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Overview of Technologies Aimed at Reducing and Preventing Large Animal Strikes

April 2003

ASFBE

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TRANSPORT CANADA
Ottawa, Ontario
K1A 0N5

Overview of Technologies Aimed at Reducing and Preventing Large Animal Strikes

INTRODUCTION

In the past four years there has been an increase in the number of collisions involving large animals on Canadian roads. Collisions between large wildlife and motor vehicles represent a significant concern for Transport Canada.

The purpose of this report is to provide an overview of the different technologies available to assist in the prevention of animal strikes, including various road infrastructure initiatives and automotive devices. Some of these initiatives and automotive technologies are being tested and some are currently being used in different areas of the world. The intent of this report is not to review each design, but to summarize the different methods currently available.

The document will focus on collisions involving large animals, in particular moose and deer. These types of collisions are common in Canada and usually result in severe consequences for the occupants of the vehicle as well as for the vehicle itself.

STATISTICS

Canadian data collected from 1988 to 2000 indicate that there are, on average, over 25,000 collisions a year involving a large animal (see Chart 1). Of that number, an average of 1,486 collisions resulted in injuries to the travelling public and 18 resulted in fatal injuries (see Chart 2). These numbers have been extracted from the Traffic Accident Information Database (TRAID), which is a collection of data pertaining to traffic collisions occurring in the provinces and territories. These collisions are all those deemed reportable; in other words, they resulted in bodily harm and/or property damage exceeding a certain dollar threshold set individually by each jurisdiction, and they occurred on public roads. Transport Canada is working on the assumption that these reports are restricted to collisions with large animals such as deer or moose. Furthermore, we suspect that these numbers are underestimated, as instances where the driver directed the vehicle off the road to avoid contact with an animal were not recorded as an animal-related collision.

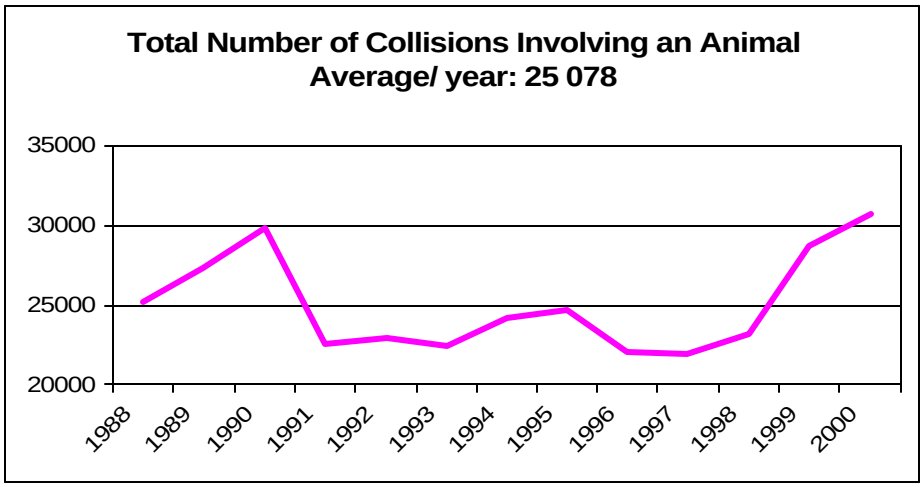

Chart 1: Collisions involving an animal

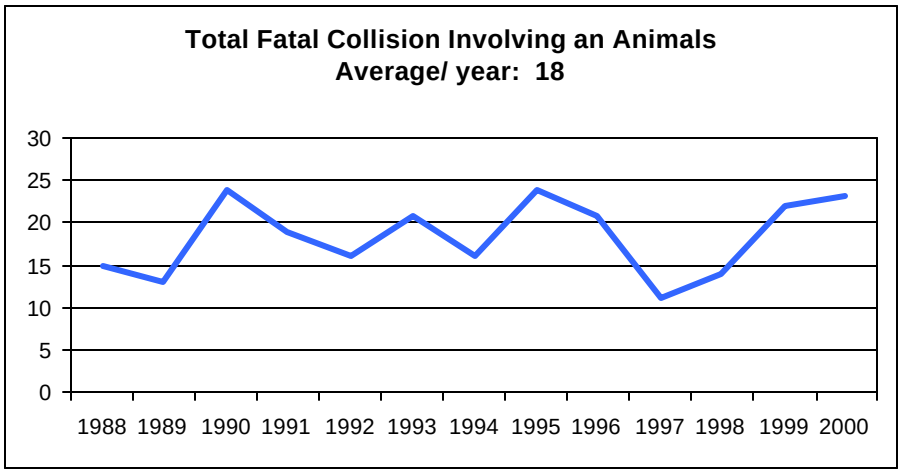

Chart 2: Fatal collisions involving an animal

According to State Farm Insurance, when a deer or a moose is struck by a moving vehicle, average property damage is about $3,000. Using a value of $2 million for each human life lost, the financial impact of collisions involving large animals is estimated at $111 million a year in Canada.

According to the Government of Newfoundland and Labrador, an estimated 70% of moose/deer-vehicle collisions occur each year between June and October, and 75% of those collisions happen between dusk and dawn, at a time when the driver's ability to see is limited and moose/deer activity increases.

This number is significant enough to warrant studies of behaviour patterns in animals, primarily deer and moose, as part of the larger effort to determine the course of action that should be taken to reduce the number of collisions.

CASE STUDIES

As groundwork for this report, 12 of the 52 animal-vehicle collisions investigated by the Transport Canada Road Safety Collision Investigations Group were reviewed. Six of these collisions involved a moose and six involved a deer. Nine of these collisions occurred in New Brunswick, one in Nova Scotia, one in Ontario and one in Saskatchewan. In 83% of the cases the collisions occurred after dark.

In the six case studies involving a deer, the collisions resulted in damage to the front bumper, the grille, the headlamps, the hood and the fender area. The windshield was commonly cracked but still intact, as the deer was deflected to the side or the front of the vehicle. They were no cases where the roof of the vehicle was damaged. The air bags deployed in all instances. Four of the six vehicles were un-repairable. No fatalities were recorded for these cases.

In the six cases involving a moose, the collisions were more severe due to the height and mass of the animal (around 2.5 metres and 450 kilograms). An important factor in these crashes is that the main part of the body of a moose is higher than the hood of most vehicles. When struck, the moose is often thrown into the passenger compartment. In all cases, the legs of the moose were broken when they were hit by the front of the vehicle. The animal was then projected onto the roof area of the vehicle. In the six cases that were studied, the air bags deployed and the vehicles were un-repairable. ***Two collisions were fatal*.** These case studies demonstrate that a collision involving a moose will tend to cause the most severe human injuries and deaths of any animal-related collisions in Canada.

Photos 1 and 3 show typical damage patterns caused by a moose; photos 2 and 4 show typical damage caused by a deer.

Photo 1: Car/moose collision

Photo 2: Car/deer collision

Photo 3: Minivan/moose collision

Photo 4: Minivan/deer collision

ROAD INFRASTRUCTURE COUNTERMEASURES

This section provides an overview of the road infrastructure measures aimed at preventing animal strikes. A summary table of these initiatives is attached in Appendix A.

1. Fencing

Fencing has been used in the United States and Canada, and studies have found it to be effective in reducing the number of crashes involving animals in both countries. Recent installations that combined passage structures and fencing have successfully reduced moose crashes at several sites in Alaska. One disadvantage of this method, however, is that fencing can become a trap for animals. An animal caught on a fenced road may because it is unable to escape create a greater danger to motorists.

2. Passage Structures

Underpass and overpass structures are used in the United States, Canada and Europe. They are usually located in areas where there is a wildlife corridor. These structures are expensive in comparison to other alternatives, especially if engineers do not take advantage of existing infrastructure such as a stream culvert. Monitoring efforts in the United States and Canada are underway to assess the use of passage structures by wildlife.

3. Reflectors

The aim of this method is to create an optical warning fence that will scare the animals away from the road. When the headlights of an approaching vehicle strike the reflectors, which are placed at regular intervals, the reflectors create a reflection fence in the adjoining area of the road. Maintenance and calibration of the reflectors is essential because if one of the reflectors is damaged or misadjusted, it will result in a hole in the fence or could also reflect back at the driver. There is currently no conclusive research on the ability of a deer or moose to perceive the colour wavelength of reflective light.

4. Biological and Chemical Repellent

In this method, odours are used to repel animals from the area. Two types of repellent exist: odours associated with predators (wolf urine) and odours associated with bad smells (rotten eggs). This method has had limited success in the United States, and the effectiveness of the repellent has not been documented. One important consideration is that animals may become accustomed to the smell; moreover, it is relatively expensive to use over large areas.

5. Animal Detection

Detection systems use radio frequencies, infrared sensors or collars on animals to detect the presence of large animals on public roadways. Pilot systems are being placed in areas known for frequent animal-vehicle collisions. These systems warn drivers as they are entering the area; yellow lights flash above a sign reading "Animal present when flashing."

6. Vehicle Detection

These systems, undergoing operational testing in the United States and Canada, detect the presence of approaching vehicles and send a signal to remote units strategically placed further down the road. Upon receiving the signal, the remote units use sound, light and/or scent to repel wildlife. The alarms could scare animals down the road or "fence" them in.

7. Highway Lighting

Lighting has been used on numerous occasions and has been shown to be effective in high crash locations because it gives drivers a longer reaction time. Animals may avoid lighted areas, but lights do not prevent animals from crossing the road. Moreover, the site requires power lines nearby, or the lights must be attached to a self-charging power supply.

AUTOMOTIVE TECHNOLOGIES

This section provides an overview of automotive technologies aimed at preventing animal strikes. A summary table of these initiatives is attached in Appendix B.

Crash Avoidance method

1. Infrared Camera

An example of the system is developed by Raytheon, this technology is intended to enable drivers to see well beyond the range of the car's headlights. The technology is currently being offered as an option on the Cadillac DeVille. The infrared sensor, mounted in the front grille, picks up heat energy from a person or an animal. The image

is projected onto a monochromatic display on the lower part of the driver's side of the windshield. GM claims that the range in sight will increase from 200 yards with high beams to 500 yards with the infrared sensors. The night vision system powers up automatically when the car's headlights are turned on. The system can be turned off and the intensity of the image can be adjusted. The product is sold only as a factory-installed option and costs approximately $3,500.

The displayed image looks like a black and white photographic negative (see Photo 5). Hot objects appear white and cool objects appear black. The system is designed to be used outside urban areas because too much surrounding light may flood the display. The system also as limitation in bad weather.

Some drivers have noted that objects are difficult to see and appear fuzzy due to the field of view that is too limited to be useful. Others have complained of headaches after only one hour of use. Some drivers have been bothered by sun reflection on the projection screen during the day. There was also risk that drivers may only look through the display.

Photo 5: Cadillac DeVille night vision system
(Illustration of the General Motors system from the GM Corporation website)

For more information, consult
http://www.cadillac.com/cadillacjsp/models/deville/nightvision.html

2. Whistles

A) Air-fed Whistle

This device is a small plastic object attached to a car's bumper or the exterior of the vehicle. It relies on the car's speed to produce a warning that translates into an ultrasonic wave (it requires a speed of 70 km/h to start). These types of whistles were determined to

be acoustically ineffective in a study conducted by Peter Scheifele, an animal bioacoustics and audiologist expert at the University of Connecticut.[1]

The RCMP also evaluated these devices over a number of years but were unable to ascertain if they were effective. The RCMP confirmed that at least one animal (a moose) was struck by an RCMP vehicle equipped with this type of device. It was also noted that the build-up of insects or ice on the whistle can make the device ineffective.

B) Electronic Whistle

This device emits both an audible and an ultrasonic sound. It is wired to the electrical system of a car and can be turned on or off manually. The Hornet deer avoidance device, manufactured by XP3 Corporation of Oregon, is the main electronic deer whistle on the market today. The price of a unit is approximately C$75. XP3 Corporation claims that the use of the Hornet along with driver awareness can reduce the incidence of deer collisions. According to the manufacturer, "The whistle is effective with deer due to the fact that deer have extremely keen hearing and are very skittish animals. The whistle may not be effective with other animals such as moose, cows or kangaroos."

There may be other concerns with this device. First, it produces a sound that may cause discomfort in humans and pets. Equipping a significant number of vehicles with the device could result in substantial noise pollution. In addition, there are no known tests or research to substantiate the claim that this type of device will scare an animal away from oncoming traffic. In his research, Peter Scheifele of the University of Connecticut questioned how deer will behave when they hear the sound: "Will the deer freeze in its tracks, run off, or charge toward the sound? The response will depend on a number of factors, including age, sex and surroundings."[2]

For more information on the Hornet device, see **http://www.xp3hornet.com**

3. Better Driver Visibility

A) HID Headlights

The use of high intensity discharge (HID) headlights will provide drivers with better visibility and a larger area of illumination in the dark. These headlights work by creating an electrical discharge between two electrodes within an arc tube. The xenon contained in the headlight is then ionized, resulting in photons moving from a lower to a higher energy state; this results in light emission. The xenon HID headlight has approximately two to three times the light output and 10 times the life expectancy of standard halogen headlights. Because of the intensity of these lights, extra brightness tends to be distributed to the periphery of the vehicle. This makes the driver's view wider. The HID lights may also appear brighter to oncoming traffic. Nonetheless, a study conducted by Michael Flanagan of the University of Michigan Transport Research Institute shows that properly installed HIDs produce less glare than tungsten-halogen headlights. HID

[1] Peter Scheifel. 2002. *Air-fed Deer Whistles Scientifically Tested,* University of Connecticut. **http://www.news.uconn.edu/rel02112.htm**

[2] Peter Scheifel. 2002. *Air-fed Deer Whistles Scientifically Tested,* University of Connecticut. **http://www.news.uconn.edu/rel02112.htm**

headlights are currently available on some luxury vehicles and can be obtained for approximately $800.

B) Adaptive Front Lighting Systems

Lighting manufacturers are working towards designing intelligent lighting systems capable of changing automatically to meet road and ambient lighting conditions. An adaptive front lighting system can rotate by up to 40 degrees (in the Z axis) from the normal position to deliver light where it is most needed when the vehicle is approaching a bend in the road. The lights can also rotate in the Y axis so that they dip when there is oncoming traffic and then return to their original position after the oncoming vehicle has passed. This reduces glare for the approaching driver.

An example of this type of system, called Bending Light, is manufactured by Valeo (see Photo 6). These swivelling lamps are able to illuminate bends in the road and can automatically adapt to different light and road conditions. The Bending Light system is able to recognize daylight, twilight and night, tunnels, and rain, fog or snow. It will adapt to road conditions with up to five different beam patterns. The system activates electronically by taking into account signals from the steering wheel sensor and the wheel speed sensor. Some experimental systems are using satellite navigation systems (GPS) to direct the lighting beams.

These types of systems may make a significant contribution to driver safety, comfort and convenience by reducing the stress and fatigue associated with difficult night driving conditions.

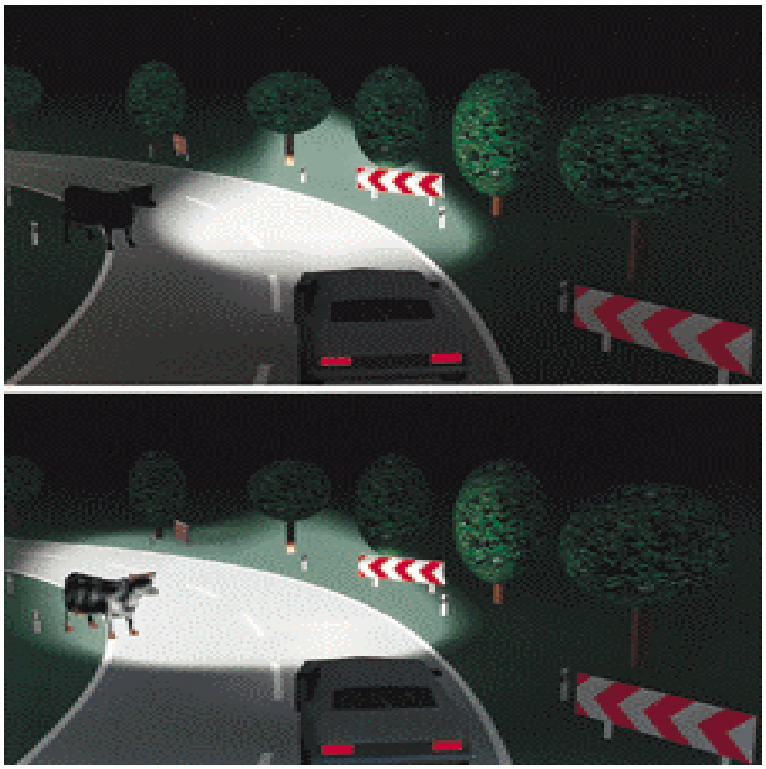

Photo 6: Illumination of bend in the road,
(Photo from Hella KG Hueck & Co. website)

For more information, consult **http://www.hella.com**

4. Test for a Severe Lane Change Manoeuvre (Moose Test)

This test simulates what happens when a person or a moose suddenly runs onto the road. The driver must attempt to avoid the obstacle by directing the vehicle into the left lane and then must change into the right lane after driving around the obstacle. This test as also been referred to the moose test due to the frequency of roll over collisions resulting from trying to avoid a moose on the road. A procedure for this test, which is designed to determine the lateral stability of a vehicle, is drafted in International Standard ISO/DIS 3888-2. This testing standard points out that this particular test cannot be regulated because the outcome is dependent on driver behaviour.

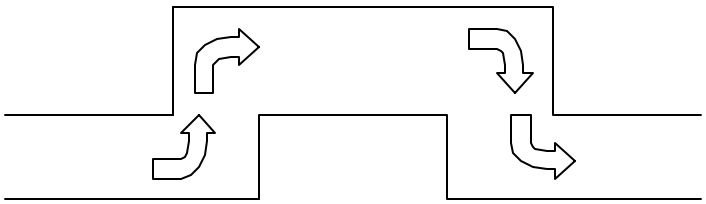

Figure 1: Lane change manoeuvre

This test method could assist in developing a minimum standard for vehicle rollover resistance. The objective would be the development of dynamic stability tests that might lead to minimum standards. Transport Canada will conduct analysis of lateral stability and will also initiate research into crash avoidance to reduce the frequency of rollovers due to collisions.

The following is a list of feature that may assist in passing this test:

- Electronic stability control system
- Springs and shocks stabilizer bars
- Anti lock braking system
- Traction control system
- Electronic throttle control
- Variable assisted steering and suspension systems

[3] Magnus Gens. 2001. Moose Crash Test Dummy, Swedish National Road and Transport Research Institute. **http://www.vti.se/pdf/reports/S342A.pdf**

5. Collision Warning Systems

Collision warning systems are composed of a multitude of sensors and instruments on a vehicle to measure road conditions and environmental factors. This real-time information is fed into decision-making software. In turn, the system software will alert the driver of oncoming danger or, if collision avoidance controls are engaged, take control of the accelerator and brakes to slow down the vehicle. The system incorporates the use of long-range radar, optical sensors, mapping systems and global positioning tied together by software and computers that are capable of detecting potential hazards at the front of the vehicle. What still remains unclear is whether the system would be able to detect an animal standing still or moving in the road area. Further studies are required.

Crash Worthiness method

1. Crash Test with Moose Dummy

The Swedish National Road and Transport Research Institute is currently evaluating crash tests with moose dummies. This research looks at the damage when a dummy (rubber) moose is involved in realistic and repeated simulated collisions with a vehicle. The long-term goal of the study is to produce a special test method for collisions that involve large animals to improve vehicle safety. The rubber moose itself was designed by Magnus Gens[4] as part of his master's thesis project in vehicle engineering at the Royal Institute of Technology of Stockholm in Sweden (see Photo 7).

Photo 7: Moose dummy
(Photo from Swedish National Road and Transport Research Institute Website.)

The implication of the results of this test may result in new requirements such as: A-pillar windscreen strengthening, pedestrian airbags or other mechanisms.

[4] Magnus Gens. 2001. Moose Crash Test Dummy, Swedish National Road and Transport Research Institute. **http://www.vti.se/pdf/reports/S342A.pdf**

CONCLUSION

Accidents between motor vehicles and large animals continue to be a safety concern in Canada, however the problem is complex and there is no simple solution. All of the countermeasures identified in this report will have a positive effect in some instances, but may introduce some concern in others. For example, high intensity discharge headlights will provide the driver with better visibility but could also introduce discomfort to oncoming drivers if the headlights are misaligned or dirty. The electronic whistle might work on deer but it is noted to be ineffective on moose. Yet crashes involving moose cause the most vehicle damage and personal injuries, including death, due to their size.

Thus it is recommended that Transport Canada:

1. Study improvements in vehicle lighting technologies given that most collisions with large animals occur at night, when the driver's ability to see is limited and when the animals are the most active. The study of lighting systems, such as adaptive or intelligent front lighting, may represent a promising solution in reducing the number of collisions with animals. Transport Canada should continue to work with European manufacturers and should consider amendments to the existing regulation if research is conclusive. Providing drivers with better visibility at night may reduce the number of collisions involving animals.

2. Investigate the test for a severe lane change manoeuvre as proposed in ISO 3888-1 and determine if this test could assist in the assessment of new stability control devices that may be used to prevent rollovers that often occur when a collision is avoided with a moose or a deer.

3. Review the research on crash tests with a rubber moose dummy which is being carried out by the Swedish National Road and Transport Research Institute. This could assist in accessing automotive technologies that would aid in protecting passengers when a vehicle-moose collision occurs.

4. Examine new avoidance methods to assist with driver reaction time. Systems such as radar detection and infrared sensors currently being developed by manufacturers seem to be promising and should be studied further.

Appendix A

Road Methods

Method	Pros	Cons	Location	Cost $Can
Fencing	- Low installation cost (relative) - Known method - Can be successful with passage structure	- Maintenance cost - Can trap animal on fenced highway - Can eliminate animals' travel corridor - Widespread application is difficult - Entanglement of animals in the fence is possible - Must be inspected regularly	US, Canada	$10-$18/foot Maintenance: 1% of construction
Passage structures (Culvert/Overpass)	- Useful at specific sites (wildlife corridors) - Low cost if incorporated at stream culvert location - Can be successful with fencing	- Installation cost may be high - Choice may be limited if using infrastructure - Maintenance cost may be high - Animals may be reluctant to use underpass	US, Canada, Europe	$110K to $230K (2 and 4 lanes)
Reflector Devices placed at regular intervals on the road that reflect light in the adjoining area Manufacturer: Swareflex	- Can be used over long distances - Low cost (relative)	- Regular maintenance required - Effectiveness is unknown (visual acuity of animal?) - No effect if animal is on the road - Animals may get accustomed to reflectors	US, Austria	$8-$12K/km Maintenance: $500/km
Biological and chemical repellent	Natural avoidance by animals	- High cost over long distances and over time - Animals can adapt to the scent - May cause discomfort in humans	US, Germany	

Method	Pros	Cons	Location	Cost $Can
Animal detection May use infrared, radio frequency or collar sensors (when animal is detected, lights flash on a sign) Manufacturer: STS	- Animated signs may capture drivers' attention (motorists are warned of imminent danger rather than simply being informed) - Drivers may be less likely to get accustomed to signs	- Maintenance and control needed for collar method - Costs are high for large areas	US, Europe	Radio frequency sensor device: $30K/km
Vehicle detection Repels wildlife with light, sound or scent Manufacturer: IRD	- Low cost for small area - When there is no traffic, animals may cross the road - Animals are less likely to become accustomed to warnings	- May cause animal to run on the road - May contribute to "freezing" behaviour in animals	Canada	
Highway lighting (On the road and roadside)	- Animals may avoid lighted areas	- Area must have power - Contrast between animal and road not always sufficient	US, Canada, Europe	

Appendix B

Automotive Technologies

Method	Pros	Cons	Manufacturer	Cost $Can
Infrared sensors	- Increases driver response time - Suitable outside urban areas - Increases vision (100 to 500 yards) - Promising technology	- Available on high-end vehicles only - May become distracting - Complaints about size and resolution	Cadillac	3,500
Xenon HID headlights	- Increases driver response time - Suitable outside urban areas - Increases vision 2X to 3X - Longer life 10X - Enhances peripheral vision	- May blind other drivers if lights are not adjusted or cleaned - Available on high-end vehicles only	Most manufacturers	800
Adaptive front lighting system	- Dynamic bending of light, enhances vision up to 40 degrees in curves - Improves driver comfort and safety - Reduces glare on wet road	- In research phase, 2005 for standard in Europe	Valeo Hella	
Whistle, air-fed	Low cost	- Deemed ineffective		10-25
Whistle, electronic (continuous sound)	- Suitable outside urban areas - Low cost	- Studies have not demonstrated that deer are frightened by frequency or sound - Animal may get used to sound - May cause discomfort in humans (continuous sound) - Designed for deer only	XP3 Corp. (Hornet)	70-100
Moose crash test dummy (test method)	- May influence safety research - May lead to safer cars - May enable better vehicle comparison for customers	- Limited research data	Saab/GM	
Test for a severe lane change manoeuvre ISO3888-1	- May help in evaluation of lateral stability of vehicle - May enable better vehicle comparison for customers	- Driver influenced - Hard to regulate	ISO standard	
Collision warning systems	- Increases driver response time - Suitable outside urban areas - Promising technology	- Available on high-end vehicles only - Limited research data	Most manufacturers	