicated that the milepost of influence is the corridor between the locations of CMS at Yreka and Weed.

7. What are the typical characteristics of the travel in these corridors? Check the proposed motorist survey method for the site?

South Coast System

Jerry Gregory

There is a significant amount of local freight up to Coos Bay and there is also good number of commuters from Brookings. (This prompted the residential survey of motorists to include the Brookings area as well). Joe Costa Trucking Company runs a lot of trucks around this corridor. There are also trucks to and from Crescent City and Smith River.

Yaquina Bay Bridge

The majority of the truck traffic is delivery truck traffic to the coast from the valley. There is also a good amount of RVs and campers driven by tourists.

Interstate 5 System (Yreka)

Phill Pitts:

The traffic here is primarily long-distance and there are high winds all around the year in this region.

8. Does the maintenance staff possess any records on the activation of signs before the signs were automated?

South Coast System

There is a local program being used by the maintenance staff that may be used to get the activation records. Bill Roberts is responsible for the maintenance of this system.

Yaquina Bay Bridge

Dave/Robb:

There are regular winds all over the year averaging at speed of 40 to 45 mph. The night crews were usually called in about 30 times a year.

Interstate 5 System (Yreka)

Phill Pitts:

The wind gets too high three to four times a year, and the roads were required to be closed at these times.

9. Have they had any liability issues with these systems?

South Coast System

These signs are just advisory, so there are no liability issues.

Yaquina Bay Bridge

These signs are just advisory in nature and the maintenance staffs go out with high patrol to close the bridge when the bridge gets closed for high profile vehicles.

Interstate 5 System (Yreka)

Phill Pitts:

No information provided.

10. Can we get a copy of the design documents?

South Coast System

Copies of the design drawings were provided.

Yaquina Bay Bridge

Copies of the design drawings were provided

Interstate 5 System (Yreka)

Phill Pitts

No design drawings; contact Ian.

11. How/ why did the agency decide to deploy the particular instrument/ technology that they chose?

South Coast System

Galen/Doug/Stacy

The Atek interface system was in place when Doug joined ODOT and Atek has been used in a flood warning system in Texas. Atek was preferred for the following reasons

1. It supports voice modem and data modem

2. It can give voice system notification over phone system during the alarm.

Yaquina Bay Bridge

Galen/Doug/Stacy

NTCIP and NWS compliant interface that works better than Atek interface for wind data archiving.

Interstate 5 System (Yreka)

The system is designed and run by the District 2 office. Phill has been out of the loop for the deployment of this system.

12. What are the pre implementation and post implementation operations procedure?

South Coast System

Galen/Doug/Stacy

This system covers 27 miles of the US Route 101 corridor from Port Orford to Gold Beach. The anemometer is placed in Humbug Mountain. The Atek interface that is part of the system placed at humbug receives the wind speed and direction data and determines whether the winds are higher than 35 mph and turns on the sign at Port orford and the sign calls up the regional TOC and reports its activation. The interface then calls up the sign at Gold Beach and activates the sign. This sign also reports to the TOC that it is activated. The same procedure is followed for deactivation of these signs. Activation and deactivation takes up to seven telephone calls. The phone line is desired to be transformed to SCR frame release network.

Yaquina Bay Bridge System

Galen/Doug/Stacy

There are three warning levels at this site. When the wind speeds are 30-35 mph, a warning message is displayed. A caution message is issued when the wind speeds are above 60 mph and less than 85 mph. The bridge is closed for high profile traffic when the wind speeds are above 85 mph.

There are no competitive alternate routes to get across the bay. There are turn around facilities near both the ends of the bridge. The road closure warning would enable the high profile vehicles to turn around and wait until the gusts die down or take another route that may be 20 to 30 additional miles.

Interstate 5 System (Yreka)

Phill Pitts:

No information provided.

REFERENCES

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