Rural Issues with Optimal Sensor Placement for Transportation Applications

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DISCLAIMER

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1. INTRODUCTION

Many types of sensors are used in managing transportation systems. These sensors supply critical information used by transportation managers for a variety of purposes such as real-time response to changes in travel and traffic conditions, or planning for improvements to the transportation system. In the absence of well developed methodologies to plan the deployment of these sensors, the processes that are used in selection of their location do not always follow a set of criteria that optimize their usefulness. Development of location selection guidelines will assist transportation managers in making the most efficient use of these sensors. This is particularly true in rural areas, given the unique challenges related to topography and remoteness. This report provides an overview of some of the issues and concerns encountered in locating sensors in rural areas that are used for assessment of travel conditions, incident detection, incident verification and collection of planning data. The sensors discussed include road weather information system (RWIS) stations, closed circuit television (CCTV) cameras and inductive loop detectors. Dynamic message signs (DMSs) are also examined as they are commonly co-located with other devices.

2. APPLICATIONS

Intelligent transportation systems (ITS) employ sensors for a number of purposes. Sensor applications discussed in this report include travel time estimation, incident detection, incident verification, and collection of planning data. For more information on the applications discussed in this report and other rural ITS applications, refer to the Rural ITS Toolbox (http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/13477.html).

2.1. Travel Time Estimation

ITS elements are useful in determining travel times along individual routes and/or highway networks. Real-time measurements of travel times can help in determining problem areas within the transportation system and provide valuable traveler information. Determining the optimal sensor placement for travel time estimation is a key issue in urban areas where congestions is a major factor affecting these estimates. Travel times in rural areas are less impacted by traffic congestion than by incidents caused by weather, crashes and landslides. Therefore, the focus of placing sensors in rural areas should be on detecting these incidents, or their causes, which is discussed in section 2.2.

If travel times are to be estimated in rural areas, use of permanent sensors (such as inductive loop detectors) following methodologies employed in more urban environments will result in a large number of sensors to cover the long distances involved. The use of probe vehicles is a more feasible approach. Many trucking companies utilize a service that will track their trucks in real-time through a satellite connection to in-vehicle global positioning systems. The American Transportation Research Institute (2005) showed that real-time corridor travel times could be estimated based on truck data already collected by these services.

For these reasons travel time estimation using permanent sensors will not be discussed further in this report.

2.2. Incident Detection and Verification

Unplanned incidents and events in rural areas can include crashes, weather events and landslides. If cellular coverage exists, the incident is discovered and reported quickly by motorists with cell phones. In areas without cellular coverage call boxes can be used.

CCTV cameras can be helpful for incident and event verification, but the number of cameras required to provide visual coverage of the entire rural network is cost prohibitive. CCTV cameras placed in rural areas should have a good vantage point that provides views of a large area. Camera effectiveness is also optimized by placing them in areas where incidents and events are commonly known to occur.

Most efforts toward incident detection relate to weather events. With RWIS, weather events can be detected immediately and even predicted with an appropriate weather model.

2.3. Planning Data

Another use of sensors in rural areas is the collection of planning data, primarily consisting of traffic counts for estimation of average annual daily traffic. This is typically accomplished with inductive loop detectors and portable road tubes.

3. TYPES OF SENSORS

The sensors discussed in this chapter are related to the applications discussed in Chapter 2 (Table 1). Dynamic message signs, which are not a sensor, are also discussed because sensors and DMSs are often located together in rural areas due to power and communication issues. For a discussion of co-locating DMSs with sensors, refer to Section 5.5.

Table 1: Matrix of Sensors and Applications

	Application		
Sensor	Incident Detection	Incident Verification	Planning Data
RWIS	O	O	
CCTV		O	
Loops			O

Although inductive loops are commonly used for incident detection in urban areas, they are impractical in rural areas due to the long distances and lower traffic volumes. In rural areas, loops are used almost exclusively for collecting planning data. Weather events can be detected and even predicted by RWIS stations. CCTV is often used to verify events.

3.1. Road Weather Information Systems

Having information about the road surface is especially important when dealing with adverse weather conditions. Road weather information systems (RWIS) stations are used to collect area weather information as well as road surface conditions. Information collected includes wind speed, air temperature, surface temperature, precipitation amount and type, visibility, and road condition.

RWIS data can be sent to traffic management centers, consolidated to an Internet webpage, or used as inputs to local weather or pavement surface conditions prediction models. State DOTs can use this data to plan winter maintenance activities (plowing and deicing) and to detect weather events. RWIS stations are commonly located in areas where inclement and abrupt changes in weather often occurs such as mountain passes. RWIS stations are more effective when there is a network of stations with wide coverage of the rural region.

3.2. Closed Circuit Television

Closed circuit television (CCTV) camera systems include a network of cameras that collect images of current roadway conditions. The images are sent to a monitoring location where they can be viewed and analyzed. These images can provide information about area traffic and roadway conditions, be used to detect and verify reported traffic incidents, and assist in activity management.

There are many benefits of being able to monitor current roadway conditions at important locations. Information about the current status of the roadway can aid in making the area safer for travel. CCTV can be used to detect incidents and help with incident response time. CCTV can provide information about roadway surface conditions, which is important for winter maintenance and for traveler information. Images from CCTV cameras can be made accessible to the public via the Internet, which can help ensure that drivers are prepared for hazardous conditions. CCTV cameras can also be a useful tool in providing security in locations such as rest areas. Some state DOTs use CCTV cameras to view DMSs to verify the current message being posted.

3.3. Inductive Loop Detectors

Inductive loop detectors (also referred to as loop detectors) are placed underneath the road surface and detect vehicles that pass over them. Information provided by loop detectors can be analyzed to determine patterns and volumes over time, or the detectors can be used to provide useful data in real-time. In urban areas real-time information collected by loop detectors relates to incident detection, traffic monitoring, or travel-time forecasting. Due to the traffic and travel challenges in rural areas, they are generally used solely for planning or analysis purposes such as:

- Estimates of average annual daily traffic (AADT) for roadway segments;
- Pavement design data such as lane distribution, directional distribution, percent trucks and possibly truck weights; and
- Operation characteristics such as peak-hour flow and average speed.

This report focuses on the methods used to determine optimal locations for collecting statewide AADT data. To accomplish this, the sampling method relies upon permanent or continuous count locations (comprised of inductive loops) and portable count locations using road tubes.

It should be noted that there are numerous alternatives to inductive loops such as magnometers, piezoelectric sensors, and a wide range of non-intrusive detectors that use radar, sound, video image processing and other technologies to detect vehicles. For more information on vehicle detection technologies visit the Vehicle Detector Clearinghouse web site at New Mexico State University (http://www.nmsu.edu/~traffic/).

3.4. Dynamic Message Signs

Dynamic Message Signs (DMSs) can be used to display real-time information to drivers about hazardous surface conditions, traffic problems, road construction, or any other issues that may affect traveler safety or convenience. Alerting drivers of upcoming conditions may result in safer driving actions ranging from more attentiveness, to reducing speed, to stopping to put chains on the vehicle. At a broader level, DMS can be used to influence motorist route selection when an incident occurs. Thus they are often placed upstream of major junctions or interchanges.

The signs can be fixed or portable depending on whether the need is temporary or permanent. For example, portable signs work well in areas that are under construction. Fixed signs are ideal in locations where the drivers' need for safety information is continual, such as road segments where traffic incidents or weather events are a common occurrence. This document focuses on locations for permanent DMS installations.

4. RURAL CHALLENGES

Rural areas are, by nature, more remote and sparsely populated than urban areas. In California, rural regions are often characterized by rugged or inhospitable terrain such as mountains and deserts. These elements provide challenges that affect sensor location selection, described below:

- There is limited access to power. It can be costly to run electricity from the nearest access point to power the sensors. Other power sources such as solar panels and batteries can be employed, but they require more components on the roadside that require maintenance and are susceptible to vandalism. These practical concerns with stand alone power systems should be considered when selecting sensor locations.
- Communications to allow remote data retrieval and incident notification are critical to making use of sensors. Ideally sensor locations should have access to landline communication. Cellular networks offer another option. If cellular is used, bandwidth and connection issues should be considered, as some system designs will lead to excessive cellular charges.
- Maintenance of sensors requires trained staff. Rural districts face staffing issues associated with ITS because staff with appropriate training to calibrate and maintain ITS devices are often stationed at the district office which may be some distance from a remote ITS device. This affects location selection because it increases travel costs associated with checking and maintaining sensors. If possible, locations should be selected that are readily accessible to maintenance staff. Sensor locations should also have safe, convenient access, such as wide shoulders or pullouts. If sensors are to be installed in more remote locations, consideration should be given to more robust (and typically more expensive) installations that will perform reliably of longer maintenance intervals.
- Rural areas have few alternate routes. If motorists are to choose an alternate route based on information from an incident detection system, they may need to be notified many miles upstream at the nearest junction. Furthermore, they may still choose to continue on their original route, as the travel time added by taking the alternate route could offset the benefit of avoiding the incident.
- Rural areas have longer emergency response times. Areas with long emergency response times and high crash frequency may be ideal locations for CCTV cameras.

5. LOCATION SELECTION

The following sections discuss location selection criteria that are specific to each type of sensor mentioned—RWIS, CCTV, inductive loops, and DMS. The last section provides guidance on location selection criteria that are common to all devices. These criteria are summarized in Table 5 in Chapter 6. In light of the variability in their intended function and the uniqueness of each deployment site, the guidance on sensor placement, offered in this report, is intended more to highlight rural issues, rather than to provide implementation and design guidelines. For an example of applying these principles of location selection in a specific region, refer to Strong et al. (2005).

5.1. Road Weather Information Systems

RWIS stations generally are most useful in areas of adverse weather conditions. These could be areas with high variability in weather patterns or areas that are prone to weather events that affect the transportation system such as high winds, fog, precipitation and freezing temperatures. Considerations for siting RWIS stations include locations with:

- Known weather issues such as mountain passes (ice and snow), bridge decks (ice), and valleys and shaded areas (icy patches)
- Frequent traffic during adverse weather conditions, such as ski areas
- High amounts of snow, rain, fog, or wind
- A higher frequency of weather-related accidents
- More likelihood of flooding (FEMA classification “A”)
- A higher frequency of road closures caused by storms, avalanches, or weather-related crashes.

Although it is helpful to place RWIS stations in areas with weather problems for incident detection at specific locations, they can also be used collectively to monitor regional weather and pavement surface conditions. Local prediction models can also be developed that utilize regional weather forecasts and a system of several local RWIS stations. For regional monitoring and prediction RWIS stations should be located for the best area coverage and spread across the region, with more locations in areas of higher variability. Ballard et al. (2002) recommends that a licensed meteorologist provide guidance on RWIS station placement. For more information on using RWIS for regional models and coordinating weather data with other agencies, refer to the Federal Meteorological Handbook (http://www.ofcm.gov/fmh-1/fmh1.htm). More detail on the generalized location guidelines summarized above for siting RWIS stations can be found in several publications:

- RWIS Environmental Sensor Station Siting Guidelines (http://ops.fhwa.dot.gov/publications/ess05/ess05.pdf)
- RWIS Volume 1: Research Report (http://onlinepubs.trb.org/Onlinepubs/shrp/SHRP-H-350.pdf)
- RWIS Volume 2: Implementation Guide (http://onlinepubs.trb.org/Onlinepubs/shrp/SHRP-H-351.pdf)

5.2. Closed Circuit Television

CCTV is used to provide a visual picture of current conditions at remote locations. While other sensors provide statistical measures of current conditions, CCTV can be used to visually confirm and monitor conditions. Criteria used to select RWIS station locations also apply to locating CCTV cameras when they are to be used to verify weather events.

It is common to use CCTV cameras at intersections, junctions and major interchanges to monitor traffic. Because of merging traffic, these locations are susceptible to congestion and higher crash frequencies. Monitoring the traffic at these locations can be beneficial because it allows for quicker deployment of emergency vehicles in case of an accident. Monitoring video of how an intersection performs during certain traffic events, such as closing time for a ski area, can be useful in determining ways to alleviate the problem.

Common crash locations, whether at intersections or other road segments, should be considered potential sites for CCTV cameras.

CCTV is also commonly used for security purposes. Places where people congregate or where vehicles are left unattended, such as rest areas or parking areas, can have security problems. It may be desirable to install CCTV cameras in these locations for the security they can provide.

CCTV can be used to verify that a nearby DMS is working and displaying the appropriate message. The goal of verifying DMS messages by itself probably does not justify a CCTV camera installation, but is an additional benefit if other location selection criteria are met.

For CCTV to be effective, the camera needs a clear unobstructed view of the area being monitored. Using the cameras on straight, open stretches of road optimizes the range of effectiveness of the camera. To ensure that the best picture quality is achieved, the camera should be mounted to a fixed, steady structure such as a bridge or overpass. Cameras mounted on poles can be affected by wind and provide poor quality images. If the camera is mounted on a structure that vibrates with passing traffic, the picture may look blurry and the images may be of little use. Locations to consider for siting CCTV cameras include:

- Location of existing or planned RWIS stations (see previous section)
- Locations that provide a view of existing or planned DMS
- Locations with high frequency of crashes
- Rest areas
- Major intersections or interchanges
- Structures such as overpasses
- Locations with a clear view

Washington and Wisconsin use one-mile spacing between CCTV cameras in urban areas as a general rule (Strong et al., 2005). This level of CCTV camera density is not feasible in rural areas. Typically the number of CCTV cameras deployed is based on budget constraints, with locations limited to the highest priority areas.

5.3. Loop Detectors and Planning Data

Inductive loop detectors can be used for incident detection and ramp metering in urban areas, but in rural areas are typically only used for collecting planning data. Inductive loops are used for permanent count stations at locations that are chosen based on a pre-determined sampling scheme. These permanent count stations are supplemented by short-term counts made with portable road-tube counters. The layout of the permanent count stations (number and location) is determined to minimize the potential error in traffic estimates across the region or state. More detail on the general approach, described below, can be found in the FHWA Traffic Monitoring Guide (http://www.fhwa.dot.gov/ohim/tmguide/). This approach, although used, is not specific to rural areas.

First, roadways are categorized by facility type as shown in Table 2. Generally, the seasonal and weekly variations in traffic are similar for roads of the same facility types.

Table 2: HPMS Functional Code (FHWA, 2001)

Rural Functional System Codes	Urban Functional System Codes
1 Principal Arterial Interstate	11 Principal Arterial Interstate
2 Other Principal Arterial	12 Principal Arterial Other Fwys & Exp
6 Minor Arterial	14 Other Principal Arterial
7 Major Collector	16 Minor Arterial
8 Minor Collector	17 Collector
9 Local	19 Local

Next, these functional classifications are combined into functional groups with similar seasonal and weekly variations in traffic. FHWA (2001) recommends three to six groups, or more if needed to account for regional differences. A potential functional group categorization is shown in Table 3.

Table 3: Minimum Groups (FHWA, 2001)

Road Function	HPMS Functional Code
Interstate Rural	1
Other Rural	2, 6, 7, 8
Interstate Urban	11
Other Urban	12, 14, 16, 17
Recreational	Any

The permanent counters are assigned within these groups. The minimum number of permanent count stations needed within a functional group depends on the variability of daily traffic counts within that group. More permanent count stations should be placed within groups of higher variability. The following equation can be used to determine the minimum number (n) of count stations for a desired precision (D*) and a variability of the facility group (in this case the coefficient of variation, C).

$$D^* = t_{1-d/2,n-1} * \frac{C}{\sqrt{n}}$$

Minimum count stations for groups with different coefficients of variation have been calculated and listed in Appendix A. The coefficient of variation should be based on previous counts. If the coefficient of variation is unknown, an estimate can be chosen from the ranges in Table 4.

Table 4: Variation Coefficient by Area Function (FHWA, 2001)

Area Function	Variation Coefficient
Urban Area	<10%
Rural Area	10%~25%
Recreational Area	>25%

If resources exist for additional count stations above the minimum for each functional group, they should be assigned proportionally to these minimum numbers. More count stations will yield more accurate results. The optimum number, above the minimum, is open for debate. As a point of reference, in Iowa, with 8,909 miles of state roads, Souleyrette and Pattnaik (2003) found that the 130 permanent detectors yielded adequate results. Resources for collecting planning data should be appropriated such that there are 10 to 20 portable road-tube counters for every permanent count station (Ross et al., 2004).

Thus new permanent count stations should be located on roadways within a functional group such that, when compared to other groups, the proportion of counters located on the types of roadways within that group is equivalent to the minimum number, when compared to the minimum number of other groups. Ideally, locations on roadways within these functional groups should be selected randomly. However, to improve accuracy, they should be located on straight segments of roadway.

5.4. Dynamic Message Signs

DMSs are commonly used in areas where there is a need to detour traffic or warn motorists of downstream conditions. A typical use for DMSs in rural areas is to display information pertaining to weather conditions, such as warning drivers of icy conditions as they approach mountain passes, and whether snow chains are needed. Such a sign would usually be placed at the bottom of the pass or in advance of a junction, turn-around point, or a pull-out/chain-up area.

The signs must be large enough that the motorist can read them at highway speeds. Thus, they must be placed in locations where they can be seen from an adequate distance such as a straight stretch of roadway longer than 800 feet. The signs must also be visible at all times of the day, giving consideration to sun glare or headlight reflection. Considering DMS use in rural areas, they should be placed:

- Two miles prior to major junctions
- Two miles prior to snow chain areas
- After 800 feet of straight road
- Locations that meet placement requirements of guidance signing in the Manual on Uniform Traffic Control Devices
- Upstream of common weather events

5.5. All Devices

There are several location criteria that are common to any ITS device in the rural environment, such as availability of power and communications. Although solar power and satellite communication can be used, landlines for power and communication are preferred, as previously discussed.

Sensor maintenance costs are potentially of greater concern in rural environments, as travel distances, and associated travel costs, to perform inspection and maintenance activities can be significantly higher. Travel time (i.e., the distance from the sensor to the maintenance office or district office) is an important consideration. If a remote area has significant challenges that could benefit greatly from ITS elements, travel costs should not preclude the placement of an ITS device, but they need to be considered.

It is often more cost effective to install new ITS elements in conjunction with new construction projects. When ITS elements are included in construction projects, economies of scale can be realized with design, mobilization and traffic control. It is also easier to run power and communication lines to ITS elements while the road is under construction. Disruption to traffic during the installation is also reduced if the ITS elements are installed during construction since the traffic would already be disrupted.

The proximity of each element to other ITS elements should be considered. Similar types of devices should not be duplicated in the same area. Similarly, if there are large gaps in the system, it may be desirable to install an element where data can be obtained for the underserved area. Note that if CCTV cameras without pan/tilt capabilities are used, two may be used in one location to view each direction.

Because of the power, communication and maintenance challenges in rural areas, it may be advisable to take a node approach to ITS devices. A single communication and power hub may be set up for CCTV, RWIS, loops, and DMS in a single area. The devices could be mounted on the same structure, or within the same area as long as they are close enough together to share the communication hub.

Regardless of the sensor type, the following location considerations should be made:

- Planned construction project
- Available power
- Available communication
- Close to maintenance yard (e.g., within three hour drive)
- Directly adjacent to maintenance yards
- No existing device of the same type nearby (e.g., within two miles of similar device)
- Co-locate ITS devices
- Good access (e.g., near a pullout)

6. SUMMARY

This report summarizes the primary attributes of good locations for sensor placement in rural areas. To optimize sensor placement, locations should be prioritized for a district or region. First, location attributes that are important for the district should be identified from those in Table 5. Note that it may be beneficial to place DMS upstream of locations with many of the criteria listed (e.g., mountain passes and common weather events) placing the DMS at the problem locations may not be beneficial. Second, a set of ranking criteria or point system should be developed for each of these criteria. An example that was developed by Strong et al. (2005) for prioritizing DMS and CCTV cameras is presented in Appendix B. Third, the ranking criteria should be applied to roadway data to develop a prioritized list of locations.

Table 5: Location Selection Criteria

Location Criteria	RWIS	CCTV	Loops	DMS
Mountain passes	X	X		
Ski areas	X	X		
High wind, rain, snow, fog	X	X		
Common icy conditions	X	X		
Shaded areas	X	X		
Bridges	X	X		
High proportion of weather related crashes	X	X		
Flooding locations	X	X		
High frequency of road closures	X	X		
View of DMS		X		
High frequency of crashes		X		
Rest areas		X		
Major intersections and interchanges		X		
Structures		X		
Good view		X		
Straight road		X	X	X
Upstream of junctions				X
Upstream of chain up areas				X
MUTCD				X
Upstream of common weather events				X
Planned construction project	X	X	X	X
Available power	X	X	X	X
Available communication	X	X	X	X
Can visit from maintenance yard in one day	X	X	X	X
At maintenance yard	X	X	X	X
Not within 2 miles of same type of device	X	X	X	X
Co-located with other devices	X	X	X	X
Good access	X	X	X	X

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8. APPENDIX A: ESTIMATED NUMBER OF COUNT STATIONS

The following table provides the number of permanent count stations (N) needed for a 10 percent precision interval for a functional group with a given coefficient of variation.

Table 6: Number of Count Stations (N) Based on Variability of Traffic (C)

Area Function	C	N
urban	1%	2
	2%	3
	3%	3
	4%	3
	5%	3
	6%	4
	7%	4
	8%	5
	9%	5
Rural	10%	6
	11%	7
	12%	8
	13%	8
	14%	10
	15%	11
	16%	12
	17%	14
	18%	15
	19%	16
	20%	18
	21%	19
	22%	21
	23%	23
	24%	25
	25%	26
Recreational	26%	28
	>27%	30

9. APPENDIX B: TABLES TAKEN FROM STRONG ET AL. 2005

Table 7: 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

Table 8: 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