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Maine Statewide Deployment and Integration of Advanced Traveler Information Systems

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ABSTRACT

Advanced Traveler Information Systems (ATIS) are new to the State of Maine and there are many unanswered questions regarding the effect that they have on motorists. Dynamic Message Signs (DMS), Variable Speed Limit Signs (VSLS) and Overheight Vehicle Detection (OHVD) systems are key components of ATIS, and are means through which motorists can be provided with en-route information pertinent to their travels.

Speed data was collected during inclement weather events in order to determine what effect VSLS have on traveler speed. Speeds were collected during storms of varying intensity. The data suggests that motorists adjust their speed to conditions and what they feel is appropriate. This is also supported by survey responses. The fact that they do not slow down to the posted speed could be due in part to the VSLS not being enforced.

An OHVD system was installed in Bangor in August of 2006. The system has shown potential, with no hits to the I-95 overpass since installation.

Also part of the study was identifying and evaluating the institutional issues and barriers associated with Intelligent Transportation System (ITS) deployment. Some of these issues include: long-term funding commitments for ATIS, acceptable messaging, integration of information databases, inter-agency coordination, enforcement, and education of the public.

INTRODUCTION

Current highway infrastructure capacity is often insufficient to handle traffic at a high level of service during morning and evening peak-hour travel, especially when crashes and/or inclement weather occur. According to a July 2005 article in *Public Works* it is estimated that the cost of travel delay and wasted fuel from congestion surpassed \$63 billion in 2004. In addition, it is estimated that another \$60 billion is lost annually in productivity losses due to time spent in traffic (1). The problem may not be as significant in Maine as in more populated states but there are certainly daily instances in the state when poor weather conditions or crashes delay traffic, sometimes closing down entire roads for several hours. And snow or freezing rain sometimes delay traffic in large regions and such weather also leads to an increased likelihood of crashes causing further delay also to drivers not directly involved in those crashes. Traffic moving to parallel roads can at times also cause undue delay if drivers do not seek optimal alternatives. It is possible that some type of information systems can significantly improve road-user mobility as well as safety.

OBJECTIVES

The primary objective of this research is to measure the effectiveness that new information and warning systems in Maine have on the service provided by its highways. By integrating the use of Dynamic Message Signs (DMS) in specific problem locations, drivers can be provided with real time traveler information using CARS (Condition Acquisition Reporting System) as well as FORETELL (a road and weather predicting system) models being deployed under TRIO (Tri-State Rural Advanced Traveler Information System). These systems can improve highway efficiency and safety. In a few locations, Overheight Vehicle Detection (OHVD) systems have also been installed to prevent damage to bridges by overheight traffic passing underneath. Finally, new Variable Speed Limit Signs (VSLS) replaced old and less flexible models in 2007. The effects of these systems were studied and results are presented here. A complete version of the report can be obtained from the University of Maine (2).

LITERATURE REVIEW

In order to better understand the systems being utilized, literature relevant to DMS, VSLS, and OHVD Systems were reviewed with respect to maintenance costs, perceived driver hazard, revealed safety effects, and effectiveness and reliability of displayed messages. These advanced information and communication technologies are often referred to as Intelligent Transportation Systems (ITS).

The Advanced Traveler Information System (ATIS), a key component of ITS, provides drivers with dynamic information on road traffic conditions. This technology has not only been established, but is undergoing field tests in many areas around the world. A full literature review is provided in the University of Maine report (2). Below follows a short summary of this review.

Dynamic Message Signs

According to the 2002 ITS deployment tracking database (3), there had been as much as \$330,000,000 spent on acquiring and installing DMS to that date. These signs have not only been used to display adverse road conditions, traffic incidents and construction but have been valuable assets to America's Missing: Broadcast Emergency Response (AMBER) alert situations, and na-

tional security/emergency messages. However, there have been numerous instances in which the DMS have been underutilized or provide impertinent information while traffic conditions are deteriorating. Regardless of the underlying reasons behind either ineffective or questionable messages, the traveling public interprets DMS as an ineffectively used, often ignorable, and expensive piece of technology. (4)

Formatting Effective DMS Messages

In order to be effective, a DMS must communicate messages that are not only meaningful but can also be read and comprehended by motorists during the short time that they have available to read them. In order to avoid adverse effects on traffic flow and the credibility of the agency responsible for the DMS, one must refrain from displaying messages that are too long to read at typical highway speeds or too complex or inappropriately designed. Factors that should be considered when developing messages in order to enhance understanding of them include: simplicity of words; brevity; standardized order of words; standardized order of message lines; and use of understood abbreviations. In general, four main components of DMS message formatting need to be considered: message load, message length, message familiarity, and message framing. Ullman et al. suggest that comprehension time is directly affected by message length; where eight-word messages at four to eight characters per word displayed in a high-vehicle-operating-speed setting would approach the limit of the average motorist's processing capability. Message familiarity will enhance a motorist reading and reduce comprehension time. Finally, message framing is the division of a DMS message into multiple parts (frames) and shown in sequential patterns. (5)

Variable Speed Limit Signs

Variable Speed Limit Systems (or Signs) (VSLS) are a type of ITS that display appropriate speeds at which drivers should be traveling based on several methods such as speed and volume detection, weather information, and/or road surface conditions. VSLS have been in use for 30 years in parts of Europe and Australia. If used properly, VSLS can improve safety by restricting speeds during adverse conditions and restore the credibility of speed limits.

The Swedish Road Administration (SRA) initiated work spanning 2004-2007 implementing VSLS on motorways, rural highways, and at intersections—a total of 19 sites, nine of which are weather and/or traffic actuated. One of the weather-controlled VSLS locations is an interurban motorway, E6 in Halland in southwestern Sweden. The length of the test section is 55 km (1 km = 0.62 miles) which was divided into eight sub-links which could each be given individual speed limits. The fixed speed limit was raised from 110 km/h to 120 km/h at the introduction of the VSLS in July 2005. During adverse weather conditions, the speed limit is decreased in increments of 10 km/h with a speed of 60 km/h being the lowest to be displayed. The speed limits are controlled based on the expected friction coefficient for the road during various conditions. The expected friction coefficient is based on temperature, moisture, wind speed, and wind direction. Speed measurements were conducted before and after implementing the VSLS. FIGURE 1 illustrates the average speeds in various weather conditions for one of the detector points. One can see that during the pre-study, the decrease in speed from dry to very slippery conditions was only 9 km/h. Also surprising is that the difference in average speed from increasing the fixed speed limit from 110 km/h to 120 km/h was only 1 km/h. The speed measurements show relatively small adaptations in snow conditions; however, when the speed limits are reduced during

severe weather conditions, the average speeds are lowered by 27 km/h from dry conditions and 14 km/h from when there were no VSLS. (6)

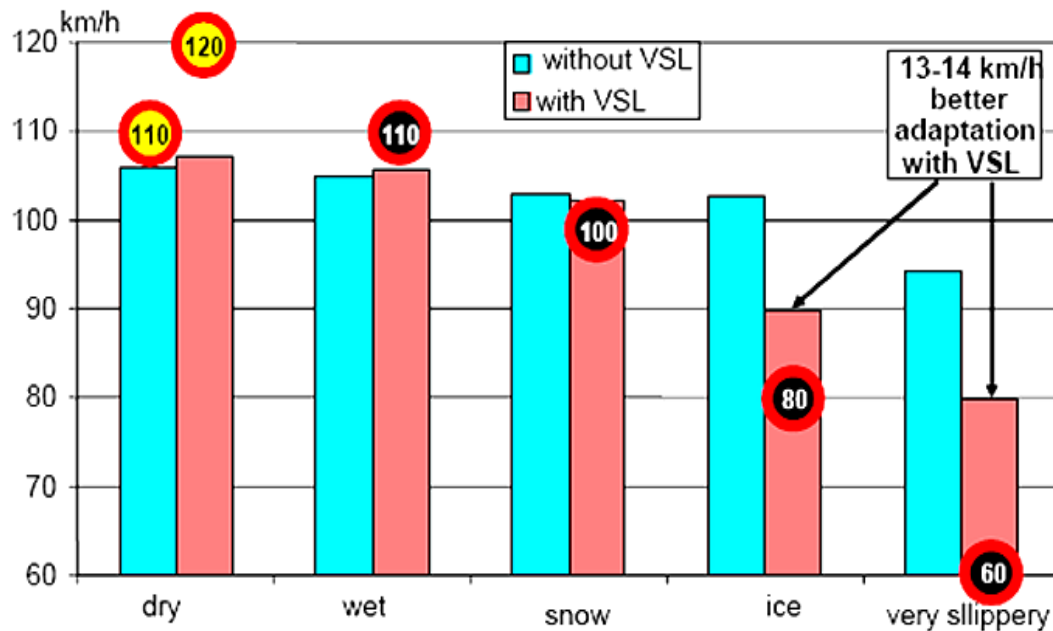


FIGURE 1 Average speeds after VSLS implementation on E6, Sweden.

Looking at accident records, there was a reduction of the number of injury accidents from 34 to 29, yet the number of accidents during the winter increased by 40% - a confusing fact when it was assumed that the effect of VSLS towards accidents would be beneficial. However, weather and roadway conditions can vary from year to year making trend comparisons difficult.

The Washington State Department of Transportation (WSDOT) is currently using a VMS and VSLS system in order to improve safety and increase the availability of road condition and weather information to motorists crossing Snoqualmie Pass (I-90). The system consists of 12 VMS over 40 miles. Information regarding weather and road conditions is obtained from six weather stations as well as sensors in the pavement. Currently, a computer gathers this information and then suggests a speed limit defined by preset variables and an operator then confirms that limit. The fixed speed limit during dry conditions through Snoqualmie Pass is 65 mph. When the road conditions begin to worsen, the speed limits can be reduced in increments of 10 mph – which depends on whether traction tires are advised or required, or whether chains are required. (7) There has also been a matrix developed for other speeds which are based on elements such as visibility and weather severity. The signs currently only display during adverse conditions (8). A study showed that drivers who receive precautionary messages decrease their speeds (when being informed of a new lower speed limit) beyond what they would have done without such information. However, it is also suggested that the effect on driver behavior terminates shortly after passing the sign – increasing the risk in this newly created “acceleration zone” downstream from the sign (7).

There are several roads where VSLS are enforceable by local/state public safety agencies, for example in Minnesota (still in the demonstration stage), Nevada (along Interstate 80), New Jersey (the New Jersey Turnpike), New Mexico (I-40 Eastbound in Albuquerque), and in Finland (E18 in Southern Finland), Germany (along Autobahn A8 between Salzburg and Munich, A3 near Sieburg, and A5 in Karlsruhe), and the United Kingdom (M25 London Orbital; enforced by photo radar).

Overheight Vehicle Detection System

Overheight Vehicle Detection (OHVD) systems are a relatively new technology in comparison to ATIS. OHVD systems detect overheight vehicles moving toward overhead obstacles (bridges, overpasses, tunnels, etc.) and individually warn drivers that their vehicle may be too high to travel under the obstacle. There is little literature on their use and success due in part to the fact that they are in their infancy but also because their effectiveness is determined simply by reduction in hits to the problematic location. With a relatively low cost of an OHVD system in comparison to damage to a structure from an overheight vehicle, it can be assumed that the avoidance of one hit can be deemed a success.

According to David Fifer (Personal Communication, February 2008) of the Oregon Department of Transportation, the Harrisburg Bridge was struck by a large crane on January 21st, 2001. This resulted in a closure of the bridge for a period of 15 days while undergoing nearly \$350,000 worth of repairs. The closure meant a very significant rerouting of traffic increasing the average travel time from 10 minutes to 45 minutes for many commuting residents. In addition, economies on both sides of the bridge suffered during the rehabilitation period. An Overheight Detection project came about in response to concerns from the local citizens regarding the effect that closure had on the community. The bridge had also been hit a few years earlier. The \$75,000 cost of installation for the OHVD system was considered to be justified in comparison to a \$30-\$40 million dollar cost of replacing the bridge itself.

A study was done by the University of Maryland in order to assess the magnitude of overheight vehicle collisions with highway bridges resulting in structural damages and/or injuries at both the State of Maryland and national level. It was found that there were 116 overheight accidents in the state from 1995 to 2000, out of which 49 occurred within Baltimore City. This does not include damages discovered during routine bridge inspections. According to the Bridge Inspection Database, 309 bridges (over 20% of all bridges in Maryland) were found to be damaged by overheight vehicles. Statistics on injuries and fatalities as a result of overheight accidents were also compiled. It was found that there was an average of 3.2 injuries per year in the period of 1995 to 2000. In 1999, there were five injuries and one fatality and then another six injuries in 2000. Also, survey data from 29 states which responded show that 55% reported using some form of automated detection systems and most were satisfied with the performance of these systems. The vertical clearances under the bridges had been increased by grinding pavement of raising the overpass itself according to 24% of responses, proving to be effective in reducing collisions. However, none of the states provided statistics to quantify the effectiveness of their countermeasure strategies. (9)

MAINE SITES: DYNAMIC MESSAGE SIGNS

Description of System

Currently there are seven Dynamic Message Sign (DMS) (sometimes referred to as Variable Message Sign) locations along I-95 and I-295 that are part of the Maine Department of Transportation (MDOT) ITS Deployment Project. Also, portable DMS are placed in specific locations as needed for planned events. The goal of the DMS system is to provide drivers with accurate, timely and reliable information regarding roadway conditions or incidents on their intended route of travel so that drivers are able to make informed decisions and ultimately complete their trip in a safe and efficient manner. The MDOT Radio Room relies on the State Police, maintenance crews, and the traveling public to inform them of conditions on the roadway. Once this information is obtained (and verified if received from the public), the information is supplied to a private company who control the CARS and 511 systems (a phone and web-based traveler information system). There is the capability of having the DMS linked directly to the CARS/511 database but a substantial cost is charged to have the database linked directly to state information technologies. Because of this, the DMS system still relies on a human interface.

Acceptable information (as established by MDOT) to be displayed on the DMS include: weather and roadway conditions, special events, travel time, enforcement actions, and congestion management.

Unacceptable messages include: advertising, public service announcements, generic messages (i.e. slogans, greetings, or holiday wishes), date/time/temperature, or static signing that is intended for long-term display.

Findings

According to the MDOT's Standard Operating Procedures for DMS, the signs are to remain blank when no message is to be displayed. However, Jeffrey Paniati of the FHWA (4) suggests that "a 'dark' or blank DMS is a transportation investment that is not being fully utilized. We should be asking why it is dark and what it will take to get travel times posted on an ongoing basis." He also goes on to state that there should be no new installations of DMS along heavily traveled routes "unless the operating agency and the jurisdiction have the capability to display travel time messages." This is not to say that travel times are appropriate for every location but it should be a consideration, especially for southern Maine which experiences periods of recurring congestion. It should be noted that unforeseen complications, relating to data storage at MDOT, arose that hindered the completion of some of the originally planned DMS study.

DMS Survey Results

A survey was sent out and 62 responses were generated. A copy of the survey can be found in Appendix A of the earlier mentioned report (2). Overall, 98% remembered that they had encountered messages being displayed on the DMS on sections of the Maine Interstate. Of those, 72% found the information being displayed useful but only 31% used the information to alter their traveling route from what they had originally planned. The general consensus was that it would take longer to divert their route than it would be to sit in traffic. However, 68% indicated that if while driving on the interstate they encountered a DMS that read "Accident Ahead at Mile ...," they would leave the interstate and find another route. The 32% that responded "no" to the previous question stated that they wouldn't leave the highway because they would assume the information to be either incorrect or old, not be familiar with the area in order to be able to find

another route, or be interested in seeing the accident. Some of the participants indicated that along with seeing messages regarding detours, speed limit reduction and construction, they also encountered messages that read “Thank you for your patience,” “Happy Holidays,” and “Drive Safe.” A majority, 64%, of participants would find it useful if the DMS displayed air and/or roadway temperature during the winter. About 45% of respondents were familiar with the 511 system but only 19% had actually used it, and about two in three of these people did not find the system useful. None of the individuals that had used the 511 system encountered the 511 information being displayed on a DMS.

VARIABLE SPEED LIMIT SIGNS

Description of System

The newly installed Variable Speed Limit Signs (VSLS) along the Maine Interstate and Maine Turnpike corridors are an updated version of the old “flashing 45 mph’s.” The “variable” feature allows the units to be set at any speed rather than just at 45 mph. Incidents that require speed reductions include traffic incidents (crashes), construction activity, emergency situations (fire, evacuation, flood or structure failure), special events (fairs, concerts, etc.) that have an impact to travel lanes and ramps, and weather. Guidelines and conditions used by the MDOT for variable speed posting based on weather are currently incomplete; only giving ranges of speeds for a few conditions.

During inclement weather, the State Police are responsible for notifying the MDOT Radio Room when it is appropriate to activate the VSLS. However, it has been experienced that the State Police do not always call when the conditions are deteriorating on the interstate. Maintenance crews will often call the Radio Room and notify them as conditions worsen, at which point a Radio-Room operator has to call the State Police to request permission to turn the VSLS on. Personnel in the Radio Room are also monitoring conditions through a few CCTV feeds as well as other publicly available video. Unlike the procedure needed for the activation process, the deactivation process does not require the permission of the State Police and can be done so as seen fit per request of MDOT Maintenance crews and public informants.

Findings

Throughout the 2006 to 2008 winter season, speeds were taken (using a radar gun) during numerous inclement weather events that varied in intensity. The condition of the roadway surface also varied greatly between each event. Typically, speed data was collected in two-hour intervals during the morning and/or evening commute. TABLE 1 gives a summary of the findings where P_{avg} indicates average speed and P_{85} indicates the 85th percentile speed.

TABLE 1 Speeds during Snowfalls with Different Intensities

Date	Time (military)	Snow Intensity	P _{avg} (mph)	P ₈₅ (mph)
February 14 th , 2007 (VSLs active over entire period)	8:30 – 9:30	Moderate	53	58
	9:30– 10:30	Moderate	53	59
	14:00-15:00	Heavy	42	48
	15:00-16:00	Moderate	44	51
March 2 nd , 2007 (VSLs active over entire period)	8:30-9:30	Moderate	44	51
	9:30-10:30	Moderate	44	50
	14:00-15:00	Moderate	43	49
	15:00-16:00	Moderate	41	46
March 17 th , 2007 (VSLs active over entire period)	8:30-9:30	Moderate	44	50
	9:30-10:30	Moderate	44	50
	14:00-15:00	Light	54	59
	15:00-16:00	Light	53	58
March 18 th , 2007 (VSLs active over entire period)	8:30 – 9:30	Very Light	64	72
	9:30– 10:30	Very Light	66	74
April 5 th , 2007 (VSLs active, but none encountered prior to location)	8:30-9:30	Heavy	40	45
	9:30-10:30	Heavy	42	46
	14:00-15:00	Light/None	67	74
	15:00-16:00	Light/None	66	74
November 20 th , 2007 (VSLs active over entire period)	14:00-15:00	Light/Mod	67	69
	15:00-16:00	Light/Mod	65	71
December 3 rd , 2007 (VSLs active over entire period)	8:00-9:00	Heavy	43	46
	9:00-10:00	Heavy	44	46
	14:00-15:00	Moderate	48	54
	15:00-16:00	Moderate	49	54
December 4 th , 2007 (VSLs active over entire period)	8:00-9:00	Light	55	61
	9:00-10:00	Light	55	60
December 16 th , 2007 (VSLs active over entire period)	8:00-9:00	Light	60	66
	9:00-10:00	Light	60	66
	14:00-15:00	Heavy	43	47
	15:00-16:00	Heavy	43	46
December 17 th , 2007 (VSLs active over entire period)	8:00-9:00	None*	56	64
	9:00-10:00	None*	56	62
December 18 th , 2007 (VSLs active over entire period)	8:00-9:00	None*	62	68
	9:00-10:00	None*	63	70
January 14 th , 2008 (VSLs active at 11:45am)	11:00-12:00	Heavy	51	54
	12:00-13:00	Heavy	51	54
	14:00-15:00	Heavy	43	47
	15:00-16:00	Heavy	43	47
February 1 st , 2008 (VSLs active over entire period)	17:00-18:00	Light w/Fr. Rain	56	64
	18:00-19:00	Light w/Fr. Rain	43	47
*No precipitation, but road conditions were that of ice-packed snow cover				

This data suggests that drivers adjust their speeds to the conditions and what they feel is appropriate. The VSLS appear to have very little, if any, bearing on motorist speed. It was also noticed that in many conditions, the VSLS remained active during periods when there was no precipitation and the roadway conditions were satisfactory. Leaving the signs activated when conditions are suitable for normal speeds, motorists will begin to get the impression that VSLS are not reliable. It is basically a form of conditioning in that the motorist is being “trained” to disregard the posted advisory. The improper operation and display of outdated or inaccurate information on a DMS (and in general, a VSLS can be considered a DMS) has the potential to adversely affect traffic flow. Furthermore, displaying inaccurate or inappropriate information can also cause motorists to question the credibility and ignore DMS altogether (10). The DMS message, or in this case, the VSLS speed limit, should be continuously updated to display the appropriate traveling speed or present limits based on current or expected roadway conditions.

Drivers continually make choices about appropriate driving speeds and make an assessment based on the amount of risk that they are willing to take. One might think that because drivers have a strong incentive to complete their trips safely, they should be left to choose their own travel speed. There are, however, at least three principal reasons for regulating drivers’ speed choices (11): externalities, which are the imposition of risk on others; inadequate information that limits a motorist’s ability to determine an appropriate driving speed; and driver misjudgment.

The MDOT has plans of installing speed detecting radar on each VSLS that would, through “fuzzy” math, display the 85th percentile speed. Although this may help decrease the amount of deviation between traveling speeds, it will not reduce speeds enough to be appropriate for the conditions. As can be seen by the gathered data, the 85th percentile speeds tend to be high for the road conditions. It also seems that displaying the “trend” of speeds would be ineffective since the majority of drivers travel at the speed they feel fit the conditions as opposed to being the speed that is appropriate for the conditions. In order to match the suggested VSLS speed criteria, the 15th percentile speed may be used if this radar method is to be employed.

Currently, when the VSLS are being used for speed advisory during inclement weather events they are not enforceable by the State Police. However, the State Police can issue motorists with a ticket for imprudent speed if they judge the speed being too fast for the conditions. If motorist were to be issued more costly speeding citations (as well as it being “the law” and not just an advisory) for not following the VSLS guidance, then perhaps drivers would be more inclined to drive at a safe speed.

VSLS Survey Results

A survey was sent out and 62 responses were generated. Overall, 56% stated that they found the VSLS useful when driving during the winter. The 44% indicating that the VSLS were not useful stated that they “drove for the conditions.” Some even found the signs “annoying.” Still, about 45% of respondents claimed that they altered their speed according to what was displayed on the VSLS. Of these individuals, 66% said they would drive slower if the VSLS displayed 35 mph instead of 45 mph, at least if the conditions were poor enough to warrant the further reduction. The general consensus of the other respondents was that 45 mph on an Interstate was “slow enough.” The 55% responding that they did not alter their speed according to the VSLS suggested that they could judge their own traveling speed and what was safe for the conditions. People also suggested that if road conditions or specifics regarding why the speed limit had been

reduced were displayed on a DMS then they would consider adhering to the advisory. A total of 85% indicated that they had seen the VSLS still active when the road conditions were dry and there was no precipitation.

Suggested VSLS Speed Criteria

As is evident from the field study of speeds during inclement weather and survey responses, the current method of VSLS use is ineffective. A better approach would be to use roadway surface conditions (influencing friction) and snowfall rate (which directly effects visibility) to determine available braking distance and an appropriate speed for that distance. For instance, if the roadway surface was covered with untracked snow it would have a friction value around 0.35, resulting in a braking distance of 454 feet on a -4% grade (typically used for rolling terrain) at a speed of 65 mph. Now in order to achieve the same braking distance as would be experienced on dry asphalt (friction around 0.72), the traveling speed should be reduced to 44 mph. Friction values for varying surface conditions are suggested by the Society of Accident Reconstructionists (12). Using Equations 1 and 2, the stopping sight distance and braking distances (in feet) for each surface condition were calculated, respectively.

$$SSD = 1.47ut + u^2/[30(f \pm G)] \quad \text{Equation (1)}$$

$$\text{Braking Distance} = u^2/[30(f \pm G)] \quad \text{Equation (2)}$$

where u is speed in mph, t is reaction/perception time in seconds, f is the friction value and G is the grade. For this case, it seems logical to use the braking distance. Braking distance will also return more conservative speeds than will stopping sight distance. The speeds on a 4% down-grade, to match the braking distance at 65 mph on dry pavement were then calculated and these and suggested VSLS speeds for different roadway surface conditions can be seen in TABLE 2. The roadway conditions would be observed by MDOT maintenance crews or State Police and reported to the Radio Room and updated on a regular basis for separate segments of the Interstate.

TABLE 2 Suggested VSLs for Varying Roadway Conditions

Surface Condition	Average Braking Friction	Speed (mph) Calculated value	Speed (mph) Suggested design value
Dry Asphalt	0.72	65	65
Partial Frost	0.63	60.5	60
Frost	0.53	55.2	55
Heavy Frost	0.39	46.6	45
Tracked Snow	0.35	43.9	45
Untracked Snow	0.35	43.9	45
Snow & Ice	0.32	41.7	40
Black Ice	0.32	41.7	40
Sunny Ice	0.24	35.3	35
Wet Ice	0.24	35.3	35
Glare Ice	0.19	30.5	35

Also to take into consideration is the visibility that occurs during different snowfall intensities. Visibility distances have been measured for various snowfall rates (as the liquid equivalent) and these results are shown in FIGURE 2 (13). An upper bound and lower bound value were determined from these results for different snowfall rates and a logarithmic-regression curve was fit to the data. These regressions are expressed in Equations 3 and 4 for the upper bound and lower bound, respectively, where V is the visibility in feet and R_s is the liquid equivalent snowfall accumulation in inches per hour.

$$V = -1359 \ln(R_s) - 738.6 \quad \text{Equation (3)}$$

$$V = -454 \ln(R_s) - 152.9 \quad \text{Equation (4)}$$

These visibility distances were assumed to be equal to the stopping sight distance. Stopping sight distance is used because reaction time is more critical when visibility becomes an issue. A speed required to match that distance was then determined using Equation 1. Suggested VSLs speed criteria with respect to snowfall intensity become 55 mph in light snowfall (≤ 0.2 in/hr liquid equivalents), 45 mph in moderate snowfall (around 0.4 in/hr), and 35 mph in heavy snowfall (≥ 0.5 in/hr). These conditions, as with the roadway conditions, would be observed by MDOT maintenance crews or State Police and reported to the Radio Room and the conditions (as well as the DMS and VSLs) would be updated on a regular basis for separate segments of the Interstate.

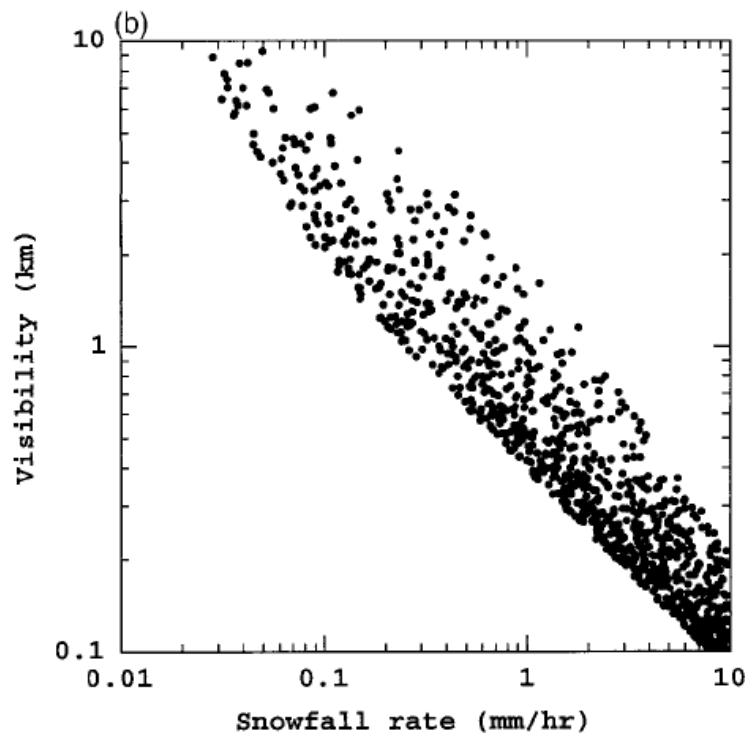


FIGURE 2 Visibility as a function of snowfall rate.

OVERHEIGHT VEHICLE DETECTION SYSTEM

Description of System

The OHVD system that was studied is located in Bangor on US Route 2 where it passes under I-95. There is also an OHVD system located a few hundred feet away on a crossroad just before it intersects with US Route 2. These systems were installed (with an initial cost of \$173,000) in August of 2006 as a result of numerous strikes to the overpass having occurred in the past: 15 strikes over the past 12 years; three times requiring repairs in excess of \$60,000. When the first sensors are tripped, it sets off a set of flashing warning signs to catch the driver's attention and inform him/her that the vehicle is overheight. If the overheight vehicle continues on past the warning signs, there is a second sensor just prior to the bridge that if tripped takes a picture of the vehicle's license plate and a five-minute video in the direction of the bridge. The system also utilizes a double-beam sensor in order to exclude vehicles traveling away from the bridge. Currently, this is the only OHVD system used in the State of Maine, but there are plans to install more systems.

Findings

The OHVD system seems to be effective since there has not been any hit to the bridge in the eastbound direction since the installation. However, based on the amount of time that has elapsed since the installation and the strike rate prior to this, there still is a 15% chance that there would have been no strikes to the bridge had no OHVD system been installed. There was one hit to the bridge in the westbound direction (where there is no OHVD system currently installed) by

a truck hauling a modular home. In order to be completely effective, OHVDs should be installed on both approaches under low-clearance bridges.

INSTITUTIONAL ISSUES AND LESSONS LEARNED

Along with the technological issues that arise with implementing new technologies, there also are institutional issues. The integration of CARS and FORETELL to DMS and VSLS has yet to be completed. As mentioned above, the MDOT Radio Room personnel supply all their data to privately owned databases (which feed the 511 system). Yet, in order to have the ATIS directly linked to these databases, there is a substantial fee. Therefore, information is separately sent to the newly deployed ATIS. This is what sometimes causes discrepancies between the two systems. The general consensus of the MDOT seems to be that, although more difficult, it is cheaper and more effective to develop an in-house system than to rely on current private operator.

The Maine Turnpike Authority (MTA) does not always send their traffic information to the CARS/511 database, thus causing more discrepancies. Also, the MTA will only display information if a delay greater than 30 minutes is anticipated. The MDOT, on the other hand, has a policy to display any information generating a delay greater than 10 minutes. Currently, the MDOT is working with the MTA to get on the same level with displaying information as to not cause confusion as well as sharing information with emergency responders and neighboring states.

As was previously mentioned, the ATIS system is highly dependent on updates from the State Police. Experience has shown that the State Police do not always inform the radio room in a timely manner, if informing them at all.

As made apparent by the survey results, there are certain parts of ATIS technologies (such as the 511 system) which the public does not know much about. It may be beneficial to have a public service announcement regarding such technologies, and how the public can utilize them to best suit their traveling needs.

It can also be expected that there will be a demand for more VSLS and DMS and an increase in their capabilities. This brings in to question the long-term funding commitments currently in place for ATIS.

CONCLUSIONS AND RECOMMENDATIONS

The primary use of DMS is to inform the public of road and traveling conditions at a given point beyond the location of the sign. The effectiveness of the signs can be determined by measuring traffic divergence from I-95. Though the use of DMS extends well beyond diverting traffic from a normal route, there is no quantitative way to measure these other uses. NC-200 Nu-Metric Traffic Analyzers were used in order to measure traffic divergence during specific events. Having the devices in place for long periods of time would allow for comparisons between “normal” traveling conditions and events when the DMS were active. However, the study of the DMS was inconclusive, even though data obtained from the detectors proved to be detailed and reliable, since no DMS logs were kept by the MDOT Radio Room. There was debate amongst personnel as to the benefit of keeping such logs. Since these logs were not kept, no comparisons could be made to volume data for the I-95 off-ramps obtained from the sensors. As a result, no conclusions can be drawn to date about their use other than the public feedback obtained from our survey – showing mixed feedback on whether motorists find them useful or not.

The purpose of VSLS is to notify motorists when the conditions of the road warrant a reduction in speed. During winter storms, speeds were collected using a radar gun. These speeds were compared for storms of varying intensity. The effect of VSLS on motorists' speeds during inclement weather proved to be negligible. As shown by obtained speeds, motorists drive at a speed that they feel is appropriate for the conditions as opposed to driving in accordance with the advisory. Friction values, based on the studies of literature, were used to calculate safe and appropriate speeds based on calculated braking distances for corresponding road conditions. Visibility during several snowfall rates were used to determine safe and appropriate stopping-sight distances. Originally, the variable function of the VSLS was to be used in order to display different speeds based on different conditions. This function was not used in any of the study periods and only "45 mph" was displayed. This hindered the study slightly, in that planned comparisons of speed data for different displayed speeds could not be done. It is suggested that the use of the variable function be employed in the near future in accordance with the suggested VSLS speeds in TABLE 2 based on road conditions and snowfall rates as presented above.

The effectiveness of the OHVD system was measured simply by comparing the number of hits to the I-95 overpass prior to and after installation. Either a reduction in number of hits, or no hits at all after installation, would be an indication of a successful system. The OHVD was found to be effective since no hits were experienced in the direction in which the system has been installed.

In addition, several agencies were contacted in the United States and Europe to gain knowledge on benefits and issues of ATIS systems already in place. The OHVD and VSLS have had very limited research focused on them and are often assumed to be effective once implemented.

There are many improvements that can be made to current ATIS practice in Maine. Some of these improvements are dependent on what funding is available since ATIS components often are expensive. Other improvements require only policy changes or an increased effort of the parties involved in updating and disseminating information. These improvements should be included in a best-practice program for ATIS that would ensure that each system is being used effectively.

Guidelines should be developed in order to improve ATIS procedures. These guidelines should ensure that there is—what we would like to call—"Effective Facilitation of Functional and Enforceable Controls for Transportation Information Systems" (EFFECTIS). This would incorporate the current standard operating procedures and guidelines suggested by the FHWA as well as certain amendments and additions to current state practices as mentioned in the following paragraphs.

In terms of the DMS, the FHWA guidelines are very clear and well-developed. However, the current method of use by the MDOT could be improved. When remaining blank for long periods of time, their functionality begins to come into question by passing motorists. Information should be constantly displayed on the DMS; whether that is travel time information, temperatures, construction schedules, or other traveling information relevant to motorists. The number of DMS should also be increased. At the moment, only Interstate segments in the three major metropolitan areas of Maine have DMS. Intermediate locations should be established to make the DMS system more effective. A motorist should encounter a DMS (at least) every 30 minutes.

The VSLS ultimately need to be enforced if they are to have any significant effect on traveling speeds during inclement weather. Motorists feel that they can safely judge their own speed

for given conditions; yet during normal conditions their speed is regulated to an enforced standard. This should also hold true for speeds posted during inclement weather when crash likelihood is increased. As with the DMS, the number of VSLS locations should be increased to ensure that motorists are constantly reminded of the speed reduction. The DMS should be used in conjunction with the VSLS; not to post the speed limit reduction, but to post a description of the road conditions. VSLS should be deactivated at an appropriate time as to not condition motorists into thinking the signs are unreliable.

When implementing an OHVD system for a low-clearance overpass, the system should be installed on both approaches in order to have complete effectiveness. Each system should also be equipped with video capture and photo capabilities.

Finally, there needs to be less reliance on the human transfer of information as exists currently with the DMS and VSLS in Maine. This has proven to be the largest barrier of the ITS Deployment Project. This would also help reduce the discrepancies that occurred between databases. The technology exists where these systems can be made self-sufficient with optional human-overrides if necessary. There also need to be state or region-wide press releases or public service announcements whenever ATIS technologies are being deployed so that motorists are made aware of and know how to fully utilize their capabilities. As made apparent by the survey, a majority of the public is still unfamiliar with the 511 system – even though it has been available since May 2003.

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