REFERENCE

Huijser, M.P, T.D. Holland, M. Blank, M.C. Greenwood, P.T. McGowen, B. Hubbard, and S.Wang. *The Comparison of Animal Detection Systems in a Test-Bed: A Quantitative Comparison of System Reliability and Experiences with Operation and Maintenance*. FHWA/MT -09-002/5048. Federal Highway Administration and Montana Department of Transportation, 2009.

INTRODUCTION

The research documented in this report measured and compared the reliability of various roadside animal detection systems (ADSs). These systems use various detection technologies to sense large animals, often ungulates (e.g., white-tailed deer) that move into or along the roadside. The detection of an animal then activates one or more animal crossing warning signs (typically with flashing lights) to increase driver awareness of the potential hazard. This study focused on determining the detection reliability of several ADSs. Horses and llamas were used as substitutes for large ungulates and the systems were appropriately placed within an isolated testing area without the influence of a roadway with active traffic.

SYSTEMS STUDIED

Nine different animal detection systems from five different manufacturers were installed and tested during this study. The systems studied had area-cover sensors (which detect body heat and motion of animals within a certain area) and break-the-beam sensors (which detect animals that cross infrared beams, lasers, or microwave radio signals). The different systems, along with their manufacturer and characteristics (as described in the referenced report), can be found in Table 1.

The researchers also estimated the costs of each animal detection system. Costs are for each unit, as installed in this study, and the estimated costs cover varying expenses, are included in the referenced report. The systems considered, along with their cost (e.g., $260 to $17,314), are highly variable. The expenses included and excluded from these estimates, along with the year in which the estimate was completed, are also documented in the referenced report. The knowledge gained by the researchers during the installation, operation, and maintenance of each system is also documented.

DATA COLLECTION

The ADSs were studied at an isolated and fenced test-bed in central Montana. The test area was 300 feet wide to accommodate the distance spanned by eight of the nine systems (See Figure 1). Six infrared cameras were installed perpendicular to the systems to record animal movements. These movements were then compared to the logged system detections and the results were used to measure the reliability of the ADSs. The researchers determined animal positions within the test area by placing orange construction cones at the detection location of the ADSs. Figure 1 shows the test-bed. The circles indicate detector location and the arrows represent the direction of detection signal. ADSs one to six were installed in pairs (above and below each other), but ADSs seven to nine were set up separately.

Table 1. Animal Detection Systems Studied

System	Manufacturer	System Name	System Type	Sensor Type	Maximum Range
1	Xtralis	ADPRO	Area cover	Passive infrared	500 feet
2	Xtralis	ADPRO	Area cover	Passive infrared	200 feet (one detector on each side)
3	STS	RADS I	Break-the-beam	Microwave radio	0.25 mile
4	STS	RADS II	Break-the-beam	Microwave radio	More than 0.25 mile
5	Calonder Energy	CAL 92, LS-WS-WE 45	Break-the-beam	Laser	984 feet (developed areas) to 1148 feet (open areas)
6	Calonder Energy	Cal 92, IR-204-319/M3	Area cover	Passive infrared	328 feet
7	Camrix	A.L.E.R.T.	Area cover	Infrared camera technology	300 feet (detects both sides of road)
8	Xtralis	ADPRO	Area cover	Passive infrared	200 feet (two detectors facing opposite directions)
9	Goodson		Break-the-beam	Active infrared	90 feet

Detection data and camera information were collected during eight test periods between January 10, 2007 and December 9, 2007. Each test period lasted 7 to 11 days. During these periods the individual system detections were continuously logged and the infrared cameras were constantly recording animal movements. In order to evaluate the data collected, the researchers studied various time segments within the 7 to 11 day test period. The segments of time selected for consideration included the following:

- Three one-hour time periods randomly chosen each day;
- Time periods with unusual detection patterns (i.e., unusually high or low detections) and weather events;
- Time periods with no large animals present but with recorded detections.

The reliability of the ADSs was only evaluated with the data from the randomly selected time periods (i.e., the first test segment scenario listed above). All of the data collected, however, was used to analyze environmental factors (i.e., weather) that might influence the integrity of the ADSs.

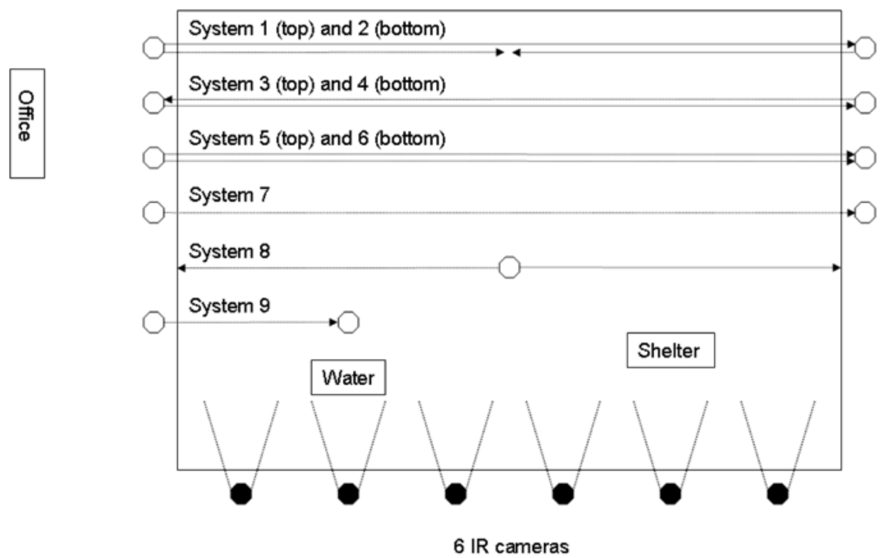

Figure 1. Study Test Area. (Inserted from referenced report)

Overall, 225 hours of data were used to analyze the reliability of eight of the nine ADSs (see Table 1). Data from about 91 hours were used to evaluate the fourth system (See Table 1 and Figure 1) because it was installed later than the others.

RELIABILITY RESULTS

The logged detection data from the three hours randomly selected each day during the test period were compared to the animal locations in relation to the systems (from the camera information) to calculate the number of false positives (i.e., an animal detection but none are present) and false negatives (i.e., no detection but an animal is present). The results are shown in Table 2. Overall, it was found that the percentage and frequency of false positive detections was relatively low for all systems (i.e., ≤ 1 percent and 0 to 0.1 per hour). However, the percentage and frequency of false negative detections was highly variable (i.e., 0 to 30 percent and 0 to 1.3 per hour). Based on these results it was concluded that some of the systems were more reliable than others.

The researchers compared these ADS reliability results to the performance requirements of the transportation and natural resource agencies that might use them and the driving public. They acquired this knowledge by surveying these groups about their expectations related to this subject. Overall, these three stakeholder groups generally suggested that ADSs should correctly detect 91 to 95 percent of large animal intrusions and have a false positive rate of 6 to 10 percent. Five of the nine systems considered (i.e., 1, 5, 6, 8, and 9) met these suggested reliability performance requirements. The stakeholders surveyed also believed the systems should at least result in a 71 to 80% reduction in wildlife-vehicle collisions. This study did not address this issue, but information on it can be found in one or more documents summarized or included within the www.deercrash.com website.

Table 2. False Positive and Negative Detections

System	Percent False Positives	Percent False Negatives
1	0.00	10.29
2	0.00	20.88
3	0.00	30.91
4	0.00	15.94
5	0.60	0.48
6	0.00	1.16
7	0.00[1]	27.00[1]
8	0.97	6.53
9	0.82	0.00

[1]Results presented for system seven occurred after system modifications during testing.

ENVIRONMENTAL FACTOR ANALYSIS RESULTS

The evaluation of the ADSs also included an analysis of how several environmental factors might impact their detection reliability. The researchers used multinomial logistic regression models to analyze the potential impact of environmental conditions on the system detections (using the data and information described in the previous data collection section. Overall, it was found that high winds (e.g., more than 15 mph) appeared to increase the number of false negatives for most of the area-cover systems. It was believed that these results occurred because this type of system became less sensitive in these conditions. Similar results for false positive detections were found for break the beam systems. In this case, it was suggested that the high winds pushed the sensors out of alignment and caused these false detections. The direction of the wind also seemed to be a factor in these results, but the researchers acknowledged that these data were difficult to interpret. In general, it was also found that higher temperatures, as well as higher relative humidity, appeared to produce more false positive and negative detections in all the systems. The difference with the detection reliability in the daylight and nighttime, however, produced variable results. Finally, good visibility appeared to be important to the operation of the break-the-beam systems and horses were more easily detected than the llamas (presumably because of their larger size). The difference in species detection appeared to be especially obvious with the passive infrared area-cover systems. Based on these results, a cost-benefit analysis, and a site characteristic evaluation, the authors suggested several locations in Montana for potential ADS implementation.

DVCIR CENTER FINDINGS

This document includes some valuable information about the detection reliability of several roadside animal detection systems (ADSs). It also includes some conclusions about their reliability during different environmental conditions. Cost information about the systems evaluated is summarized, but the estimates will likely vary from location to location (and this information should be considered in this context). This document (and the others focused on similar subject material and included in this toolbox update, see www.deercrash.com) should be useful to those considering the implementation of a roadside ADS. The results of this particular study support the conclusion that these systems are still evolving in their detection capabilities and that a cautious system selection approach is important. Benefit-cost information is also included in several of the other summaries being done for this toolbox update. Most include data about roadside ADSs. The content of those summaries and this document represent the current state-of-the-knowledge for roadside ADSs.