DEVELOPMENT OF CRITERIA TO IDENTIFY LOCATIONS FOR ITS DEPLOYMENT

Showcase Evaluation #21

Final Technical Report

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GLOSSARY OF ABBREVIATIONS

AADT	Annual Average Daily Traffic
CCTV	Closed-Circuit Television
DMS	Dynamic Message Sign
DOT	Department of Transportation
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GIS	Geographic Information Systems
HTCRS	Highway Travel Conditions Reporting System
ITS	Intelligent Transportation Systems
LRS	Linear Referencing System
MPO	Metropolitan Planning Organization
MUTCD	Manual on Uniform Traffic Control Devices
ODOT	Oregon Department of Transportation
RWIS	Road Weather Information Systems

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

As the extent of their deployment has increased in recent years, intelligent transportation systems (ITS) are becoming a more widely accepted and trusted part of the surface transportation system. Local residents, businesses and agencies appreciate the benefits of these systems, which in turn increases the demand for more such deployments. Both of these trends are evident in Oregon, where the Oregon Department of Transportation (ODOT) is responsible for deploying ITS elements on the state's highway system, which includes over 8,000 miles of roadway. In a fiscally-constrained environment, however, ODOT will be unable to meet the full demand. It is therefore desirable to establish criteria to help ODOT prioritize the location of future field elements as funding becomes available. These criteria will allow ODOT's ITS infrastructure to yield the highest potential benefit or rate of return by deploying field elements in the most efficient and productive locations.

To respond to this need, ODOT worked with the Western Transportation Institute at Montana State University to undertake a research project, with funding by the U.S. Department of Transportation's Research and Innovative Technology Administration. Under this project, quantifiable criteria would be developed for selected ITS technologies using data readily available from ODOT to assist in prioritizing potential locations for field element deployments. This analysis would be done in a geographic information systems (GIS) environment to maximize the potential for examination of spatial relationships.

This report summarizes this research project. Chapter 2 reviews similar efforts undertaken in other jurisdictions. Chapter 3 expands on the methodology that was used in this project. Chapter 4 describes the different data sources that were used in generating and evaluating the criteria. Chapter 5 presents the resulting criteria, and applies them to ODOT's highway system. Finally, Chapter 6 summarizes the project's findings and provides recommendations for next steps.

2. LITERATURE REVIEW

An extensive review was performed to find how specific ITS field elements are typically placed by transportation agencies. Numerous organizations were contacted including state department of transportations (DOTs) and ITS organizations and vendors both inside and outside the United States. The information gathered from the vendors was limited to how the specific ITS element worked and how to physically set them up once a location had been selected.

Among ITS organizations, ITS America provided useful information as well as contacts to assist in the research. Contacts with ITS organizations internationally, including ITS Sweden, ERTICO (ITS Europe), ITS Canada, ITS Japan and ITS Australia did not yield any applicable findings.

The state DOTs that were contacted and had pertinent information were Arizona (1), Utah (2), and Washington (3). ITS design guidelines from the Wisconsin Department of Transportation were also helpful (4), as was the Federal Highway Administration's (FHWA) Freeway Management and Operations Handbook (5). This chapter summarizes the guidelines developed by these states for dynamic message signs (DMS) and closed-circuit television (CCTV) cameras, and discusses potential applicability to Oregon.

2.1. DMS Guidelines

The placement criteria for DMS from these references are listed in Table 2-1, and may be summarized as follows.

- Support Detour Information. Signs should be located two miles prior to interchanges with major routes or alternative routes as defined by the DOT, and just prior to the first off-ramp for cities having three or more off-ramps. Two miles is considered a good distance in order to ensure the motorist remembers the message and has time to react.

- Other Traveler Information. Signs should be placed two miles prior to mandatory snow chain areas. Signs should also be placed five miles prior to a border or a port of entry.

- Site Design. When possible, signs should be placed in areas where there is at least 800 feet of straight road. The sign spacing should follow the same rules as described in Section 2 of the Manual on Uniform Traffic Control Devices (MUTCD), "Guide Signs: Freeways and Expressways". Finally, signs should be placed and designed so as to be visible at all times. The sun should not interfere with the motorist or reflect off of the sign. This may require consideration of pixel luminosity or shielding.

Table 2-1: DMS Placement Criteria for Selected States

State	Guideline
Arizona	▪ Place two miles prior to interchanges with major routes ▪ Place two miles prior to first exit into city having three or more off-ramps ▪ Place two miles prior to alternate routes for full standard roadway closure ▪ Place on all interstate freeways within five miles of a border or port of entry ▪ Place two miles prior to areas with mandatory snow-chain usage
Utah	▪ Place at least two miles prior to every freeway-to-freeway and major highway interchange ▪ Place at all inbound freeway state border crossings.
Washington	▪ Place where possible with at least 800 feet of straight road ▪ Sign spacing to follow MUTCD Section 2 "Guide Signs-Freeways and Expressways" ▪ Place so visible during day as well as night with little or no sun interference
Wisconsin	▪ Locate in advance of alternative route access points, at a minimum distance of 1 mile on freeways ▪ Place on sites located on tangents to allow a motorist at least 900 to 1,000 feet (for freeway speeds) or 500 feet (for arterial speeds) of clear sight distance ▪ Place on sites where vertical grade is less than 4 percent (ideally less than 1 percent) ▪ Place at least 800 feet from a Type I guide sign on freeways, or 400 feet on arterials
FHWA	▪ Should not compete with existing roadway signs ▪ Upstream from major decision points (e.g. exit ramps, freeway-to-freeway interchanges, or intersections of major routes that will allow detours) ▪ Upstream of bottlenecks, high-accident areas, and/or special event facilities ▪ Locate where information concerned weather conditions is essential

2.2. CCTV Guidelines

Table 2-2 summarizes the placement criteria for closed-circuit television (CCTV) cameras as presented in the various guidance documents. These criteria may be summarized in a few general categories.

- Urban Area Monitoring. Maximum camera spacing in congested areas, such as interchanges, should be one mile to help monitor arterial flow. Cameras should be used when volume to capacity ratios exceed 0.90. Finally, CCTV should be placed so that there are no blank spots in busy sections of road.

- Other Monitoring. CCTV can also provide monitoring outside of urban areas. The guidelines suggest camera placement in areas that are known to have adverse weather conditions such as high winds, flooding, and avalanches. Another criterion that could be used is to place cameras near rest areas and other parking areas such as park and ride lots for security purposes. Finally, CCTV can be placed near other ITS elements such as DMS or road weather information systems (RWIS) for monitoring purposes.

Table 2-2: CCTV Placement Criteria for Selected States

State	Guidelines
Arizona	▪ Place at locations where adverse weather conditions are present ▪ Place at locations where power and communications are present or will be present ▪ Place near RWIS or DMS for monitoring purposes ▪ Place on fixed structures such as bridges to ensure a shake-free picture.
Utah	▪ Place at freeway interchanges where arterial volume to capacity averages are greater than or equal to 0.9. ▪ Place to monitor DMS ▪ Place near Intermodal Transit Facilities and Park and Ride Lots for security purposes
Washington	▪ Locations should provide clear line of sight with minimal obstructions ▪ Located at a maximum distance of one mile between cameras ▪ Use on busy sections of road so there are no blank spots ▪ Locate at each interchange to monitor merging traffic ▪ Use two cameras at freeway-to-freeway interchanges (one camera for each direction) ▪ Use to verify DMS (instead of sending personnel on service calls)
Wisconsin	▪ Place at 1-mile spacing for urban areas for full freeway or urban area coverage ▪ Use at isolated interchanges for spot location surveillance related to incident verification or crash investigation ▪ Place in order to verify ramp meter or DMS operation ▪ Place in order to see major cross streets in addition to primary freeway or arterial

- Site Design. Cameras should be placed so there is a clear view of the road and traffic. CCTV should be placed near power or in areas where power will soon be available. As often as possible cameras should be placed on fixed structures such as bridges to ensure clear and steady pictures.

2.3. Summary

The guidelines developed by these states are helpful in identifying candidate locations and assessing considerations related to site selection and system design. If a particular location meets at least one of the guidelines, then it would merit consideration for that element. Nevertheless, these guidelines are not fully defined and would require engineering judgment to identify the best locations for these technologies. In these ways, these guidelines function similar to the warrants that have been developed for considering whether traffic signals should be installed.

As each of the states include a mix of urban and rural applications, these guidelines provide useful input in helping Oregon develop guidelines for DMS and CCTV deployment in its own state. However, these guidelines are not sufficient for Oregon for three reasons. First, these guidelines are not helpful when comparing one location, where one guideline is satisfied by a significant margin, against another location, where several guidelines are only marginally met. Second, these guidelines reflect the functionality of each technology as used by each state; in some cases, however, Oregon may use DMS and CCTV to meet different transportation system requirements. Third, these guidelines do not provide enough information for a systemwide identification of priority locations for these technologies.

Therefore, this research project will seek to develop quantifiable guidelines, building on this earlier work, to help ODOT identify prospective locations for DMS and CCTV on a statewide basis.

3. METHODOLOGY

As was discussed in the previous chapter, several jurisdictions have given consideration to quantitative or objective guidelines to assist in the deployment of ITS field elements. However, these considerations are, more often than not, heuristic or "rule of thumb" approaches that were not easily applicable on a statewide level. Therefore, a methodology had to be developed for a statewide analysis. This methodology for developing individual criteria is shown in Figure 3-1, and is described in the remainder of this chapter.

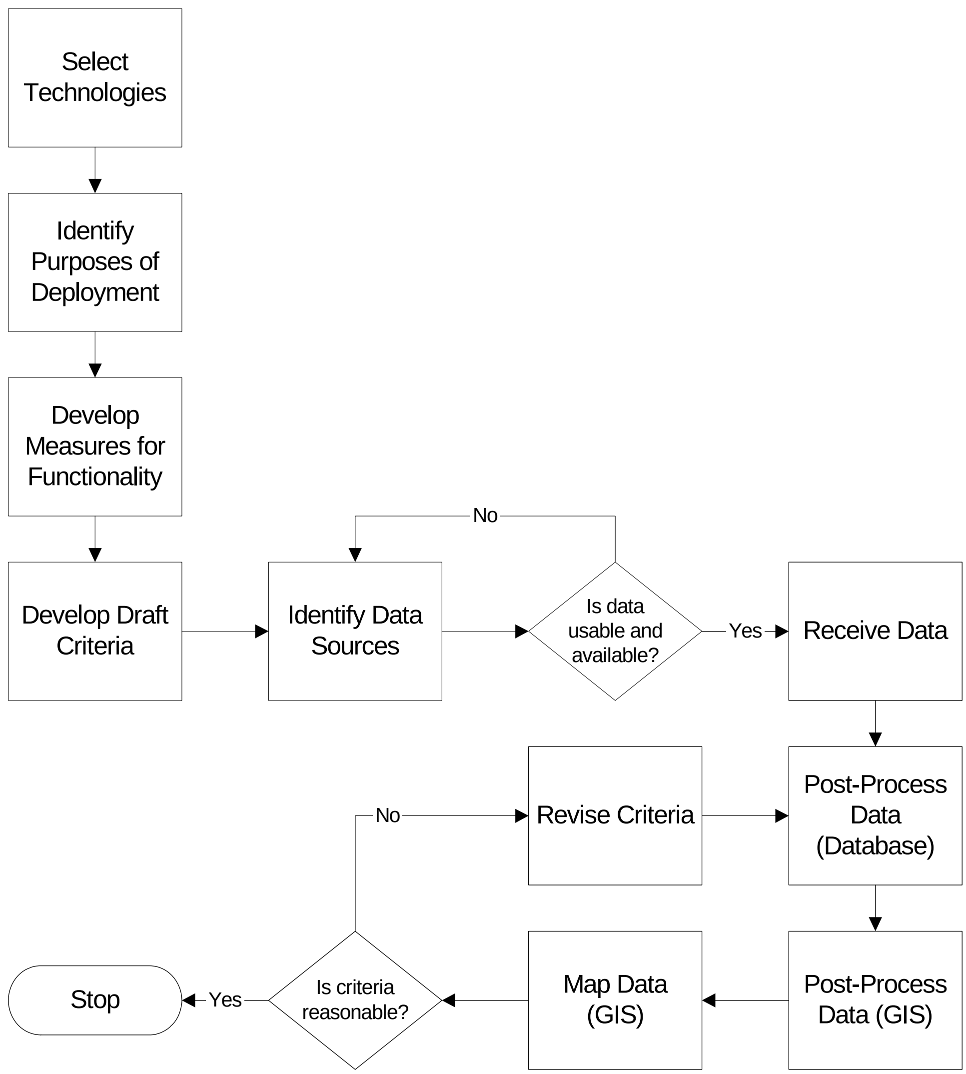


Figure 3-1: Methodology for Developing Criteria

3.1. Technology Selection

At the outset of the project, three candidate technologies were identified for consideration in this project: dynamic message signs, closed-circuit television cameras and road weather information systems (RWIS). While there are some common considerations across these and other technologies (e.g. power availability), the problems addressed by specific technologies were felt to be diverse enough that the research team focused on only two technologies – DMS and CCTV cameras. If the methodology were to be successfully developed for these technologies, it may be transferable to other technologies.

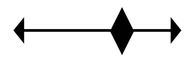
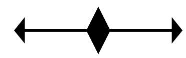
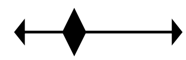
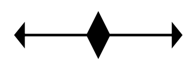
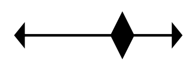
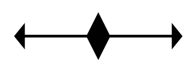
3.2. Purposes of Deployment

In order to best assess where ITS field elements should be deployed, it is important to identify the potential needs served by each deployment, and link these applications to potential measures and data sources. This section lists the applications that were identified for each technology under consideration, and potential measures and data sources.

3.2.1. DMS

The purpose of DMS is to provide real-time, en-route traveler information to drivers to help them make their trip safely and efficiently, with the least inconvenience. Several potential applications were identified for DMS, including incident prevention, incident management, non-incident congestion management, work zone activities, weather warnings and AMBER alerts. Table 3-1 describes how the DMS can be used for each of these applications, along with identifying, in general, whether such an application is more common in urban or rural deployments.

Table 3-1: DMS Applications

Applications	Description	Urban – Rural
Incident Prevention	DMS can inform motorists of conditions that may affect safety, including weather conditions, unexpected curves and grades	
Incident Management	DMS can inform motorists of incidents that are ahead. This will alert drivers to potential safety risks, potential delay, and advise them of alternative actions, such as detours.	
Non-Incident Congestion Management	DMS can inform motorists of recurrent congestion at major activity centers (e.g. sports/concert venue, national park, major tourism attraction, etc.) to advise them (e.g. parking locations, recommended detours)	
Work Zone Activities	DMS can inform motorists of current work zone activities, to warn them of potential delay, advise them of alternative routes, and encourage them to slow down (thereby enhancing worker safety). DMS can also inform motorists of future work zone activities (pre-trip information). Drivers can then prepare to take alternate routes or modes to avoid delay.	
Weather Warnings	DMS can warn motorists of inclement weather conditions ahead (e.g. flooding, high wind, dust, snow zone, fog) that may affect travel, and recommend action (e.g. slow down, take detour)	
AMBER Alerts	DMS can inform motorists of child abductions to help speed the safe return of a child to his/her parents or guardians.	

Within each of these applications, there may be several data measures which could be used. In some cases, an individual measure may only provide a part of the picture; therefore, multiple data sources may be needed to develop that measure. These are summarized in Table 3-2. It can be seen that there is some redundancy of data sources across different applications. It should be noted that these lists were developed before considerations of data availability.

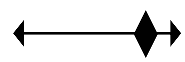
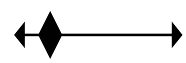
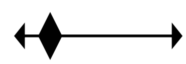
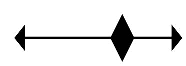
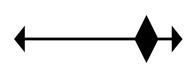
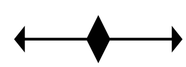
Table 3-2: Measures and Potential Data Sources for DMS Applications

Application	Elements	Data Requirements
Incident Prevention	High-crash locations	• Crash frequency by milepost • Daily and peak hour traffic volumes
	Areas prone to bad weather	• Snow zone locations • Mountain passes • RWIS locations • High-wind locations (e.g. Columbia Gorge, US 101) • Flooding locations • Percent of crashes due to weather
	Areas with steep grade / tight curves	• Percent of crashes due to geometric feature
Incident Management	High-crash locations	• Crash frequency by milepost • Daily and peak hour traffic volumes
	Impact of crashes on traffic flow	• Frequency/duration of road closures due to incidents • Frequency of incidents • Duration of incident impacts on traffic (e.g. clearance time) • Daily and peak hour traffic volumes
	Locations where documented detour is available	• Locations of detour start and end points
Non-Incident Congestion Management	Major trip generators	• Daily traffic generation estimate for sites • Frequency of events at sites • Daily mainline traffic volume for primary access routes
	Locations with significant commute traffic	• Peak hour level-of-service for mainline traffic (in counties which contain part of an MPO) • MPO boundaries • County boundaries
	Locations where detour is available	• Daily mainline traffic volume • Daily ramp-to-ramp traffic volume • Locations of major junctions
Work Zone Activities	Locations of with significant traffic impact, night work or long-term work zone activities (e.g. lane, ramp, road closure or detour)	• Locations and durations of significant traffic impact or long-term work zone activities
AMBER Alerts	High-visibility locations on likely escape routes	• Location of other DMS • Daily traffic volumes

3.2.2. CCTV Cameras

The purpose of CCTV cameras is to provide remote surveillance of highway operations, in order to improve incident response and management, improve maintenance efficiency, and provide real-time, pre-trip traveler information to drivers to help them make their trip safely and efficiently, with a minimum of inconvenience. Several potential applications were identified for CCTV cameras, including incident detection, incident response and management, non-incident congestion management, pre-trip traveler information, maintenance and security and verification. Table 3-3 describes how CCTV cameras can be used for each of these applications, along with identifying, in general, whether such an application is more common in urban or rural deployments.

Table 3-3: CCTV Applications

Applications	Description	Urban – Rural
Incident Detection	CCTV can be used to provide quicker detection of incidents, especially in remote areas where traffic volumes are lower and cellular coverage is poor. Detection may occur by observing crashes, but more typically by identifying locations where traffic is unexpectedly slow.	
Incident Response and Management	CCTV can be used to provide more detailed information of highway incidents to help coordinate and execute a quick response. In urban areas, major highway corridors are often covered with cameras deployed at a 1-mile spacing, to ensure the ability to remotely verify and manage all incidents.	
Non-Incident Congestion Management	CCTV can help traffic management center staff identify congestion hot spots, in order to identify the location and nature of information that needs to be provided to motorists.	
Pre-trip Traveler Information	CCTV images can be posted on an Internet site or TV to provide motorists with pre-trip information about conditions they will experience at locations which frequently experience severe congestion or weather problems.	
Maintenance	CCTV can provide maintenance staff with pictures of current conditions so they know whether to go to remote locations (e.g. snowplowing, change a rotary drum sign, perform other maintenance activities)	
Security and Verification	CCTV can be used to verify the security of major transportation assets, such as bridges and tunnels, and to monitor vehicles entering the state for unusual activity. CCTV can also be used to confirm messages on DMS.	

Measures and potential data sources for each of these applications are listed in Table 3-4.

Table 3-4: Measures and Potential Data Sources for CCTV Applications

Application	Elements	Data Requirements
Incident Detection	High-crash locations	• Crash frequency by milepost
	Slow emergency notification times	• Emergency notification times • Areas with poor cellular phone coverage
	At major junctions	• Locations of freeway-to-freeway interchanges • Location of major interchanges in urban area
Incident Response and Management	High-crash locations	• Crash frequency by milepost
	Slow emergency response times	• Average emergency response times
	At major junctions	• Locations of freeway-to-freeway interchanges • Location of major interchanges in urban area
	Coverage of urban corridors	• Urban area boundaries • Locations of existing CCTV cameras
Non-Incident Congestion Management	Areas with recurrent congestion	• Urban locations with poor level-of-service
Pre-trip Traveler Information	Unfavorable conditions	• Mountain passes • Bridges, tunnels and other normal highway bottlenecks
	Locations of interest	• Mountain passes and ski areas • Beaches • National and state parks • Other destinations
Maintenance	Far from maintenance yards	• Maintenance yard locations
	Locations where weather is critical	• Current and proposed RWIS locations
Security and Verification	Locations of major transportation assets	• Locations of bridges and tunnels • Annual average daily traffic volumes
	Locations of DMS for message verification	• Locations of DMS deployment
	High-visibility locations on major routes	• Locations of state highways serving as points of entry into state

3.3. Development of Criteria

The research team's approach to this project was to develop a set of independent criteria that would be evaluated individually on a point scale. Each location on the state highway system would be evaluated over all criteria, and the points for that respective location would be summed. The locations with the highest summed values would be recommended as strong candidates for application of a given technology[1].

With the identification of purposes and potential applications of each technology along with prospective data sources, an iterative process began. The research team developed initial criteria which were reviewed at a high level by ODOT stakeholders to determine where it was feasible to use existing data sources to quantify these criteria on a statewide basis. As the research team worked with the data, it became clear in certain cases that the data was not of sufficient accessibility, quality or detail to be readily usable in this project. Criteria were modified accordingly.

After this iteration, the research team developed maps showing how each of the criteria would be evaluated on a statewide basis. The criteria were then refined to provide for consistency in scale across maps. The scores developed under each criterion were then added together to develop a list of locations for each technology, which were presented to ODOT Traffic Management Section staff for a review of reasonableness.

[1] The prioritization of actual deployment in these locations may differ based on other factors, which are described in Section 5.3.

4. DATA SOURCES

This project used a variety of data sources and analysis methods in order to develop the criteria for identifying locations where ITS could be deployed. This chapter summarizes some of the key data and the post-processing work that was done in either GIS or spreadsheet environments to develop criteria.

4.1. Highway Network

The foundation for the analysis is establishing a highway network. This was accomplished by using three highway network files that were provided by ODOT for the years 2002-04. The plan was to combine these three files in order to create a highway network that would accommodate as much data as possible. However, the highway network has slight variations from year to year. This created problems in mapping the various data elements, especially the location of crashes (described later). Segments were taken from all three years using manual means until all but four crashes were accessed.

Once a common network was developed, the highways were sorted by ODOT's Linear Referencing System (LRS) highway number[2]. A GIS program was written that determined the smallest start milepost and the largest end milepost for each LRS. Another program was written that divided each highway into one-mile segments. This program started at the smallest start milepost and ended at the largest end milepost. The programs were then combined and the result was a template that would be used throughout the remainder of the mapping process.

4.2. Average Annual Daily Traffic

Three files were provided that contained annual average daily traffic (AADT) data for 2000, 2001 and 2002. The highway segments for which the AADT had been calculated varied from year to year (i.e. the milepost ranges were different). In order to use these files they first needed to be combined. This was done through the use of a table that divided the segments into smaller segments so that all segments were consistently defined across the three files.

An example of two segments from two different files is shown in Figure 4-1. The result of combining the two segments is also shown in this figure.

[2] Mileposts are defined according to LRS highway number, not the posted Oregon State Route or US Route highway number. Using posted route numbers as references would lead to non-unique milepost identification.

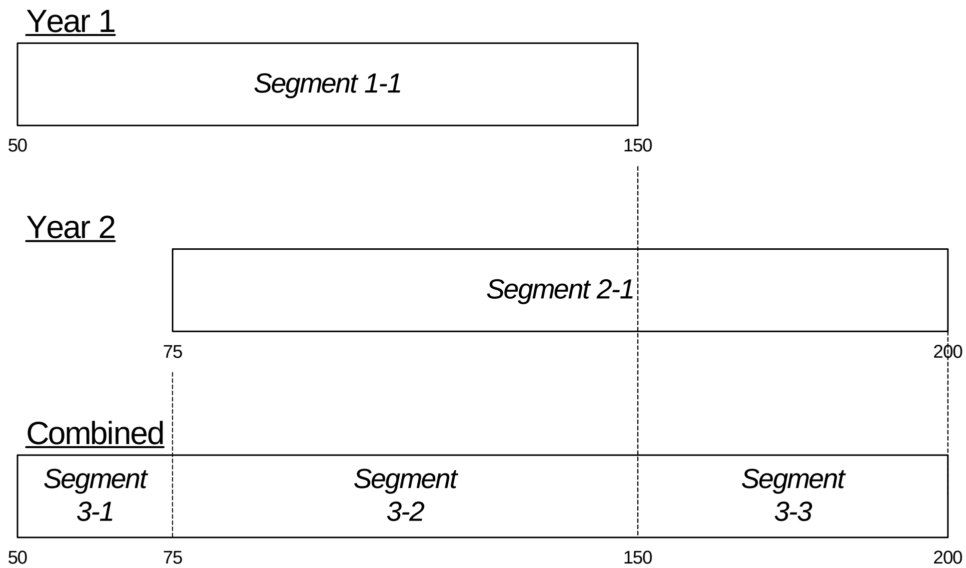


Figure 4-1: Mile Segment Division

During the blending of the files, all of the AADT values were preserved. This would preserve three years of AADT for calculation of a three-year crash rate. If a segment was represented by only one year of AADT then it was multiplied by three. Similarly, if a segment only had AADT values for two years then it was multiplied by 1.5.

Another program was written that would calculate AADT for the mile segments for the entire state. An attribute was added in the template file that contained the AADT value for each mile segment. The program would then read the combined segments that contained AADT values. The program would calculate AADT values for those portions where the AADT segments overlapped for a given mile segment.

The AADT data that was provided did not cover both sides of divided highways; therefore, the AADT value for the other side of the highway had to be calculated. The simplest method for obtaining values for the other side of the highway was when the mileposts matched. If the mileposts did not match than it was calculated based on how much of the highway proportions overlapped.

4.3. Truck Traffic

ODOT provides percentages of truck traffic according to FHWA’s 13-bin vehicle classification system, shown in Table 4-1. For the purposes of this study, vehicles in classes 5 through 13 were classified as trucks.

Table 4-1: FHWA 13-bin Vehicle Classification System

Vehicle Class	Description
1	Motorcycles
2	Passenger cars
3	Other 2-axle, 4-tire single-unit vehicles
4	Buses
5	2-axle, 6-tire single-unit trucks
6	3-axle single-unit trucks
7	4- or more axle single-unit trucks
8	4- or less axle single-trailer trucks
9	5-axle single-trailer trucks
10	6- or more axle single-trailer trucks
11	5- or less axle multi-trailer trucks
12	6-axle multi-trailer trucks
13	7- or more axle multi-trailer trucks

(Source: 6)

ODOT estimates these percentages of trucks at scattered locations throughout the state, as opposed to average daily traffic estimates which are calculated for the entire length of each highway. To interpolate estimates on truck percentages between consecutive points A and B on a highway, it was assumed that truck percentages on the highway would remain at values observed at point A until a point equidistant from point B. This is shown in Figure 4-2.

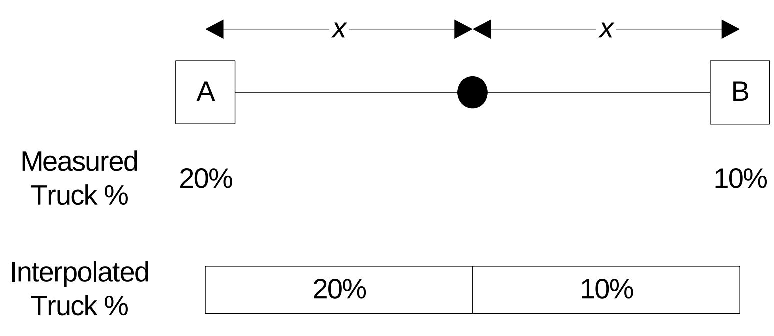


Figure 4-2: Interpolating Truck Percentage Values

4.4. Congestion

ODOT provided information on congestion on highways not in conventional level-of-service terminology, but in terms of percent time congested. This measure refers to the percentage of traffic using a segment of roadway that would be expected to experience congestion on a given day. This measure was defined into four quartiles: 0 to 25 percent, 25 to 50 percent, 50 to 75 percent, and 75 to 100 percent.

4.5. Highway Types

Using the template created earlier, the highway segments were classified as freeway or non-freeway, primary or secondary, and rural or urban. These segments were defined as follows.

- Freeway/Non-Freeway. Freeways include the Interstate system along with other controlled access facilities in Oregon, including the Sunset Highway (US 26), the Beltline (OR 69), OR 217 and OR 144.

- Primary/Secondary. Primary highways are those for which the LRS number is less than 100. Secondary highways have LRS numbers greater than 100. Primary highways tend to be longer and provide intercity access, while secondary highways are often shorter and provide more localized access.

- Rural/Urban. For crash analysis purposes, ODOT considers highway segments to be urban if they are within incorporated city limits, regardless of whether a city has 1,000,000 people or 1,000. While this may be adequate for crash analysis purposes, the research team believed that ITS deployment may have a different character not on the basis of an incorporation boundary, but rather between metropolitan areas and non-metropolitan areas. Metropolitan areas tend to be characterized by commute-related traffic congestion that could influence the locations of cameras and dynamic message signs. Oregon has six metropolitan planning organizations (MPOs) – Metro (Portland), Lane Council of Governments (Eugene), Salem-Keizer Area Transportation Study, Rogue Valley Council of Governments (Medford), Bend and Corvallis. Planning boundaries were obtained for each of these MPOs. Segments of state highways which went through these jurisdictions were designated as "urban"; all other highway segments were designated as rural.

Based on this categorization there were eight possible combinations of highway types. The highway types were then joined with the AADT mile segments data. Problems arose when there were unknown highway types, missing mile segments or overlapping mile segments. These were dealt with by editing them manually.

4.6. Vehicle Crashes

Crash records were provided in three separate files for the years 2000 through 2002. Among other fields, these records provided the LRS number, milepost, and conditions at the time of the crash (e.g. road conditions, lighting, and weather). The crash data was sorted according to LRS number and starting milepost. Using the mile segment template described earlier, attributes were added for crashes, weather and road conditions for each crash scene. A program was written that would read both the crash data and the template file simultaneously. Therefore, crashes for each mile segment were tabulated, along with separate tabulations for the number of crashes associated with specific road and weather conditions.

4.7. Crash Rates

Crash rates were calculated for each mile segment using the following equation:

$$Crash\_Rate = \frac{\#\,of\ Crashes \times 1{,}000{,}000}{AADT \times Segment\ Length \times 366\ Days}$$

The number of crashes and AADT were summed over the length of the segment. An average crash rate for each highway type was calculated, along with a standard deviation. These three-year average crash rates were checked against ODOT's annual crash rates (7) to ensure general comparability. The crash rates for each segment were then compared to the average values to identify high-crash mile segments. This process is summarized in Figure 4-3.

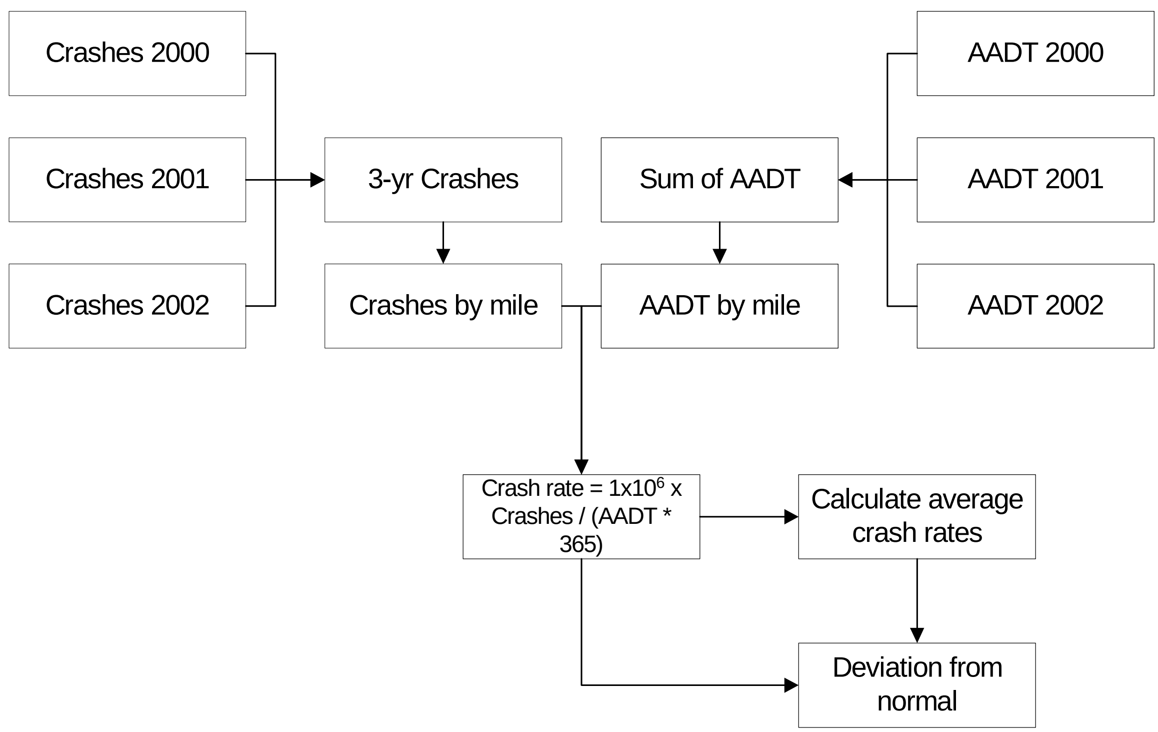


Figure 4-3: Method for Calculating Crash Rates

4.8. Crash Percentages by Road and Weather Conditions

The crash data indicated the road surface and weather conditions at the time of the crash. Road surface conditions were classified as unknown, dry, wet, snowy, icy and ash. Weather conditions were classified as unknown, clear, cloudy, rain, sleet, fog, snow, dust, smoke and ash. The total number of crashes for which the road surface condition was something other than "dry" or "unknown", or the weather condition was something other than "clear" or "unknown" was classified as a weather-related crash.

4.9. Freeway Interchanges

Volume data for ODOT's freeway interchanges was obtained from ODOT's web site using the interchange ramp volume diagrams for 2003 (8). Figure 4-4 shows an example of the ramp volume diagrams used.

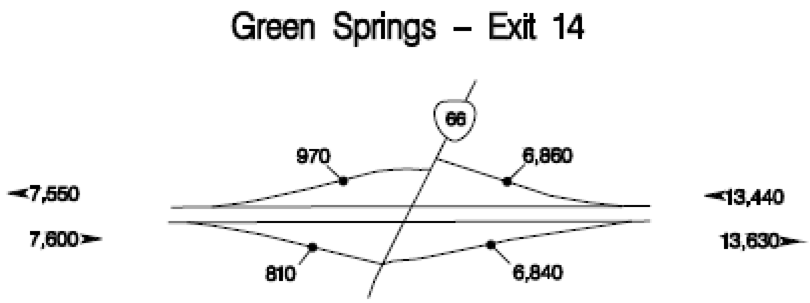


Figure 4-4: Ramp Volume Diagram

In each diagram, a simple representation of the interchange was shown along with ramp volume data. This data was input into a spreadsheet in order to calculate ratios between the ramp and mainline traffic volumes. These ratios were used as a proxy to determine how regionally significant an interchange is, and therefore how suitable it might be for detours in the event of an incident. Separate ratios were calculated for either side of the interchange (e.g. ramps to/from the north, ramps to/from the south). The ratios were calculated as follows:

$$Ratio = \frac{volume_{ramp}}{volume_{mainline}}$$

From Figure 4-4, the ramp volume is 6,860 + 6,840 and the mainline volume is 13,440 + 13,630.

$$Ratio = \frac{6{,}860 + 6{,}840}{13{,}440 + 13{,}630} = \frac{13{,}700}{27{,}070} = 0.51$$

In addition to traffic volumes, the location of each interchange – including the approximate milepost of the cross-street and the average mileposts of the ramp termini on either side of the interchange – also needed to be determined. This was accomplished using ODOT's TransGIS web site (9). Each interchange was located and the nearest milepost was also determined for each ramp of the interchange for both directions of traffic. The interchanges were located to the nearest 1/10th of a mile.

4.10. Intersection Spacing

DMS are often used to convey information about the need to take detours or alternative routes. As such, much of their utility depends on the proximity of available alternative routes. For simplicity, it was assumed that alternative routes would be limited to ODOT routes. The nearest detour would then be defined by the nearest intersection with an ODOT route. While this provides a good density of alternative routes in parts of the state, such as the Willamette Valley, it leads to few apparent alternative routes in other parts of the state, even though there may be county maintained roads which could provide reasonable alternative routes in emergencies.

4.11. Mountain Passes

Mountain passes were located by reviewing Oregon's official state map (10), along with location descriptions from ODOT's traffic volume tables. Every mountain pass regardless of elevation was included. All mountain passes were listed including the LRS number, route number, milepost, elevation and name. Mountain passes were located to the nearest half-mile using the TransGIS web site in conjunction with the statewide map.

4.12. Attractions and Ski Areas

A list of attractions consisting mostly of State Parks and other scenic attractions was obtained through the Oregon Tourism Commission (11). In order to keep the number of attractions at a manageable level, a minimum annual visitation of 200,000 was used as a cut-off value. Once the list was finalized the attractions were looked at individually.

The majority of the attractions had web sites so information about the location with respect to Oregon's highway system could be found. For simplicity, the attraction was considered to be located at the point on Oregon's highway system nearest to the entrance. Once the directions were obtained, using the state map in conjunction with the TransGIS web site, the location of the attraction was located to the nearest mile.

To estimate the cumulative effect of many attractions, the visitation associated with these attractions was summed over a five-mile radius from each mile segment.

A separate class of attractions was designated for ski areas, which may have special interest in relation to traveler information for visitors who may travel considerable distances. The following ski areas were included (12): Anthony Lakes, Cooper Spur, Ferguson Ridge, Hoodoo, Mt. Ashland, Mt. Bachelor, Mt. Hood Meadows, Mt. Hood SkiBowl, Spout Springs, Summit, Timberline Lodge, Warner Canyon and Willamette Pass.

4.13. Wind and Flood Conditions

Identifying locations with high winds and/or frequent flooding is important for safety purposes. Wind condition data was provided by ODOT in the form of a surface coverage, where every part of the state was assigned a wind power range value. This value could be used to determine the relative availability of wind for energy. Wind speed ranges were provided for each wind power range. This wind data was input into the mile segment template based on wind speed ranges. A program was then used to locate the high wind areas along routes. This information was then joined with the mile segments template. A program was then written to locate mile segments that were split by any differing wind categories. The larger wind category was assigned to those mile segments.

Federal Emergency Management Agency (FEMA) flood maps obtained from ODOT were used to identify potential flooded segments on ODOT's highway system. Maps were available for approximately 70 percent of Oregon's counties, so flooding data was not available for all counties. These maps provided estimates of flooding for different areas. Each area with a value of "A" (which corresponds to areas inundated by 100-year flooding, for which no base flood elevations have been determined) was determined to be susceptible to flooding. It should be noted that in many cases the highway is likely elevated above the flood plain so the risk of flooding may be reduced.

4.14. HTCRS

In the last few years, ODOT has developed and used an application called the Highway Travel Conditions Reporting System (HTCRS) to assist in providing traveler information. HTCRS accepts data entry from ODOT and Oregon State Police personnel regarding events that may impact travel for Oregon motorists, including incidents, construction, maintenance, and weather. Operators will create an event, and then update the event as its status changes (for example, as lanes are opened following an incident which closes a road).

HTCRS data was obtained for a period covering March 1, 2001 to December 31, 2003. Several steps were used to post-process this data to make it usable for this project. A brief review was conducted to ensure that "test" incidents (those used to demonstrate system capability or train new staff) were removed. Dates were checked for validity and reasonableness, and highway numbers were also checked for consistency over the course of an event. Following these checks, the data was processed according to the flow chart shown in Figure 4-5:

- Only incidents categorized as "accidents" or "weather" were included, as they could be expected to have some repeatability and seasonality within the time period covered by the data. The construction and maintenance categories were not likely to be evenly distributed across the highway system, while for other categories – commercial vehicle advisory, for example – it would be difficult to quantify a delay impact.

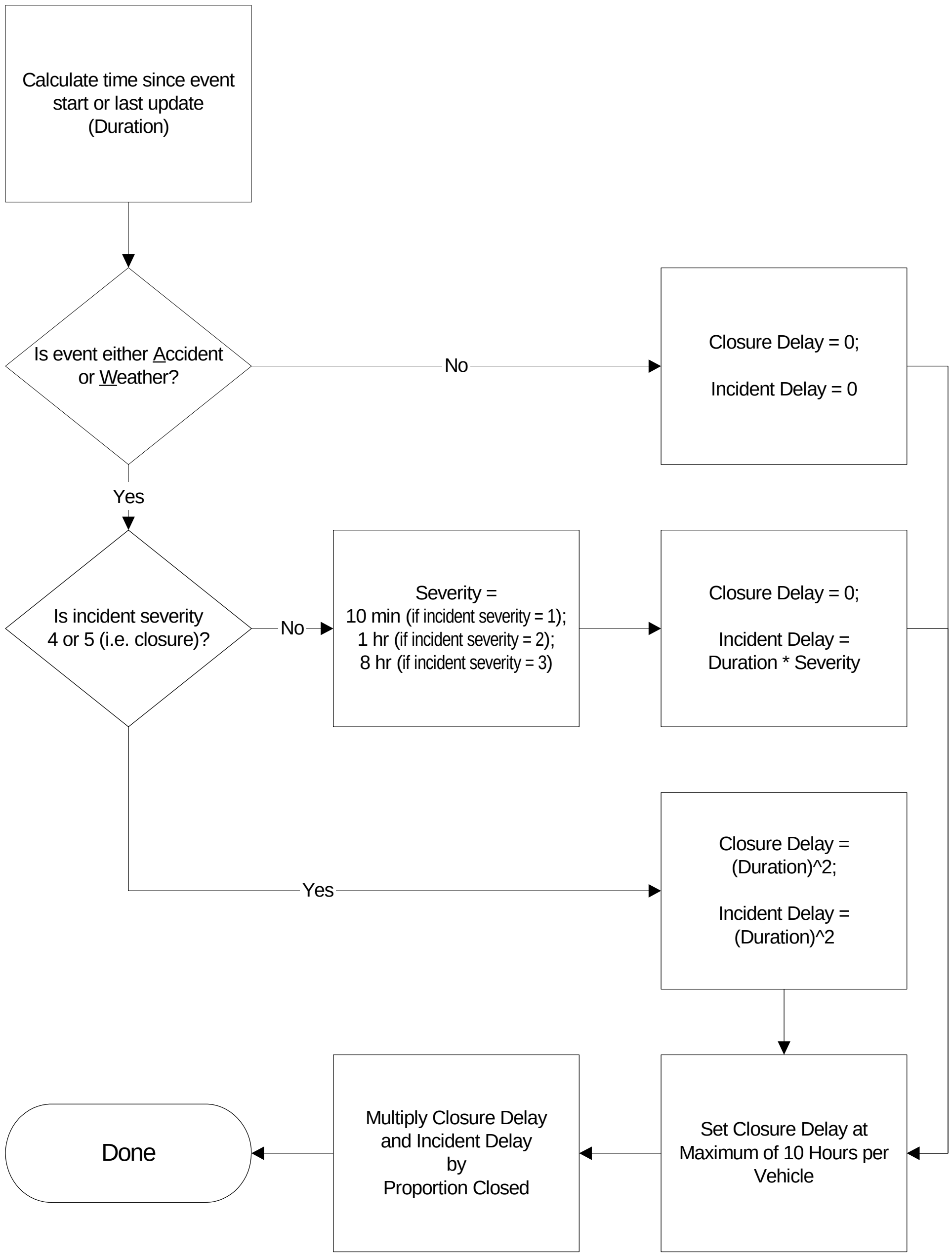


Figure 4-5: Estimating Incident Duration from HTCRS Data

- Incident severity levels of 4 or 5 refer to a highway closure. In the event of a highway closure, the closure delay and incident delay values would be the same. To calculate these delay values, the duration of the closure would be squared, to account for the potential accumulation of traffic awaiting release of the closure. In cases involving long-term closures (for example, the regular closure of McKenzie Pass over the winter, or the unexpected closure of a coastal highway because of mudslides), a maximum delay of ten hours was established for a highway closure. This assumed that travelers would be aware of longer closures through prior experience (in the case of regular closures) or other outlets of traveler information including radio, television and portable signage (in the case of unexpected closures). Either way, they would be likely to adjust their travel plans as they depart for a trip, controlling the number of vehicles experiencing the full delay.

- For lesser incident severities, average delays were based on values shown in Table 4-2.

Table 4-2: Assumptions for Incident Delay

Incident Severity Code	Range of Values	Assumed Value
1	Less than 20 minutes	10 minutes
2	20 minutes to 2 hours	1 hour
3	2 to 24 Hours	8 hours
4	>24 Hours Closure	N/A
5	Long-term Closure	

- Incident and closure delays were multiplied by a factor based on the lanes affected by an incident. This factor varied between 0 and 1, depending on whether any lanes were open, whether traffic was shifted onto a shoulder or median, whether traffic was controlled by flaggers, and similar considerations.

The resulting units of this calculation are in hours; these are then multiplied by the average daily traffic to derive estimates of vehicle-hours of delay.

4.15. Highway Geometrics

4.15.1. Horizontal Curves

A data set containing all horizontal curves on Oregon's highway system was obtained. These data included: highway, beginning milepost, degree of curvature, direction of curve (left or right), central angle, length of curve, tangent length and spiral length and angle. From the highway and beginning milepost, the type of highway was identified according to the eight classifications described earlier. For each type of highway, a typical driving speed was assigned, as shown in Table 4-3. The required radius of curvature was then calculated for each driving speed assuming a conservative superelevation (e) of 0.04. Curves where the actual radius was less than 75 percent of the required radius were identified as sharp curves.

Table 4-3: Assumed Speeds for Various Highway Types

Area	Road Type	Speed
Rural	Freeway	65
	Non-Freeway	55
Urban	Freeway	55
	Non-Freeway	45

4.15.2. Vertical Grades

A data set containing all vertical grades on Oregon's highway system was obtained. These data include: beginning milepost, percent grade at beginning milepost, elevation at beginning milepost, indication of sag, or crest and curve length. A profile of each highway was established from this data by calculating elevations at every 0.1 mile. The profiles were verified against the known elevations along each route and were found to be satisfactory for the purpose of this analysis. Significant vertical grades were identified by looking at trends in grades along each highway. Significant vertical grades were defined as those where the average grade is 5 percent for at least one mile.

4.16. Tunnels and Bridges

Tunnels and bridges were of special interest because these may represent bottlenecks in the transportation system, where incidents could have significant regional impacts on congestion and mobility. It was assumed that longer tunnels and bridges would be more likely to cause bottlenecks. Therefore, after lists of tunnels (highway number, milepost and length) and bridges (highway number, milepost and length of each span) were obtained, the total length was calculated, and tunnels less than 0.1 miles in length and bridges less than 2,000 feet in total length were excluded.

4.17. Maintenance Yards and Regional Offices

Users and maintainers of the DMS and CCTV are often ODOT maintenance personnel. In general, it was assumed that the DMS and CCTV would be used (though not exclusively) at a maintenance yard level. For example, when real-time en-route information is needed at a certain location, maintenance yard personnel may choose to deploy a portable DMS or some temporary static signage. Having a permanent DMS in the appropriate location would save them a trip. To identify current conditions, maintenance personnel may need to patrol a route; however, having a camera at the appropriate location could also reduce a trip.

Maintenance activities on DMS and CCTV elements, aside from some routine functions, are assumed to be performed out of the regional offices. ODOT offices in Portland, Salem, Grants Pass, Bend and La Grande were used.

4.18. Proximity to ITS Infrastructure

The location of existing ITS infrastructure was important for purposes of:

- complementarity, where one element could work well with an existing element (for example, a CCTV camera could verify the conditions reported by an RWIS or the message posted on a DMS);
- filling gaps in deployment of a particular technology in order to have full coverage at regular intervals (for example, CCTV cameras on urban freeways); and
- avoiding redundancy (for example, two DMS on the same highway facing the same direction with one-mile spacing).

For simplicity, it was assumed that each CCTV and RWIS[3] had consistent functionality (i.e. each CCTV has equivalent pan/tilt/zoom range, and each RWIS utilizes the same package of environmental sensors). In addition, no special consideration was given to directionality in relation to DMS placement.

There can be considerable benefits in collocating ITS infrastructure with respect to sharing of power and communications infrastructure. This advantage can only be realized at a site design level, however, and requires extremely close proximity – less than 200 feet – to be of value. Since this was less than the one mile sensitivity of the analysis, these considerations are reserved for design of a specific deployment once a location has been selected through the use of the guidelines.

4.19. Distance to Nearest Calculations

For several criteria, including those involving existing ITS infrastructure, it was necessary to calculate the distance between a given mile segment and the nearest element of interest. The GIS interface normally calculates distances on a straight-line basis (i.e. “as the crow flies”) without regard for the layout of the highway network. In order to provide for realistic driving distances, the highway network was rasterized. Cells which corresponded to points on the highway network were given a small “cost” value, while points off the highway network were given a very large “cost” value. The software then evaluated the minimum “cost” path.

As a variation on this, the inverse of posted travel speeds was used as the cost value on the highway network. This allowed for calculations of minimum travel time between a given mile segment and the nearest element of interest.

[3] RWIS locations were used for complementarity.

5. DEVELOPMENT AND APPLICATION OF CRITERIA

This chapter presents the criteria that were used to identify high-priority locations for DMS and CCTV in Oregon. For each technology, the criteria will be summarized in tabular form, with some discussion provided as to the relevance of each item. This is followed by a map showing the relative locations of the high- and low-priority locations.

5.1. DMS

The proposed criteria for dynamic message signs are summarized in Table 5-1. In this section, each criterion is explained, and then the criteria are applied to identify priority locations for DMS deployment. (Maps showing the how each criterion was scored across the state are provided in Appendix A.)

5.1.1. Explanation of Criteria

<u>Incident Prevention</u>

DMS can provide real-time warnings when conditions may warrant increased motorist caution. This was felt to be warranted at locations where weather is a causative factor in a significant number of crashes (*DMS 1*), or when there are sharp horizontal curves or sudden vertical grades that could impact driver safety (*DMS 2*). Lower weights were placed on the geometric criteria, as it is assumed that a variety of static warning signs already exist at these locations.

<u>Incident Management</u>

Incident management will first be a concern where incidents are more likely to occur. In order to correct for how the relative frequency of accidents varies according to highway type, mean and standard deviations of crash rates for each highway facility were established. Mile segments with statistically high crash rates were flagged (*DMS 3*). Assuming that crash rates for a given highway type are normally distributed over all segments of that highway type, about 84 percent of locations would have crash rates less than one standard deviation above the mean, and only 3 percent of locations would have crash rates at least two standard deviation above the mean.

Incident severity is another factor, as locations where incident removal is slow could have more significant impacts on traffic. Using the HTCRS data, vehicle-hours of delay related to highway closures (*DMS 4*) and incidents (*DMS 5*) were estimated.

DMS are effective for incident management when they can inform motorists in a timely fashion so they can make decisions regarding alternate routes. This availability of detours was established through several criteria. First, a combination criteria was established which related the proximity of a mile segment to the nearest intersection with another ODOT route, and the spacing between intersections on that highway (*DMS 6*). Different thresholds were set up for urban and rural areas, reflecting differences in travel speeds and the levels of congestion which would quickly exacerbate delays. Second, the average spacing between intersections was

Table 5-1: Summary of DMS Location Criteria

	Positive Criteria	+ 2 pts	+ 1 pt
	Incident Prevention		
1.	Percent of crashes attributable to weather	> 50%	20 to 50%
2a.	Presence of sharp horizontal curvature		10 second duration curve with radius tighter than 75 percent of recommended radius at e=0.04
2b.	Presence of sharp vertical grade		1 mi. with avg. grade of >5%
	Incident Management		
3.	Crash rate compared to state mean crash rate for similar highway segments*	>2 σ higher	1-2 σ higher
4.	Vehicle-hours of delay for road closures*	>100,000	10,000 to 100,000
5.	Vehicle-hours of delay for incidents*	>200,000	20,000 to 200,000
6.	Average spacing between state highway intersections	>40 miles, and <4 mi. to nearest intersection (Rural)	20 to 40 miles, and <4 mi. to nearest intersection (Rural)
		>10 miles, and <2 mi. to nearest intersection (Urban)	5 to 10 miles, and <2 mi. to nearest intersection (Urban)
7.	Product of average interchange or access point spacing and mainline traffic volume	>500,000	200,000 to 500,000
8.	Ratio of ramp to mainline volume	>0.5 (Rural)	0.2 to 0.5 (Rural)
		>0.3 (Urban)	0.15 to 0.3 (Urban)
9.	Proximity to freeway-to-freeway interchange		<2 mi.
10.	Percentage of truck traffic	>35%	22 to 35%
	Non-Incident Congestion Management		
11.	Percent of vehicles in congestion	>75%	50 to 75%
12.	Annual average daily traffic	> 50,000	20,000 to 50,000
13.	Total visitation of attractions within five miles		> 1 million per year
	Weather Warnings		
14.	High wind areas – using wind power value	6 or 7 (>17.9 mph)	5 (16.8 – 17.9 mph)
15.	Located in area susceptible to floods		”A” FEMA classification
16.	Proximity to RWIS		< 10 mi.
	Enabling Criteria		
17.	Distance from maintenance yard		> 50 mi.

	Negative Criteria	– 4 pts	– 2 pts
1.	Distance to nearest DMS	< 2 mi.	2-5 miles
2.	Travel time from regional office		> 3 hours (-1 pt)

* - Over three-year period

multiplied by the traffic volume between those intersections (*DMS 7*). This reflects the number of vehicles that could be "caught" between intersections and experiencing delay without the ability to take a detour. Third, for freeways, the ratio of ramp to mainline volume was calculated (*DMS 8*). This was used to approximate whether a particular interchange was regionally significant – and therefore a potential location for a detour to start – or was oriented toward providing local access. Fourth, because of the freeways' role in moving large volumes of traffic traveling longer distances, special consideration was given to mile segments located close to freeway-to-freeway interchanges (*DMS 9*).

Finally, truck traffic merits special consideration under incident management because commercial vehicles have a significantly higher value of time than general traffic (*DMS 10*). This is important from quality of life and economic vitality perspectives.

Non-Incident Congestion Management

While the majority of highway congestion arises from incidents, there are other sources of congestion, such as lack of highway capacity sufficient to meet vehicle demand, and the proximity of major trip generators such as national and state parks. To capture the effects of congestion, the percent of time a highway segment was congested (*DMS 11*) and the AADT for a given segment (*DMS 12*) were both used. To reflect the influence of tourist attractions and other major trip generators, the cumulative visitation for all large (>200,000 annual visitation) attractions within a five-mile radius was applied (*DMS 13*).

Weather Warnings

DMS could be used to provide supplementary weather warnings. Examples of weather that may be included are high winds (*DMS 14*) and flooding (*DMS 15*). Winter weather is another important consideration. Under the assumption that RWIS are located at the more extreme (higher snowfall, lower temperature) locations on the highway system, it could make sense to locate a DMS near an existing RWIS (*DMS 16*).

Work Zone Activities and AMBER Alerts

DMS could be used to provide information related to work zones and child abduction alerts (i.e. AMBER Alerts). Because of the dynamic nature of work zones, the practicality of using a permanent DMS for work zone traveler information was limited. In the case of AMBER alerts, ODOT personnel indicated that they would use DMS to inform motorists about AMBER alerts, but that it was not appropriate to locate DMS specifically based on AMBER alert considerations. Therefore, neither of these applications was believed to be adequately location-specific to be factored into DMS location decisions.

Enabling Criteria

A permanent DMS could be used as a substitute for a portable DMS or static signage in providing real-time en-route traveler information. This could provide operational savings costs to maintenance yards, proportional to the distance between the yard and a given mile segment

(*DMS 17*). This criterion was given somewhat minor importance, as few segments of highway are exceptionally distant from a yard where intermittent use of a DMS would be cost-beneficial.

Negative Criteria

In addition to the earlier cited positive criteria, there are two negative criteria for which points were removed. Of greatest weight was the distance to the nearest existing DMS (*Negative DMS 1*), as this would provide redundant functionality when the DMS face the same direction[4]. The travel time required for maintenance may be a consideration as well (*Negative DMS 2*), although it would be a minor consideration under the assumption that repair needs would be fairly infrequent, and could be done primarily on a preventative basis.

5.1.2. Priority Locations

Points were summed up for all mile segments according to the criteria presented in Table 5-1. The locations in the 99th percentile for total points were considered to be high priority locations, while those in the 96th percentile or higher were considered to be lower priority locations. This resulted in 74 mile-segments being designated as high priority locations for DMS, with an additional 202 mile-segments being low priority locations. A map showing all of these locations is provided in Figure 5-1.

Tables were also prepared to highlight the high priority and low priority locations. In many cases, several consecutive mile-segments were designated as either high priority or low priority. Therefore, for simplicity, these locations were combined. If there was a one-mile gap where the designation of priority was changed, this priority for the mile-segment in the gap was changed to match the priority on either side. The priority locations are summarized in Table 5-2 and Table 5-3.

[4] As was noted earlier, this methodology did not consider the directionality of DMS.

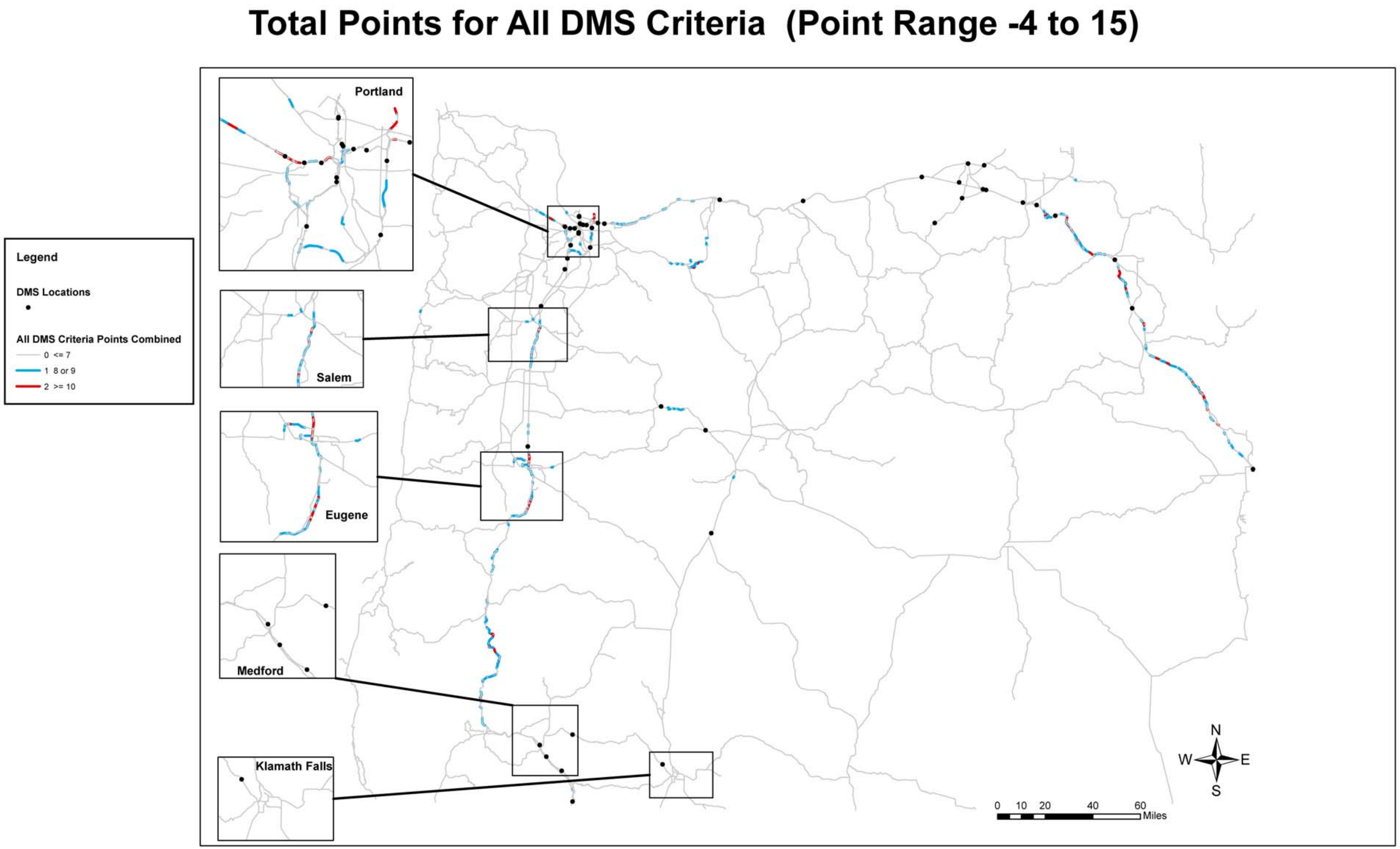


Figure 5-1: Map of High Priority Locations, DMS

Table 5-2: High-Priority Locations, DMS

Highway		Description	Mileposts	
LRS	Posted		Start	End
High-Priority Locations				
001	I-5	Glendale Junction	80	82
001	I-5	Quines Creek	86	87
001	I-5	Canyonville to Boomer Hill	98	110
001	I-5	Cottage Grove	174	176
001	I-5	Saginaw	178	180
001	I-5	Eugene and Springfield	192	198
001	I-5	South Salem	248	252
002	I-84	I-205 Interchange	7	8
006	I-84	West of Emigrant Hill	219	220
006	I-84	Deadman's Pass & Emigrant Pass	232	238
006	I-84	Meacham Summit	242	243
006	I-84	West of Hilgard	250	252
006	I-84	Ladd Canyon	268	278
006	I-84	East of Baker City	311	312
006	I-84	Weatherby	330	341
006	I-84	Farewell Bend	352	353
047	US 26	Cornell Road to Cedar Hills Blvd	67	70
047	US 26	Highlands	73	74
064	I-205	Columbia River	24	26.6
069	Beltline	NW Expressway to Delta Highway	7	10

Table 5-3: Low-Priority Locations, DMS

Highway		Description	Mileposts	
LRS	Posted		Start	End
Low-Priority Locations				
001	I-5	North of Siskiyou Summit	7	8
001	I-5	North of Grants Pass	59	63
001	I-5	Sexton Summit	67	68
001	I-5	Smith Hill Summit	70	75
001	I-5	Stage Road Pass	82	86
001	I-5	Canyon Creek Pass to Canyonville	90	98
001	I-5	Myrtle Creek	106	107
001	I-5	Dillard Highway	110	113
001	I-5	South of Roseburg	115	118
001	I-5	Roseburg	124	126
001	I-5	Sutherlin to Oakland	138	141
001	I-5	Rice Hill	144	149
001	I-5	Umpqua Highway	161	162
001	I-5	Wards Butte	166	173
001	I-5	North of Cottage Grove	176	178
001	I-5	South of Creswell	180	182
001	I-5	South of Eugene/Springfield	188	192
001	I-5	Oak Grove	207	208
001	I-5	Diamond Hill	210	211
001	I-5	Albany to Salem	235	248
001	I-5	Salem	252	256
001	I-5	Tualatin	288	289
001	I-5	Pacific Highway West	293	294
001	I-5	I-405/I-84 Interchanges	300	302
002	I-84	I-5 Interchange	0	1
002	I-84	Troutdale to Bridal Veil	17	28
002	I-84	Multnomah Falls	30	34
002	I-84	Bonneville	40	42
002	I-84	East of Cascade Locks	48	49
002	I-84	Starvation Creek	54	55
003	OR 43	Lake Oswego	6	7
004	US 97	Bend	141	142
006	I-84	Mission Highway	217	218
006	I-84	West of Emigrant Hill	220	224
006	I-84	Emigrant Hill	228	232
006	I-84	Railroad Canyon	238	250
006	I-84	Hilgard to La Grande	252	258
006	I-84	South of La Grande	266	267
006	I-84	Clover Creek Valley	278	281
006	I-84	Baker Valley	292	297
006	I-84	Baker City	303	305
006	I-84	South of Baker City	308	311
006	I-84	Pleasant Valley	312	326
006	I-84	Durkee	328	330

Table 5-3: Low-Priority Locations, DMS (cont.)

Highway		Description	Mileposts	
LRS	Posted		Start	End
Low-Priority Locations (cont.)				
006	I-84	Lime	341	345
006	I-84	Huntington	348	350
006	I-84	Pine Tree Ridge	357	358
006	I-84	North Fork Jacobsen Gulch	361	365
006	I-84	South Fork Jacobsen Gulch	368	370
009	US 101	Lincoln City	114	115
015	OR 126	Thurston Road	10	11
016	JS 20/OR 12	Santiam Pass	77	86
026	US 26	Rhodedenron	46	47
026	US 26	Camp Creek	49	50
026	US 26	Government Camp	52	53
026	OR 35	Bennett Pass	57	66
026	OR 35	Sherwood	74	75
026	OR 35	Upper Hood River Valley	77	78
030	OR 22	Doaks Ferry	22	23
047	US 26	North Plains to Hillsboro	53	62
047	US 26	Sylvan	71	72
064	I-205	Tualatin to West Linn	1	6
064	I-205	Errol Heights	15	18
069	Beltline	Barger Drive	5	7
069	Beltline	Coburg Road	10	11
092	US 30	St. Johns	8	9
144	OR 217	Beaverton	1	3
144	OR 217	Tigard	5	6
150	OR 221	West Salem	20	21
173	None	Timberline	0	1
227	I-105	Eugene	0	3
330	OR 204	Weston	2	3

5.2. CCTV

The proposed criteria for CCTV cameras are summarized in Table 5-4. In this section, each criterion is explained, and then the criteria are applied to identify priority locations for CCTV deployment. (Maps showing the how each criterion was scored across the state are provided in Appendix B.)

Table 5-4: Summary of CCTV Location Criteria

	Positive Criteria	+ 2 pts	+ 1 pt
	Incident Detection		
1.	Crash rate compared to state mean crash rate for similar highway segments*	>2 σ higher	1-2 σ higher
2.	Proximity to freeway-to-freeway interchange	1 mile	2 miles
3.	Location of nearest major interchange (urban) – ramp to mainline volume ratio of 0.15 or greater	1 mile	2 miles
4.	Proximity to bridge or tunnel	In segment	
	Incident Response and Management		
5.	Location of nearest camera (urban)	>2 miles	1-2 miles
	Non-Incident Congestion Management		
6.	Percent of vehicles in congestion	>75%	50 to 75%
	Pre-Trip Traveler Information		
7.	Proximity to mountain pass	<1 mile	1-4 miles
8.	Proximity to major attraction	<1 mile	1-2 miles
9.	Proximity to ski area	<1 mile	1-2 miles
	Maintenance		
10.	Location of nearest maintenance yard	>30 miles	20-30 miles
11.	Location of nearest current and proposed RWIS	<1 mile	1-2 miles
	Security and Verification		
12.	On roads entering state, facing inbound traffic	>50,000 AADT	>10,000 AADT
13.	Location relative to DMS	<2 miles	2-5 miles

	Negative Criteria	– 4 pts	– 2 pts
1.	Distance to nearest CCTV	<1 mile	1-2 miles
2.	Travel time from regional office		> 3 hours (-1 pt)

* Over three-year period

5.2.1. Explanation of Criteria

Incident Detection

CCTV cameras can be useful in detecting incidents, as well as in assisting incident response and management activities. Consequently, it makes sense to locate cameras near areas where crashes are more common. Mile segments with above average crash rates were flagged, using an identical calculation as DMS 3 (*CCTV 1*). In addition, it is important to locate cameras near interchanges, where they can be used to detect and manage crashes occurring on a couple of major roadways simultaneously. The criteria include proximity to freeway-to-freeway interchanges (*CCTV 2*) and near major urban interchanges (*CCTV 3*).

Another key location for cameras to be deployed in relation to incidents is at bridges or tunnels. In these cases, there will be limited space to remove incidents from the roadway, so the duration of delays can increase quickly. Immediate proximity to longer bridges (over 2,000 feet in total length) or tunnels (at least 0.1 miles in length) could be useful in helping detect incidents more quickly (*CCTV 4*).

Incident Response and Management

To assist with incident response and management in urban areas, it is common to deploy CCTV cameras in a coverage fashion – i.e. saturate the system with enough cameras so that every mile of the freeway system can be viewed by at least one camera. To ensure this level of coverage, a criterion was used for urban areas based on a lack of cameras in the immediate vicinity (*CCTV 5*).

Non-Incident Congestion Management

Cameras can also be used to manage congestion not related to incidents. To identify these locations, the percent of time each mile segment is congested – used as DMS 11 – is repeated here (*CCTV 6*).

Pre-Trip Traveler Information

ODOT has found that its camera images, available on its TripCheck traveler information web site, are among its most visible and popular features to the traveling public. Motorists may view these images before making a long trip to ensure that they are prepared for any potential winter weather, or that the weather at the destination is favorable. Locating cameras at mountain passes (*CCTV 7*) can help for winter weather conditions, while locations at major attractions (*CCTV 8*) and ski areas (*CCTV 9*) may be useful in helping motorists decide whether to make a trip.

Maintenance

Cameras can provide maintenance personnel with an easy way to see current conditions in remote locations, thus economizing on travel time. Camera locations would be more beneficial when they are further from the nearest maintenance yard (*CCTV 10*). In addition, cameras could be useful to provide visual confirmation of reports obtained by a nearby RWIS (*CCTV 11*).

Security and Verification

There has been increased interest in using cameras for security and verification purposes. So far, security has not been the dominant concern driving installation of CCTV cameras, but it may provide added value to camera installations in certain locations. In terms of deployment criteria, it was recommended that cameras could be located on higher traffic roads entering the state (*CCTV 12*).

In some cases, cameras are used to verify messages posted on DMS. This would require placement of a camera in close proximity to existing DMS (*CCTV 13*).

Negative Criteria

While the value of saturation coverage of cameras in urban areas has been described, there can be redundancy in cameras that would reduce efficiency. Therefore, a criterion was established that would penalize mile segments where cameras already exist (*Negative CCTV 1*). Finally, excessive travel time from regional offices for camera maintenance could also be a negative concern for deployments in specific locations (*Negative CCTV 2*).

5.2.2. Priority Locations

Points were summed up for all mile segments according to the criteria presented in Table 5-4. The locations in the 99th percentile for total points were considered to be high priority locations, while those in the 96th percentile or higher were considered to be lower priority locations. This resulted in 137 mile-segments being designated as high priority locations for CCTV cameras, with an additional 398 mile-segments being low priority locations. A map showing all of these locations is provided in Figure 5-1.

Tables were also prepared to highlight the high priority and low priority locations. In many cases, several consecutive mile-segments were designated as either high priority or low priority. Therefore, for simplicity, these locations were combined. If there was a one-mile gap where the designation of priority was changed, this priority for the mile-segment in the gap was changed to match the priority on either side. The priority locations are summarized in Table 5-2 and Table 5-3.

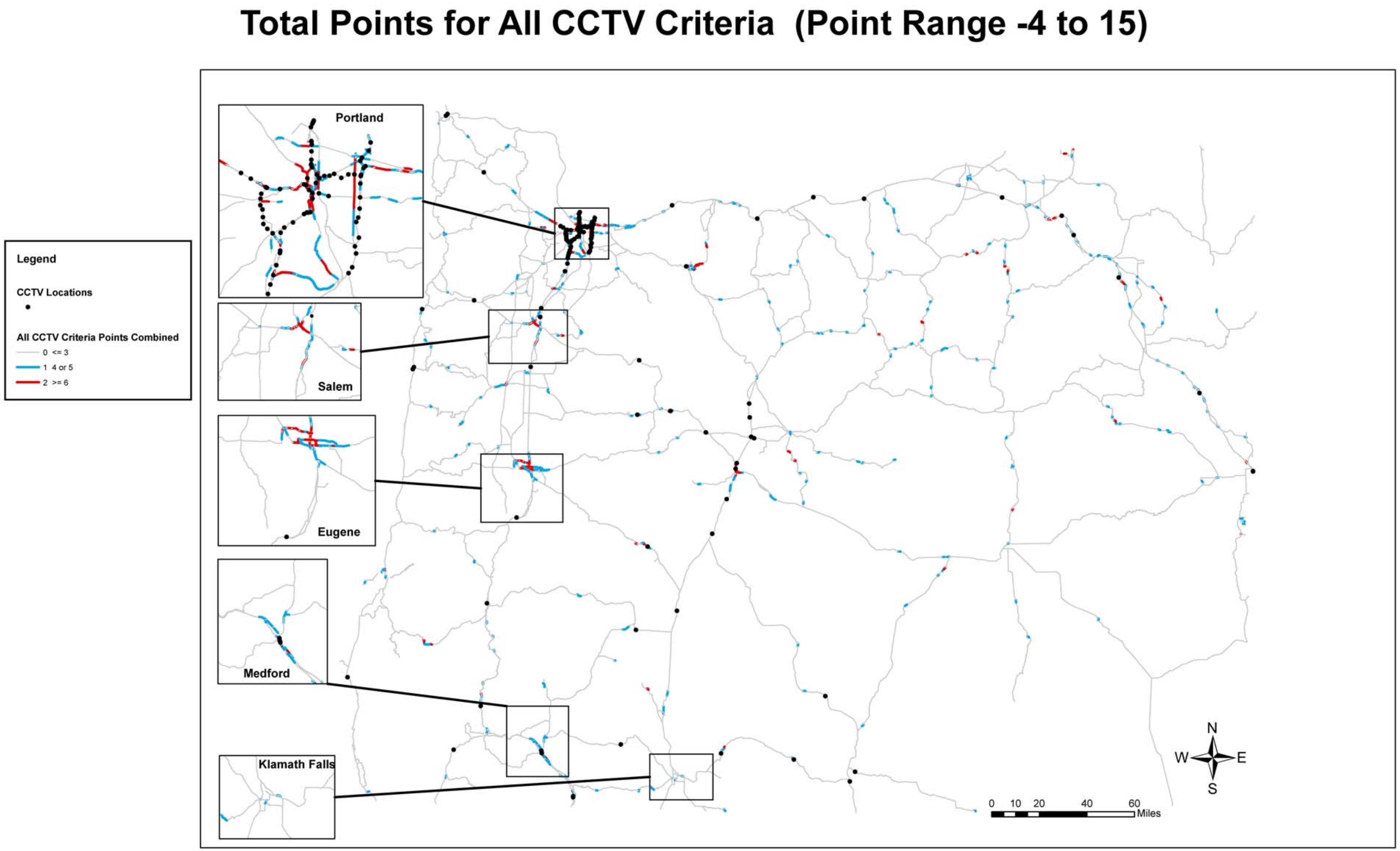


Figure 5-2: Map of High Priority Locations, CCTV

Table 5-5: High-Priority Locations, CCTV

Highway		Description	Milepost	
LRS	Posted		Start	End
High-Priority Locations				
001	I-5	North of Siskiyou Pass	5.0	8.0
001	I-5	Smith Hill Pass	74.0	75.0
001	I-5	Eugene	193.0	197.0
001	I-5	South of Salem	246.0	248.0
001	I-5	Portland	298.0	304.0
002	I-84	East Portland	10.0	14.0
002	I-84	Troutdale	16.0	19.0
003	OR 43	Portland	0.0	2.0
003	OR 43	West Linn	8.0	10.0
005	OR 19	Shelton	69.0	70.0
006	I-84	West of Emigrant Hill	222.6	226.6
006	I-84	Ladd Canyon	272.6	274.6
006	I-84	Ontario	372.6	373.6
007	US 20	Bend	0.5	2.5
008	OR 11	Walla Walla Valley	35.2	35.3
009	US 101	North Bend	235.0	236.0
014	OR 27	Swartz Canyon	9.0	10.0
014	OR 27	Prineville Dam	16.0	17.0
015	OR 126	Eugene	-0.1	1.9
016	US 20	Santiam Pass	79.0	80.0
017	US 20	Bend	18.0	18.5
018	OR 58	Upper Salt Creek	55.7	56.7
018	OR 58	West of Willamette Pass	59.7	60.7
020	OR 39	Wildhorse Canyon	31.9	32.9
022	OR 62	South of Crater Lake	87.0	88.0
026	OR 35	Mount Hood	59.0	66.0
026	OR 35	Sherwood	74.0	75.0
028	US 395	Cape Horn Summit	35.0	36.0
028	US 395	Battle Mountain Summit	39.0	40.0
029	OR 8	Hillsboro	12.1	14.1
030	OR 22	Salem	23.0	26.1
035	OR 42	Middle Fork Coquille	41.0	42.0
035	OR 42	Douglas County Line	45.0	46.0
040	OR 10	Beaverton	1.0	2.0
047	US 26	Hillsboro	59.9	63.9
047	US 26	Beaverton	67.9	68.9
047	US 26	Portland	71.9	74.6
048	US 395	Poison Creek Road	51.0	52.0
049	US 395	South of Riley	5.0	6.0
052	OR 74	Jones Hill Summit	58.0	59.0
052	OR 74	Franklin Summit	65.0	66.0
059	US 30 Bus	I-205 Interchange	4.9	5.5
061	I-405	West Portland Freeway	0.0	4.2
063	OR 99	Medford	6.0	8.0

Table 5-5: High-Priority Locations, CCTV (cont.)

Highway		Description	Milepost	
LRS	Posted		Start	End
High-Priority Locations (cont.)				
064	I-205	Tualatin	0.0	3.0
068	OR 213	Portland	0.0	6.0
069	Beltline	Eugene	5.0	13.0
070	I-82	I-84 Interchange	10.0	11.2
072	OR 99E/OR 22	Salem	4.0	8.0
081	OR 99E	Portland	-1.1	0.9
091	OR 99	Portland	-4.8	-3.8
091	OR 99	Portland	1.2	3.2
091	OR 99W	Corvallis	83.2	84.2
091	OR 99	Eugene	122.2	124.2
092	US 30	Willamette Heights	0.9	3.0
123	US 30 Bypass	Fairview	16.0	16.8
140	OR 219	West Woodburn	36.0	37.0
144	OR 217	Tigard	6.0	7.5
150	OR 221	Salem	19.0	20.8
163	OR 22	Valentine Creek	14.8	15.8
173	None	Timberline	4.1	5.5
227	I-105	Eugene	0.0	5.0
228	None	Springfield	0.0	1.4
321	OR 207	Whitetail Butte	27.0	28.0
332	None	Sunnyside	3.0	4.0
340	OR 203	Frazier Mountain	15.0	16.0
450	None	US 95 Junction	20.0	20.1

Table 5-6: Low-Priority Locations, CCTV

Highway		Description	Milepost	
LRS	Posted		Start	End
Low-Priority Locations				
001	I-5	Ashland	14.0	15.0
001	I-5	South of Medford	24.0	27.0
001	I-5	Central Point	31.0	37.0
001	I-5	Sexton Summit	71.0	74.0
001	I-5	Wolf Creek Pass	80.0	81.0
001	I-5	Canyonville	99.0	100.0
001	I-5	Myrtle Creek	108.0	109.0
001	I-5	Winston	116.0	117.0
001	I-5	South of Eugene	187.0	193.0
001	I-5	North of Eugene	197.0	200.0
001	I-5	South of Salem	245.0	246.0
001	I-5	Salem	248.0	256.0
001	I-5	Aurora	278.0	279.0
001	I-5	Stafford Road	285.0	286.0
001	I-5	Tualatin	288.0	289.0
001	I-5	Columbia River	308.0	308.4
002	I-84	I-5	0.0	2.0
002	I-84	I-205	6.0	10.0
002	I-84	East Portland	14.0	16.0
002	I-84	East of Troutdale	19.0	20.0
002	I-84	Crown Point	23.0	25.0
002	I-84	Multnomah Falls	31.0	32.0
002	I-84	Bonneville	40.0	41.0
002	I-84	East of Hood River	66.0	67.0
003	OR 43	South of Portland	2.0	3.0
003	OR 43	Lake Oswego	5.0	8.0
003	OR 43	Oregon City	10.0	11.0
004	US 197	Stag Canyon	53.0	54.0
004	US 197	Sherman Highway	66.0	67.0
004	US 97	Madras	92.0	93.0
004	US 97	Bend	137.0	142.0
004	US 97	South Bend	144.0	147.0
004	US 97	Collier	238.0	240.0
004	US 97	Chiloquin	245.0	248.0
005	OR 19	Wester Butte	26.0	27.0
005	OR 19	Condon Canyon	44.0	45.0
005	OR 19/OR 207	Muleshoe Mountain	81.0	82.0
005	OR 19/OR 207	Spray	91.0	92.0
005	OR 19	Butler Basin	120.0	121.0
005	US 26	East of Unity	214.0	215.0
005	US 26	E Camp Creek Road	220.0	226.0
005	US 26	Lost Valley Creek	242.0	243.0
005	US 26	Cow Creek	246.0	248.0
006	I-84	Ordnance	178.6	179.6

Table 5-6: Low-Priority Locations, CCTV (cont.)

Highway		Description	Milepost	
LRS	Posted		Start	End
Low-Priority Locations (cont.)				
006	I-84	West Pendleton	208.6	209.6
006	I-84	East Pendleton	213.6	214.6
006	I-84	West of Emigrant Hill	219.6	220.6
006	I-84	Emigrant Springs	234.6	235.6
006	I-84	Meacham	237.6	238.6
006	I-84	Meacham Summit	242.6	243.6
006	I-84	West of Hilgard	250.6	251.6
006	I-84	Hilgard	254.6	255.6
006	I-84	La Grande	257.6	259.6
006	I-84	La Grande-Baker Highway	264.6	265.6
006	I-84	North of Ladd Canyon	268.6	270.6
006	I-84	North Clover Creek Valley	274.6	277.6
006	I-84	North Powder	283.6	285.6
006	I-84	Magpie Peak	293.6	295.6
006	I-84	South of Baker City	311.6	312.6
006	I-84	Pleasant Valley	316.6	317.6
006	I-84	Durkee Valley	323.6	324.6
006	I-84	Gold Hill	331.6	334.6
006	I-84	Dixie Creek Road	338.6	340.6
006	I-84	South of Lime	344.6	345.6
006	I-84	Farewell Bend	352.6	353.6
007	US 20	Pilot Butte	2.5	3.5
007	US 20	Millican	19.5	23.5
007	US 20	NE Lake County	81.5	82.5
007	US 20	West of Riley	101.5	104.5
007	US 20	Vale	245.5	246.5
009	US 101	Tillamook	65.0	66.0
009	US 101	Lincoln City	114.0	115.0
009	US 101	Newport	140.0	141.0
009	US 101	Coos Bay	238.0	239.0
009	US 101	Brookings	357.0	358.0
014	OR 27	Prineville	0.0	1.0
014	OR 27	Alkali Flat	24.0	25.0
014	OR 27	Bear Creek	28.0	29.0
014	OR 27	Merrill Road	40.0	41.0
015	OR 126	Springfield	1.9	8.9
015	OR 242	Cupola Rock	61.9	62.9
015	OR 242	McKenzie Pass	76.9	77.9
015	OR 126	Sisters	91.9	92.9
015	OR 126	Redmond	110.9	111.9
016	US 20	Albany	0.0	1.0
016	US 20	Lebanon	13.0	15.0
016	US 20	Sheep Creek	60.0	61.0
016	US 20	Iron Mountain	64.0	65.0

Table 5-6: Low-Priority Locations, CCTV (cont.)

Highway		Description	Milepost	
LRS	Posted		Start	End
Low-Priority Locations (cont.)				
016	US 20	Santiam Junction	74.0	75.0
016	US 20/OR 126	Square Lake	80.0	81.0
018	OR 58	I-5 Interchange	-0.3	1.7
018	OR 58	West of Willamette Pass	58.7	59.7
018	OR 58	East of Willamette Pass	62.7	63.7
019	OR 31	N. of Summer Lake	66.0	67.0
019	OR 31	Worlow Creek	88.0	89.0
020	OR 39	East Klamath Falls	3.9	4.9
020	OR 39	Wildhorse Canyon	30.9	31.9
020	OR 39	Beer Garden Spring	62.9	63.9
021	OR 66	Ashland	1.0	2.0
021	OR 66	Lincoln	20.0	21.0
021	OR 66	John Boyle Reservoir	40.0	41.0
021	OR 66	Chase Mountain Road	47.0	49.0
021	OR 66	US 97 Junction	59.0	59.0
022	OR 62	Medford to Eagle Point	4.0	7.0
022	OR 62	Crater Lake National Park	65.0	66.0
025	US 199	Grants Pass	-2.7	-0.7
025	US 199	Cave Junction	28.3	29.3
026	US 26	Ross Island Bridge	1.0	2.0
026	US 26	East Portland	7.0	10.0
026	US 26	Gresham	12.0	13.0
026	US 26	Warm Springs Junction	57.0	59.0
026	OR 35	Crystal Spring Creek	75.0	76.0
027	OR 34	Tidewater	10.0	11.0
027	OR 34	Flynn	51.0	52.0
028	US 395	Pendelton	0.0	2.0
028	US 395	South of Nye	26.0	27.0
028	US 395	Willow Spring Canyon	33.0	34.0
028	US 395	South of Battle Mountain Summit	40.0	41.0
028	US 395	Camas Creek	54.0	55.0
028	US 395	Desolation Creek	64.0	65.0
028	US 395	Fox	93.0	94.0
030	OR 22	West of Salem	21.0	23.0
031	US 20	Albany	10.1	11.1
033	US 20/OR 34	Corvallis	51.0	56.8
035	OR 42	Middle Fork Coquille	42.0	45.0
036	OR 37	Athena-Holdman Junction	20.0	21.0
037	OR 6	Tillamook	0.0	1.0
040	OR 10	Portland	3.0	3.4
041	OR 126	Prineville	17.9	18.9
041	US 26	John Day Junction	96.9	97.9
042	US 97	Dalles Highway Junction	68.6	68.7
044	OR 216	Laughlin Hills	8.2	9.2

Table 5-6: Low-Priority Locations, CCTV (cont.)

Highway		Description	Milepost	
LRS	Posted		Start	End
Low-Priority Locations (cont.)				
045	OR 38	Umpqua River	16.0	17.0
047	US 26	Sunset Tunnel	39.9	41.9
047	US 26	Wilkesboro to North Plains	53.9	59.9
047	US 26	West Portland	68.9	71.9
048	US 395	Bear Valley	15.0	16.0
048	US 395	Ponderosa Ranch	29.0	31.0
048	US 395	Burns	67.0	67.6
049	US 395	South of Riley	6.0	7.0
049	US 395	Capehart Lake	9.0	10.0
049	US 395	Wagontire	28.0	29.0
049	US 395	Lake Abert	86.0	87.0
050	OR 39	Malin	26.1	27.1
052	OR 74	Lower Willow Creek	5.0	8.0
052	OR 74	Chesney Airstrip	11.0	13.0
052	OR 74	Saddle Butte	22.0	23.0
052	OR 74	Lena	62.0	63.0
052	OR 74	John Day Junction	73.0	74.0
053	US 26	Madras	117.4	117.6
054	US 395	Hermiston	4.0	6.0
058	OR 99E	Albany	1.0	2.0
059	US 30 Bus	Columbia River	-0.1	0.9
059	US 30 Bus	Maywood Park	4.0	4.9
063	OR 99	Central Point	0.0	1.0
063	OR 99	North Medford	5.0	6.0
063	OR 99	Medford to Phoenix	8.0	13.0
063	OR 99	Ashland	19.0	20.0
063	OR 99	I-5 Interchange	24.0	24.1
064	I-205	West Linn	3.0	8.0
064	I-205	Maywood Park	20.0	26.6
066	US 30	La Grande	1.0	2.0
066	OR 237	Ramo Flat	18.0	19.0
067	US 30	Pendleton	3.0	4.0
068	OR 213	Clackamas	6.0	9.0
069	Beltline	Royal Avenue	4.0	5.0
072	OR 99E	Keizer	0.0	2.0
072	OR 22	I-5 Interchange	8.0	8.5
073	OR 138	North Umpqua River	47.0	49.0
073	OR 138	Diamond Lake	86.0	86.0
081	OR 99E	Portland	-2.1	-1.1
081	OR 99E	Hubbard to Woodburn	28.9	31.9
091	OR 99	Portland	0.2	1.2
091	OR 99	Portland	3.2	4.2
091	OR 99W	Newburg	23.2	24.2
091	OR 99W	McMinnville	36.2	38.2

Table 5-6: Low-Priority Locations, CCTV (cont.)

Highway		Description	Milepost	
LRS	Posted		Start	End
Low-Priority Locations (cont.)				
091	OR 99	North Eugene	118.2	120.2
091	OR 99	South Eugene	124.2	126.4
100	None	Columbia Gorge	7.0	13.0
100	None	Koburg Beach	60.0	62.0
100	None	Rowena	65.0	66.0
102	OR 202	Barth Falls	15.0	16.0
102	OR 202	Fishhawk	41.0	43.0
102	OR 47	Forest Grove	88.0	89.0
104	None	US 101 Junction	6.0	6.0
123	US 30 Bypass	North Portland	1.0	6.0
123	US 30 Bypass	Sandy Boulevard	10.0	12.0
123Z	US 30 Bypass	Sandy Boulevard	11.3	11.3
130	None	Dolph	8.9	9.3
131	None	Tillamook	9.0	9.1
140	OR 219	Hillsboro	0.0	1.0
140	OR 214	Woodburn	37.0	40.0
140	OR 214	Silverton	50.0	50.7
141	None	Tigard	5.6	6.6
141	None	Tualatin	9.6	10.6
153	None	Bridewell	4.0	5.0
154	None	Amity Road Junction	6.0	6.3
161	OR 211	Estacada	32.0	33.5
163	OR 22	Cascade Highway Junction	12.8	13.8
163	OR 22	Fox Valley	25.8	28.8
173	None	Timberline	2.1	3.1
180	None	Eddyville	1.0	2.0
181	OR 229	Mowrey's Landing	13.8	14.8
181	OR 229	Siletz River	19.8	20.8
189	OR 223	OR 22 Junction	4.0	4.0
200	None	OR 36 Junction	9.9	10.9
201	None	Little Lobster Summit	4.0	7.0
225	None	I-5 Interchange	1.0	2.5
227	I-105	Springfield	5.0	10.0
229	OR 36	Greenleaf	18.0	19.0
229	OR 36	Triangle Lake	28.0	29.0
230	OR 227	Dead Horse Creek	42.5	43.5
231	OR 138	Bullock Bridge	13.0	14.0
233	OR 230	West Diamond Lake	18.0	21.0
240	None	North Bend	-0.1	0.9
240	None	Coos Bay	2.0	3.0
240	None	Cape Arago	11.9	12.9
270	OR 140	OR 62 Junction	0.0	1.0
273	None	I-5 Interchange	5.0	7.0
290	OR 216	Sherars Bridge	22.0	23.0

Table 5-6: Low-Priority Locations, CCTV (cont.)

Highway		Description	Milepost	
LRS	Posted		Start	End
Low-Priority Locations (cont.)				
290	OR 216	Grass Valley	27.0	28.0
291	OR 218	East of Antelope	13.9	17.0
291	OR 218	Clarno	21.0	22.0
291	OR 218	Porcupine Butte	29.0	30.0
291	OR 218	Stone Cabin Road	39.0	40.0
293	None	Antelope Creek	1.0	2.0
300	OR 206	Cottonwood Canyon	11.0	12.0
300	OR 206	Hale Ridge Road	55.0	56.0
321	OR 207	Chapin Creek	16.0	17.0
321	OR 207	Shaner Spring	20.0	21.0
321	OR 207	Haystack Creek	38.0	39.0
330	OR 204	West of Tollgate	13.6	14.6
333	OR 207	Hermiston	8.0	9.0
335	None	South of Helix	3.0	4.0
339	None	Sunnyside Hwy Junction	2.0	3.0
340	OR 203	Catherine Creek	8.0	9.0
340	OR 203	Big Hill	19.0	20.0
340	OR 203	Blue Mountain Loop Rd	27.0	28.0
341	OR 244	Camas Creek	3.0	4.0
342	OR 237	Union	22.0	22.1
372	None	Mt. Bachelor	18.0	19.0
380	None	Prineville Resevoir	17.0	18.0
380	None	Stewart Creek	37.0	40.0
380	None	Paulina	55.0	55.9
390	OR 207	Juniper Ridge	3.0	4.0
402	None	North Fork John Day	6.0	9.0
402	None	East of Hamilton	26.0	27.0
413	None	Cornucopia	1.0	2.0
420	None	Klamath Falls	2.0	3.0
431	OR 140	Warner	65.0	65.3
440	OR 205	Narrows	23.0	24.0
440	OR 205	Diamond Swamp	40.0	41.0
442	OR 78	Steens	56.0	57.0
451	None	Vale West	1.0	2.0
453	None	Adrian-Arena Valley	0.0	3.0
454	None	Adrian	3.0	4.0
455	OR 201	Weiser Spur	10.7	11.7

5.3. Enabling Factors

The earlier listed criteria blend the various potential applications of each technology to help prioritize locations for future deployment. It should be emphasized, however, that these lists do not represent a future program for funding of DMS or CCTV installation. Rather, these lists can help ODOT personnel to determine which locations merit further study.

The following factors need to be considered as additional factors which may affect the appropriateness or feasibility of deploying these technologies.

5.3.1. Sight Distance

For both technologies, sight distance is critical. For DMS, sight distance is necessary to ensure that motorists have adequate time to see and understand the message. At freeway speeds, this could mean providing 1,000 feet sight distance, requiring a relatively straight stretch of road. This is also important from a human factors perspective, to make sure that the difficulty of the driving task is not adversely affected by a bright DMS message. In addition, it is important to ensure that DMS are not competing with a significant amount of static signage, as this will tend to reduce the effectiveness of both.

For CCTV, sight distance is important in the sense of how far a camera can see on the road. As a rule of thumb, cameras need to be elevated approximately 10 feet for every 100 feet of roadway within view. However, this elevation may not be adequate in certain locations, depending on tree coverage (especially considering deciduous trees in full bloom), road curvature, and obstructions such as rock outcroppings or buildings.

In both cases, determination of appropriate locations will need to rely on video logs supplemented by site visits.

5.3.2. Maintainability

Both DMS and CCTV will require preventative and emergency maintenance. These needs must be considered during the site selection and design process to avoid adverse safety and delay impacts on the traveling public. This includes installing technologies in areas with wide shoulders, and allowing maintenance access to the technologies without a lane closure (e.g. through the use of CCTV lowering systems).

5.3.3. Power and Communications

The power needs for DMS when posting a message and the communication needs for CCTV cameras when providing real-time video are significant. While many alternative solutions may exist other than landline power and communications (13), these solutions may have limited applicability depending on the characteristics of a given site. Behind these concerns is cost, which can significantly affect the benefit-cost ratio of some of these deployments.

An ideal case is collocation of technologies; however, the optimal locations for different technologies may not be the same. In these cases, engineers must balance the benefits of collocation (reduced costs and maintenance) with those of keeping the locations separate (improved functionality).

These decisions ought to be made once a good general location (i.e. mile segment) has been identified for a technology, in order to determine the best site for that technology within the mile segment.

5.3.4. Agency or General Public Support

Another enabling factor for deployment is support from public agencies (including ODOT personnel) or the general public. From an agency perspective, support can help to streamline approval processes, provide for agreements to share costs and maintenance responsibilities, and leverage additional resources. Support from the general public may also be a helpful enabling factor, especially as web cameras are a very popular portion of the TripCheck web site.

In both cases, it should be emphasized that agency or public support is an enabling factor, which should not be used to override engineering judgment on locations where there is no demonstrable need for a given technology.

5.3.5. Funding

Finally, funding for design, installation, operation and maintenance of the deployment is a critical factor. Funding for new infrastructure must compete with the need to upgrade existing deployments, along with other competing priorities for ODOT. In addition, there needs to be ongoing funding to support operations and maintenance requirements. Shared funding agreements, in partnership with counties, cities or private sector enterprises, may offer promise for managing the cost burden.

6. SUMMARY AND RECOMMENDATIONS

The purpose of this research project was to develop quantifiable criteria that would help to provide objective rationale for considering the deployment of DMS and CCTV in Oregon. These criteria would be used to help ODOT headquarters staff work with ODOT regional staff and other stakeholders in deploying these technologies in a way that provides optimal benefit to the general public and ODOT personnel. They may also help in justifying or evaluating the location of current devices.

Because of their explicit grounding in functionality, these criteria provide an excellent foundation for other jurisdictions looking for rational guidance on deploying these technologies. The development of these criteria is described in Chapters 2 through 4, and the final criteria, along with the results of applying them to ODOT's highway system, are shown in Chapter 5.

The remainder of this chapter reviews the research project with recommendations toward improving the methodology, enhancing data availability and quality, and transferring this methodology to other technologies.

6.1. Methodology Recommendations

Based on the findings of last chapter, the methodology used in this project resulted in a reasonable assessment of candidate technology locations. In addition, the methodology is flexible enough to allow for consideration of additional criteria, and it would support the updating of data sources as new information is available.

However, the methodology may be improved in several ways, which are discussed in the rest of this section.

6.1.1. Real-time Updating

The methodology currently uses static snapshots from various data sources to assess the locations of each technology. While this process was effective, it is difficult to repeat as new data is available. This is of concern if ODOT wants to update priority locations, especially to reflect new deployments, on an annual basis.

Greater integration between the numerical evaluation of these guidelines and data sources could allow for a more seamless process. These two processes are compared in Figure 6-1. Under this model, ODOT would take greater ownership of the process of evaluating DMS and CCTV priority as new data is available. In some cases, perhaps a direct linkage could be established between the data source and the resulting criteria (e.g. location of existing ITS elements). In other cases, ODOT would likely not be able to effectively integrate data (e.g. tourism attractions).

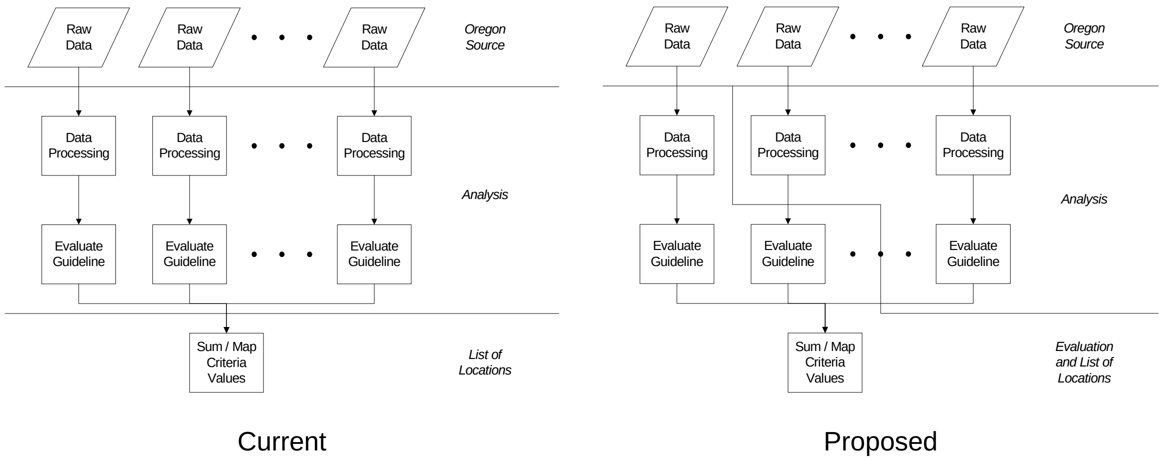


Figure 6-1: Comparison of Methodologies for Evaluating Criteria

6.1.2. Rolling Mile Segments

For this analysis, the research team chose a one-mile segment length with fixed milepost ends. Initially a more fluid analysis was considered, where a rolling one-mile segment would be used with milepost ends changing at 0.1 mile increments. These approaches are compared in Figure 6-2. As can be seen, a rolling limit approach may be more helpful, especially in working with crash data to identify mile segments with significant safety concerns. It should be noted, however, that converting the methodology to a rolling mile segment basis would add considerable complexity in data analysis and processing.

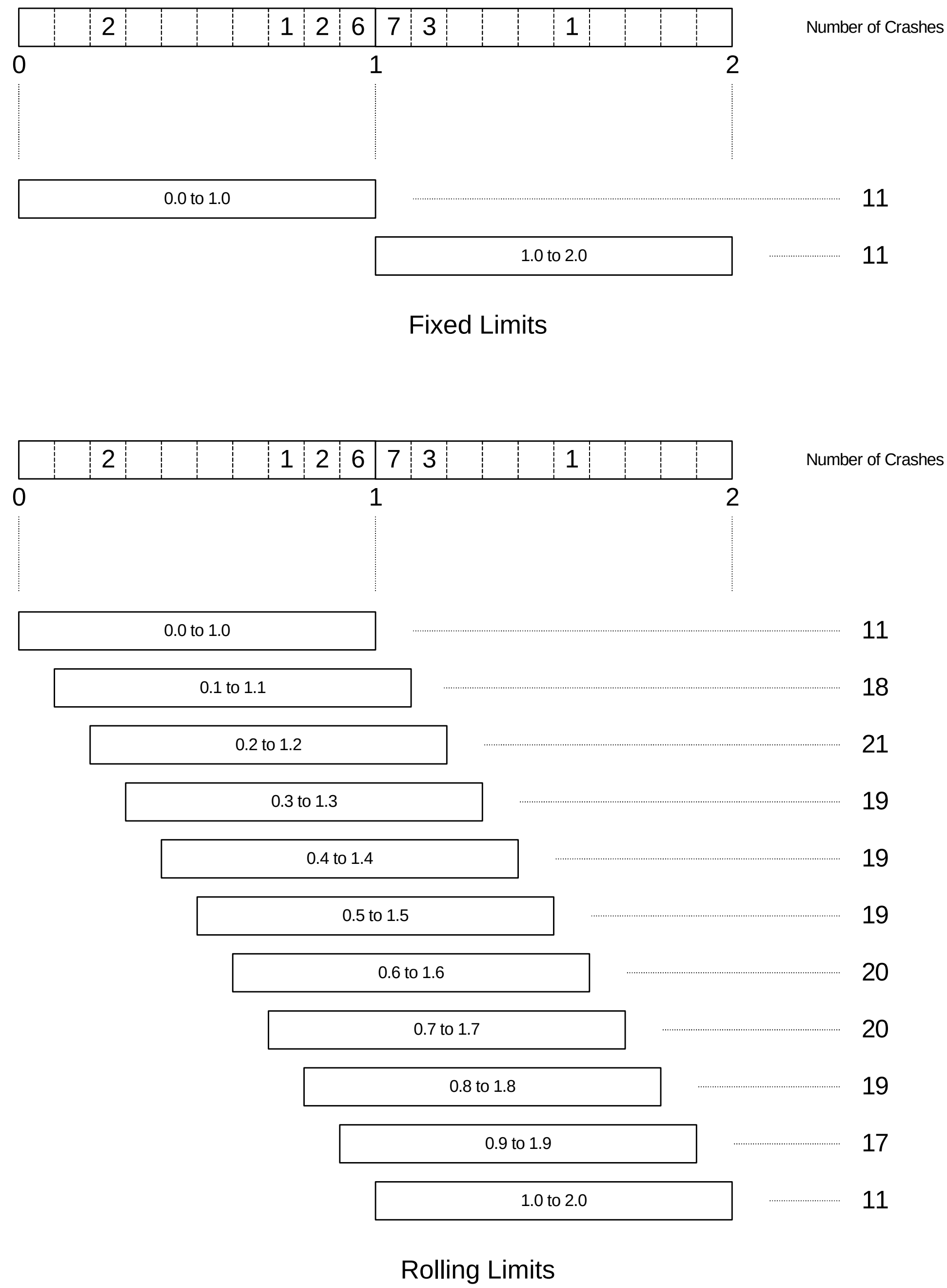


Figure 6-2: Milepost Division with Fixed versus Rolling Limits

6.1.3. Improved Determination of Detours

As was evidenced by the guidelines developed by other states, DMS are often used to provide information on detours. ODOT has formalized detours and alternative routes for some portions of its network; however, such alternative routes were not available for the entire network.

Consequently, the research team used surrogate measures to identify potential detour locations. These surrogate measures were approximate in at least a couple of ways. First, these measures ignored the potential for non-ODOT routes to be used as detours. Second, the existence of an intersection between two state highways does not necessarily imply that there is a suitable detour.

One potential method for improving detour identification would be to develop a GIS-based method for identifying detours. This method would use a network consisting of ODOT routes along with significant highways and arterials maintained by other jurisdictions. The network would be coded to include posted travel speeds, capacity and distances. A script could potentially be developed to analyze the ODOT network for suitable detours by comparing the travel time on the principal ODOT route to the best travel time available on alternative routes. In essence, this would use the same principles as trip assignment in the four-step transportation modeling process.

The development of such a script is beyond the scope of this project, but it may be helpful for incident management planning in the state.

6.1.4. Directionality

For simplicity, the analysis tried to avoid considerations of directionality. This was reflected in analyses of highway geometry, crash data, and the location of existing DMS. This is problematic for DMS, which are constrained to face only one direction of traffic. A future methodology may be more useful if it were to include considerations of directionality.

6.2. Data Recommendations

The methodology is very data-intensive; consequently, data availability and quality were key concerns in the quality of the results. There were several criteria initially suggested which were later modified or removed because of a lack of data availability. Data used in other criteria had some issues in applicability toward this research project. Each of these is discussed in turn, as are ways in which the methodology may be improved.

6.2.1. Missing Data

Emergency Response

Information about incident notification and response times was deemed to be valuable to identify remote locations where accelerated response times could improve health outcomes for crash victims. This information would have been valuable in helping to identify candidate CCTV locations. This data was not available, due to the dispersed locations of this data storage. If collected, this data could also be valuable for ODOT as a transportation operations performance measure.

Crashes Caused by Geometry

The research team initially proposed looking at crash data to identify locations where horizontal curvature or change in vertical grade had a clear impact on safety. Since this data was not easily available, the research team used available data regarding the degree of curvature and elevation profiles of the roadways. This analysis did not consider existing roadway signage, superelevation or other factors that may improve safety at these locations. Therefore, the weight on these criteria was dampened.

Tourist Attractions

For its own reporting purposes, the Oregon Tourism Commission had synthesized visitation information from a variety of public and private attractions in the state. Because of the vast number of tourist attractions in the state, this information was not comprehensive. Some gaps, which may be of interest to ODOT, include stadiums and arenas and some major festivals (e.g. air shows). Identification of some additional locations could help to highlight additional areas where DMS could be helpful.

Chains Requirements

The locations of snow zones in Oregon would help to identify areas where chains may be required, and the HTCRS data could – to some extent – supplement this by providing instances where chains requirements were added. However, the recording of this data in HTCRS was inconsistent, and therefore it was unclear for which snow zones chains would be required more frequently. Data on when chains requirements were imposed and removed, along with the milepost limits, could provide additional detail for locations where a DMS may have some added value.

6.2.2. Data Quality

Lane Closure and Delay Impacts

ODOT uses HTCRS, described in Section 4.14, to track incidents in order to provide traveler information for TripCheck and the state's 511 telephone number. A considerable amount of detail is available in this application, which enabled the research team to calculate delays and lane/highway closure durations throughout the state. This information was calculated from the highway number, mileposts of impact, denotations of the type of incident and its severity, and the lanes affected.

To establish estimates for delays and closures, the data required a significant amount of quality control and post-processing. Examples include where a highway number was incorrectly keyed at the beginning of an incident, or the chronology of time reports associated with an incident was illogical. The research team was able to convert this information into a usable format; however, it did require a significant amount of time.

If ODOT should decide to establish performance measures based on this data, it is recommended that HTCRS include some additional quality control and error-checking features to reduce the number of errors.

Weather Data

Mesoscale weather data is generally not collected at the road surface, and consequently has questionable direct applicability to surface transportation concerns. For example, bridges will often be used to elevate a highway above a flood-prone area. Wind measurements 40 feet above the ground – as are used in wind power estimates – are also not necessarily the same as wind effects closer to the ground, which may overturn high-profile vehicles. ODOT's network of RWIS stations provides good coverage for maintenance and traveler information purposes, and has data which pertains to highway users. However, ODOT's RWIS network is not complete enough to fill in the gaps by itself.

6.3. Extrapolation to Other Devices

The research team believes that this methodology could be very applicable to other ITS technologies. We would recommend the following technologies as potential candidates for a similar analysis.

6.3.1. RWIS / Environmental Sensors

One of the three technologies initially considered for this project, RWIS is well-established in Oregon as a tool for use by maintenance personnel as well as a component of ODOT's traveler information presentation.

There are a couple of options for future analysis related to weather stations. First, criteria could be developed for specific environmental sensors (e.g. high water, low visibility). The values for each criterion could be used to develop an appropriate or tailored system for each location, perhaps providing cost savings by not purchasing unnecessary sensors.

Second, weather stations could be established in connection with traveler information and safety concerns, such as chains requirements, high wind warnings, or similar messages. This would require a more detailed examination of weather-related crashes, and a better resolution of some of the weather information (e.g. flooding and wind).

6.3.2. Traffic Detectors

ODOT uses automatic traffic recorders for recording traffic volumes and speeds for planning purposes. However, it is also a common practice in many metropolitan areas (and even in rural areas, such as Interstate 5 in Siskiyou County in northern California) to use traffic detectors on a real-time basis to detect incidents or traffic slowdowns. In urban areas, traffic detection is typically provided in a similar sense as CCTV cameras, where the primary concern is the percent of the area's highways covered. This suggests that there may be ways to develop criteria for prioritizing traffic detector installation similar to those presented in this paper.

REFERENCES

1. Agah, Manny, "Application of ITS Technologies in Rural Arizona." Arizona Department of Transportation, no date.

2. TransCore, *Intelligent Transportation System Deployment Plan*. Prepared for the Utah Department of Transportation, Salt Lake City: June 2003.

3. *Intelligent Transportation Systems Design Guide*. Washington Department of Transportation Northwest Region ITS Design and Operations, Seattle: February 2000.

4. Corbin, John and Fischer, Tim, *ITS (Intelligent Transportation Systems) Design Manual*. Wisconsin Department of Transportation, Madison [WI]: January 2001. Accessed at http://www.uwm.edu/Dept/CUTS/itsdm/ on May 4, 2005.

5. Neudorff, Louis G.; Randall, Jeffrey E.; Reiss, Robert; and Gordon, Robert, *Freeway Management and Operations Handbook*. Document No. FHWA-OP-04-003, Prepared by Siemens ITS for the Federal Highway Administration, September 2003.

6. Elkins, Gary E.; Schmalzer, Peter; Thompson, Travis; and Simpson, Amy, *Long-Term Pavement Performance Information Management System: Pavement Performance Database User Reference Guide*. Document No. FHWA-RD-03-088, Prepared by MACTEC Engineering and Consulting, Inc. for the Federal Highway Administration. Accessed at http://www.tfhrc.gov/pavement/ltpp/reports/03088/index.htm on May 3, 2005.

7. Transportation Development Division, "2002 Oregon State Highway Crash Rate Tables." Oregon Department of Transportation, Salem [OR]: September 2003.

8. "Trans Dev – Transportation Data Interchange Ramp Volume Diagrams." Oregon Department of Transportation Web Page, Accessed at http://egov.oregon.gov/ODOT/TD/TDATA/tsm/rampdiagrams.shtml on January 24, 2005.

9. "Trans Dev – Transportation Data ODOT Geographic Information Services," Oregon Department of Transportation Web Page, Accessed at http://www.oregon.gov/ODOT/TD/TDATA/gis/odotgis.shtml.

10. 2003 Oregon Official State Map, Accessed at http://egov.oregon.gov/ODOT/TD/TDATA/gis/docs/statemaps/Oregon_Official_State_Map_2003.pdf.

11. Oregon Tourism Commission, "Oregon Travel News," March 2003.

12. SkiTown.com, Accessed at http://www.skitown.com/ on March 22, 2005.

13. Kamyab, Ali, *Communications and Power Improvements for Rural ITS Field Devices (Showcase Evaluation #10): Final Report*. Prepared for the California Department of Transportation and U.S. Department of Transportation Research and Special Programs Administration, Western Transportation Institute, Montana State University, Bozeman [MT]: October 24, 2003.