REFERENCES

Huijser, M.P., P.T. McGowen, W. Camel, A. Hardy, P. Wright, and A.P. Clevenger. *Animal Vehicle Crash Mitigation Using Advanced Technology Phase I: Review, Design and Implementation*. Western Transportation Institute - Montana State University, Bozeman, MT, USA. August, 2006.

and

Huijser, M.P., T.D. Holland, A.V. Kociolek, A.M. Barkdoll, and J.D. Schwalm. *Animal-Vehicle Crash Mitigation Using Advanced Technology Phase II: System Effectiveness and System Acceptance*. Western Transportation Institute - Montana State University, Bozeman, MT, USA. March, 2009.

INTRODUCTION

This set of reports focused on the implementation and evaluation of roadside animal detection systems (ADSs) as an animal-vehicle collision mitigation measure. These systems are relatively new in the United States, but some pilot applications and evaluations have been implemented. ADSs use various detection technologies along the roadside to sense the presence of large animals. These detections then activate enhanced warning signs that are intended to encourage drivers to reduce their vehicle speed. The results of this study were reported in two phases. The first phase of the project explored existing animal detection systems and documented what was learned during the implementation of two experimental systems in separate sites. The reliability of these experimental ADSs in detecting animals was also documented. The second phase of the project more closely considered the impacts of one of the ADSs on vehicle speed and the prevention of animal-vehicle collisions (AVCs). These results are documented in the second reference noted above.

PHASE I STUDY

Existing ADSs Summary and Results

The report for Phase I of this project included an extensive amount of information about 34 existing ADSs in the United States and Europe. These included all known systems at the time this report was written. The information summarized was gathered from the literature, company personnel, and other resources. Most of the systems were defined as "area-cover" or "break-the-beam" systems. The area-cover systems detect large animals that are within range of a sensor. These systems were either passive (e.g., passive infrared, video detection, etc.) or active (e.g. microwave radar). The break-the-beam systems generally detect animals when they interrupt a beam between two roadside transmitters. Specific details of each of these systems (e.g., system specifications, costs, installation and maintenance experiences, etc.) are included in the report.

Overall, it was found that many of the systems experienced installation difficulties and it was assumed that this could be attributed to, among other things, the fact that this is a relatively new application of this type of technology. The authors did qualitatively state, however, that the Swiss, Finnish, and geophone animal detection systems, as well as a radio collar system appeared to be successful, and that systems in Indiana and Montana seemed to have promise. At the same time it was recognized by the project team that the research available about the potential vehicle speed and/or crash reduction impacts of ADSs was generally lacking. The small amount of data that does exist shows variable vehicle speed results due to the activated warning signs. They also indicated that past research appears to show drivers may reduce their vehicle speed (due to the activated signs) to a greater extent in poor weather, if they are local drivers, and if it was accompanied by a legal speed reduction requirement. One Swiss study of passive infrared ADSs at seven locations did show that they produced an 82 percent reduction in night-time collisions with large animals. All seven locations experienced a reduction in AVCs. The difference in AVCs was found to be statistically significant with a one-sided Wilcoxon matched-pairs signed-ranks test. Overall, the researchers emphasized that these ADSs and their activated signs could cause drivers to be more alert, reduce their reaction time, and result in reduced stopping distances (even if their speed was not reduced).

As part of the review noted above the researchers also describe how important it is that the detections that result in the activation of enhanced wildlife warning signs (e.g., warning signs with flashing lights) be correct. The overall effectiveness of these systems requires the number of false negative and false positive wildlife detections to be minimized. Either error could cause drivers to dangerously assume that either there are no wildlife present or wrongfully believe that there are wildlife present. In turn, this might cause drivers to generally ignore the warning signs. The review by the authors found that many of the existing systems had errors in their detections. Reliability of the systems was one of the focus areas of this project.

System Reliability Evaluation and Conclusions

System(s) Considered

An attempt was also made to evaluate two experimental ADSs during Phase I of this project. One installation was a "microwave radio signal break-the-beam system" and the other a "microwave radio signal area-cover system." The first system was implemented in Montana and the second in Pennsylvania. The installation sites are described in detail within the Phase I report. Unfortunately, only the Montana system became operational. The Pennsylvania system was ultimately dropped from further consideration because several operational issues could not be overcome in the field.

The Montana "break-the-beam" system was installed, but approximately two years of operational issues had to be resolved before researchers believed it could reliably detect large animals (specifically elk). The tasks during Phase I of this project, therefore, focused on evaluating the reliability of the system. Phase II, after full implementation, considered the potential vehicle speed and crash impacts of the system. The ADS in Montana was installed along a one mile roadway segment that experienced 67 wildlife-vehicle collisions (56 were elk-vehicle collisions) between 1989 and 1998. The enhanced wildlife warning signs were not installed during this phase of the project as the detection reliability was evaluated (they were included during Phase II). More details about the function and operation of this system are outlined in the Phase I report.

Reliability Evaluation

The detection reliability of the Montana ADS was evaluated with several approaches. First, the detection data stored by the ADS was interpreted and analyzed. The specific time, location, and duration of the system detections were recorded and these variables were used to categorize them as to their likelihood of being animal or non-animal related. For example, if the detection data indicated consecutive beam interruptions along the roadway in the direction of traffic and at the speed of a moving vehicle the researchers assumed these detections could be attributed to vehicles driving too close to the roadway edge or snow plows pushing snow into the system signal. If there were clear detections on opposite sides of the roadway at relatively close distances (i.e., within each detection zone, as defined by the area between ADS transmitters and receivers), however, the researchers assumed that this was a crossing animal. The researchers acknowledge that this method of testing system reliability was relatively subjective due to the assumptions it required, and could not have perfectly accounted for all animals present.

The second method used by the researchers to evaluate the ADS reliability included the consideration of snow tracking session results (during a portion of the ADS operating time). Tracks of large animals (specific species were not mentioned) in the snow along each side of the entire one-mile road section were checked in the mornings for a total of 25 days throughout the test period. The day before each snow-tracking session the researchers covered up prior tracks so that new animal tracks could be identified. Only clear tracks that appeared to be from the same animal on each side of the road were counted. The snow tracking data was compared to the stored detection data to determine whether it may have represented the presence of an animal. The researchers emphasized that this form of reliability testing also had its shortcomings. Tracks could have been overlooked, covered, or misinterpreted. In addition, the exact time at which an animal is present (i.e., they make the snow tracks) is difficult to determine.

Finally, the researchers also analyzed system reliability by testing for blind spots along the study segment. These tests were completed on three days throughout the test period. On each particular day a member of the study team would enter the detection area on each side of the road at 65-foot intervals along the entire road segment. The time stamp for each "intrusion" into the detection area was recorded and then compared to stored detection data to determine if a blind spot or problem existed.

Conclusions

Not surprisingly, the three different approaches used to test the reliability of the Montana ADS produced different results. The data interpretation and analysis approach led to a conclusion that at least 47 percent of the ADS detections were related to large animals crossing the roadway. It was assumed that the other detections would be related to large animals that entered the area but did not cross the roadway and other activities that "broke the beam" (e.g., snowplowing, etc.). The snow tracking analysis results, on the other hand, led to a conclusion that the system detected 87 percent (n = 90 of 104) of potential elk crossings. In this case elk were the focus of the evaluation because they produced clearly identifiable tracks during the reliability test period, although coyote and wolf tracks were identified as well. The system was also specifically designed to detect elk and medium-sized animals (e.g., coyotes and wolves) did not appear to be detected. During the evaluation the researchers also identified some locations along the test segment where the ADS did not appear to be detecting large animals (as determined by the blind spot testing).

Overall, the researchers concluded that the system appeared to reliably detect large animals (i.e., elk). However, the "blind spot" (e.g., locations where the beam was obstructed) problem and the unattractive appearance of the system limited the overall acceptance of the ADS with the project partners (a more detailed survey of system acceptance was conducted during Phase II of this project). The researchers indicated that these issues would need to be overcome before this type of ADS was considered for mass implementation. Finally, it was also determined that 72.6 percent of the animal crossings lasted less than 3 minutes and that the median time duration was about 1 minute and 29 seconds. Therefore, it was suggested that once enhanced wildlife warning signs were added to the ADS, sign activation duration of three minutes would be adequate. In addition, a benefit-cost analysis that assumed a crash reduction effectiveness rate of 80 percent and system lifespan of 10 years show that benefits exceeded cost when "…at least 5 deer-, 3 elk-, or 2 moose-vehicle collisions per mile road length per year…" occurred. Some implementation guidelines and an extensive list of challenges and lessons learned related to the installation and operation of ADSs was also provided.

PHASE II STUDY

During this phase of the study the Montana ADS was improved and enhanced wildlife warning signs were installed. First, the "blind spots" (i.e., areas where the beam was blocked and detections did not occur) noted above were reduced to from 10.6 percent (approximately 1,115 feet) to 1.09 percent (approximately 115 feet) of each side of the one-mile roadway test segment. In addition, some general repairs were conducted on the system and an access road was created for maintenance and research personnel. Once all the repairs were completed, four enhanced wildlife warning signs (see Figure 1), two in each direction, were installed along the test segment (see Figure 2). After the system installation was completed and operating correctly its speed and crash reduction effectiveness were evaluated.

Figure 1. Montana Enhanced Wildlife Warning Sign.
(Inserted from Referenced Report)

Data Collection

The location of the four enhanced wildlife warning signs along the test segment can be seen in Figure 2. One sign in each direction was located at the beginning of the one mile test segment and another at about the half way point. The potential vehicle speed impacts of the Montana ADS were measured with the use of three pneumatic tube data collection devices. These counters recorded the activation time, vehicle type, vehicle speed, and time gap between vehicles. Only data from isolated vehicles (i.e., vehicles that did not cross the counters within 10 seconds of another vehicle) were considered in this evaluation. Two of the counters were placed outside of the influence area of the enhanced warning signs (approximately 1,720 to 2,460 feet from the ends of the test segment, See Figure 3), and the third counter was placed at about the test segment midpoint (near the second set of enhanced warning signs). The location of each of these counters can be seen in Figure 3. This setup allowed the measurement of vehicle speeds before they entered and after they exited the test area, as well as after vehicles traveled through the test area and interacted with the enhanced signs.

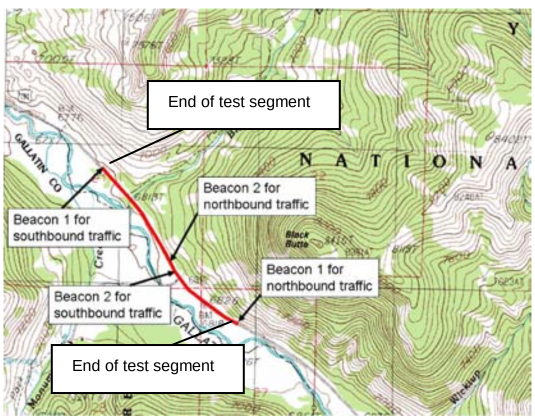

Figure 2. Enhanced Wildlife Warning Sign Locations. (Inserted from Referenced Report)

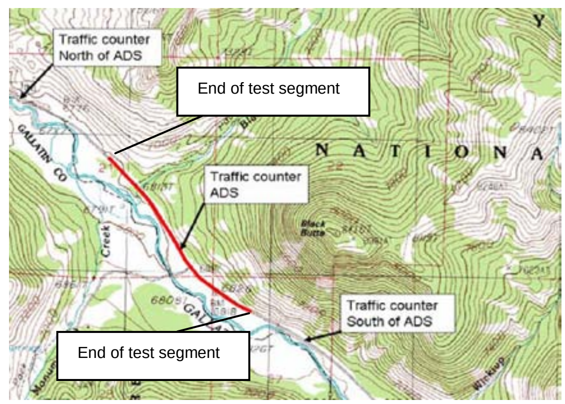

Figure 3. Traffic Counter Locations. (Inserted from Referenced Report)

Vehicle speeds were measured with and without the flashing lights activated on the signs in operation. Based on the documentation of the study the researchers manually activated the flashing lights so that all four signs would be on at the same time. However, no information appears to be provided in the report about the number of instances the signs were activated. The vehicle speed data was collected for a month and a half during the summer of 2008 and it was documented there was no notable precipitation or other external factors during that time period that may have altered the data.

Crash data was also collected by the researchers to measure the potential impact of the ADS on reported AVCs. AVC data from 1998 to 2007 was gathered for the test segment and along other road segments that were close in proximity but unrelated to this specific test segment. These unrelated road segments served as the control, and amounted to a total of 60.0

miles of roadway. These data were compared between years to the AVC data available on the test segment with the ADS, which was only operational during 2007.

Study Results

The overall difference in vehicle speed at each counter location was compared for instances when the flashing lights were activated and when they were not. Overall, the average vehicle speed for both directions at each counter location was approximately 1.52 miles per hour slower (for passenger vehicles, vans, and pick ups) when the flashing lights were activated than when they were off. Additionally, the average speed of trucks was 0.91 miles per hour lower when the flashing lights were activated.

The researchers also examined vehicle speed in each direction and between the counters inside and outside the test area. Overall, the vehicle speed data appeared to indicate that southbound drivers reduce their vehicle speed within the test area whether the flashing lights of the warning signs were on or off. Northbound drivers actually appeared to increase their vehicle speeds within the test area whether the lights were flashing or not. For example, the average vehicle speed southbound at the midpoint data collection device was approximately 1.72 miles per hour slower during the day and 1.08 miles per hour slower during the night than that measured at the counters outside the test segment (when the flashing lights were off). In addition, when the flashing lights were on, the southbound mean speed at the midpoint was 3.44 miles per hour slower than outside the test segment during the day, but 0.11 miles per hour faster at night. The data for the northbound direction, however, showed average vehicle speeds that were 2.51 miles per hour faster during the day and 1.66 miles per hour faster during the night compared to speeds collected outside the test area (when the flashing lights were off). When the flashing lights were on, speeds were also 1.47 miles per hour faster during the day and 3.55 miles per hour faster during the night compared to the counters outside the test area. The researchers suggested that the variability in these directional outcomes were the result of roadway characteristics rather than the ADS. In addition, the researchers proposed that driver alertness and awareness of the signs would also increase the crash reduction effectiveness of the ADS, but couldn't be measured by vehicle speed data.

The researchers also found that there was an average of 3.0 AVCs per year in the test segment from 1998 to 2006 and only one in 2007 (when the ADS was operational). However, the crash data analysis completed for this project was very preliminary. Only one year of "after" crash data was available. The researchers also did find that the number of AVCs in the test segment was 57.6 percent lower than the number of AVCs that occurred on "comparable" control road segments. It was acknowledged that the time period for this evaluation was not adequate to determine the crash reduction impact of this type of system.

Finally, a survey of the general public, the Montana Department of Transportation (MDT), and Yellowstone National Park system employees was completed. The results of this survey indicated some concern related to the effectiveness, cost, and the aesthetics of the system. In fact, the system, as agreed upon at the beginning of the project, was dismantled at the end of the study. The researchers documented the lessons learned during the project and also emphasized that this technology was still experimental. It was suggested that these types of roadside animal detection systems could be an effective mitigation measure against wildlife-vehicle collisions.

DVCIR CENTER FINDINGS

The two documents summarized here primarily describe the activities or tasks connected to the installation and evaluation of roadside animal detection system in Montana and Pennsylvania. Overall, they contain useful information about the challenges to the implementation of these systems in the field along with the lessons learned by the project team. The reliability results in the documents are of interest, but have limitations acknowledged by the researchers. Fortunately, this same research group has developed and published results about the reliability of several animal detection systems. This test bed project is being completed in a much more controlled environment and provides better information about this subject. Its results are summarized separately as part of this toolbox update (see www.deercrash.com). The vehicle speed data collected and compared in the research summarized here did show that vehicles generally slow when the lights on the signs are flashing. However, there appeared to be a high level of variability in the vehicle speed results. It was assumed that this variability was likely the result of the experimental design used in the project. The crash data comparison included the documents summarized is generally of little to no value. The time period evaluated between a fully functional animal detection system and report publication was too short. It is recommended that the information provided in these documents be reviewed by those jurisdictions considering the installation of roadside animal detection systems. These systems are, as the researchers indicate, still somewhat experimental in nature.