The reliability of animal detection systems and reliability norms

Marcel Huijser[1]

Tiffany Allen[1]

Matt Blank[1]

Mark Greenwood[2]

Shaowei Wang[1]

Larry Hayden[1]

Chris Haas[3]

Mohammad Sharafsaleh[4]

[1] Western Transportation Institute at Montana State University (WTI-MSU)
[2] Department of Mathematical Sciences, Montana State University
[3] SWCA Environmental Consultants
[4] California PATH

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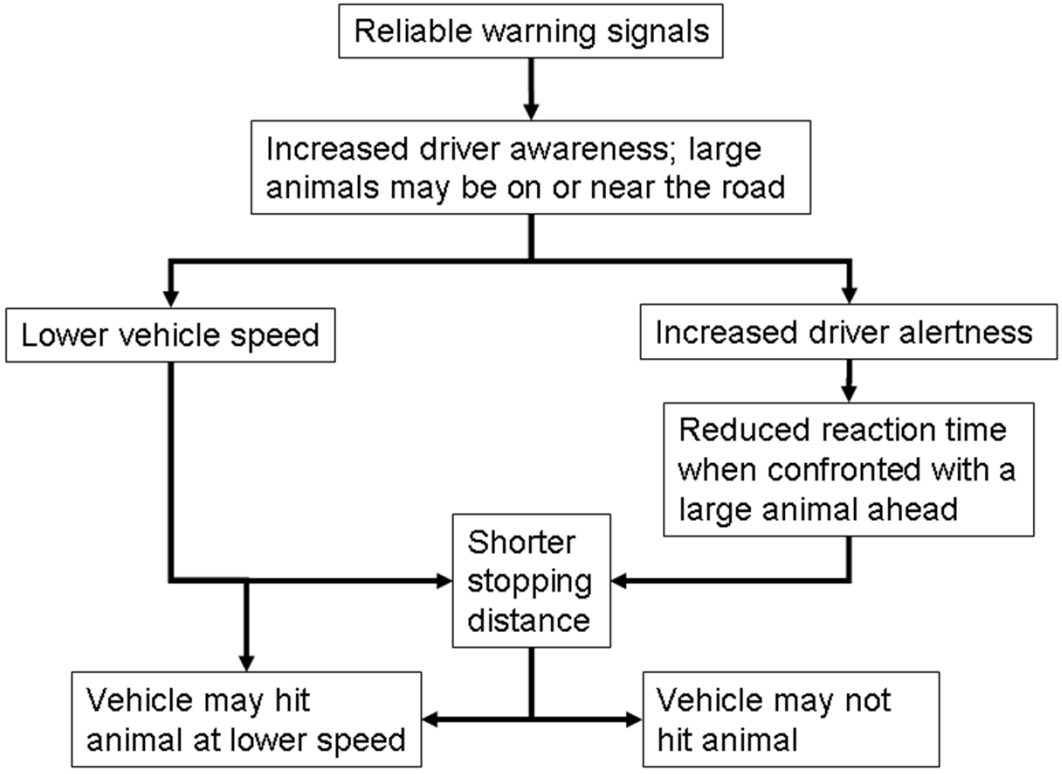
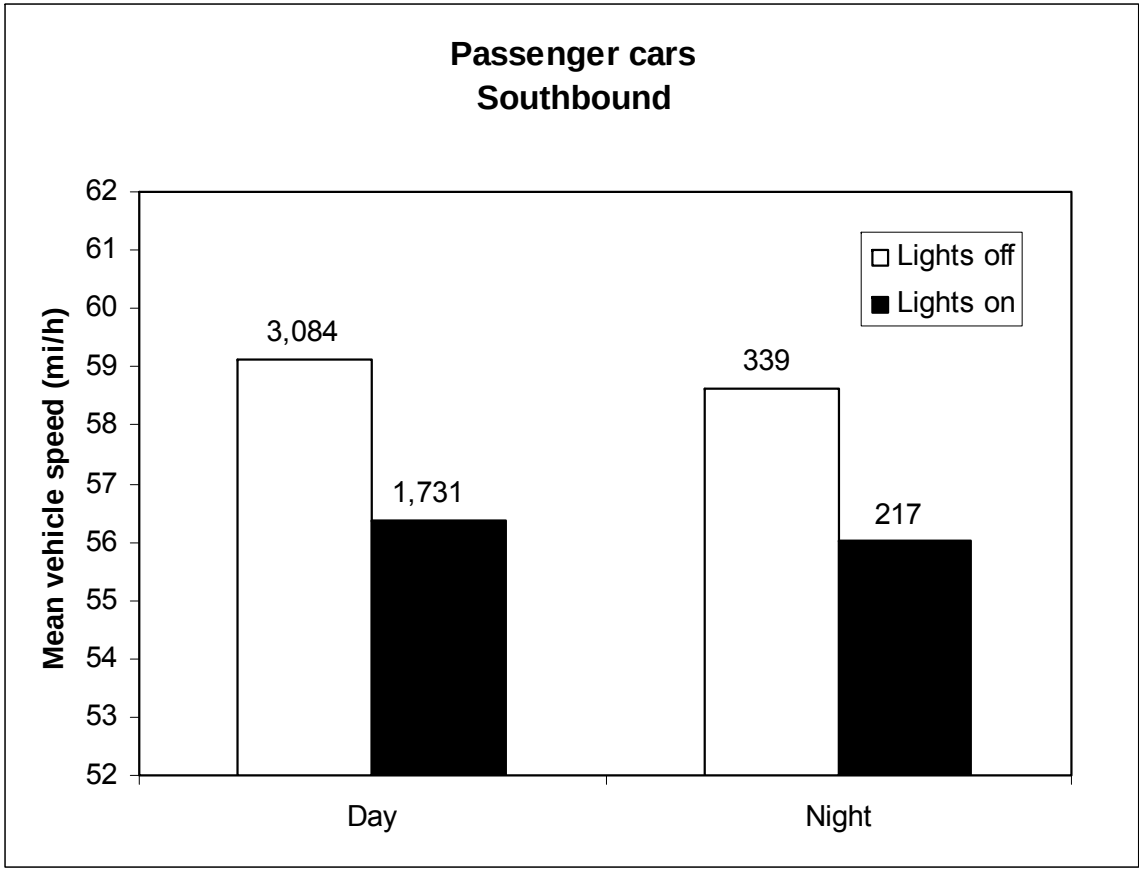
Animal detection systems and driver response



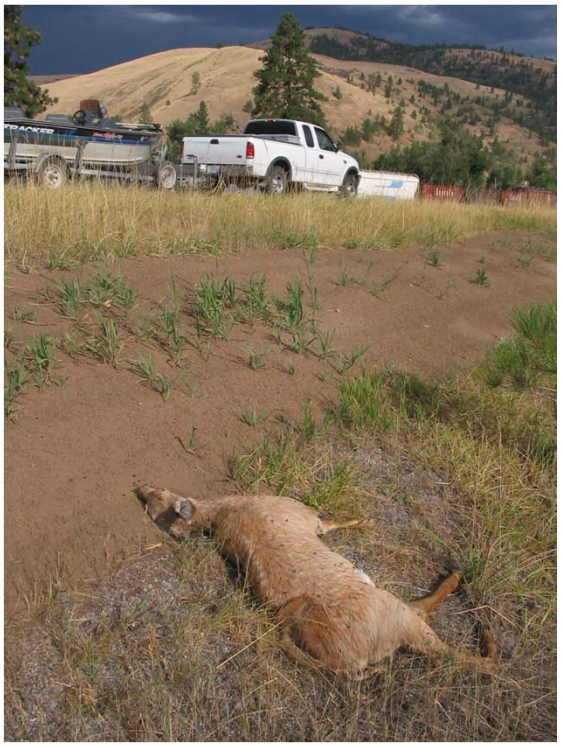
Effectiveness: speed reduction



Main effect lights on/off: P<0.001 (Huijser et al., 2009)

Effectiveness: collisions

Reduction	Location	Source
-57.6%	1 Location in Yellowstone National Park, USA	Huijser et al. (2009)
-80%	1 location, Germany	Steiner (2010)
-82%	7 locations Switzerland	Kistler (1998), Mosler-Berger & Romer (2003)
-97%	1 location in Arizona, USA	Gagnon et al. (2010)



Two new systems in test-bed

Magal Senstar
(Perimitrax)

Icx Radar Systems (STS III)

Tied to two road locations

Magal Senstar (Perimitrax)

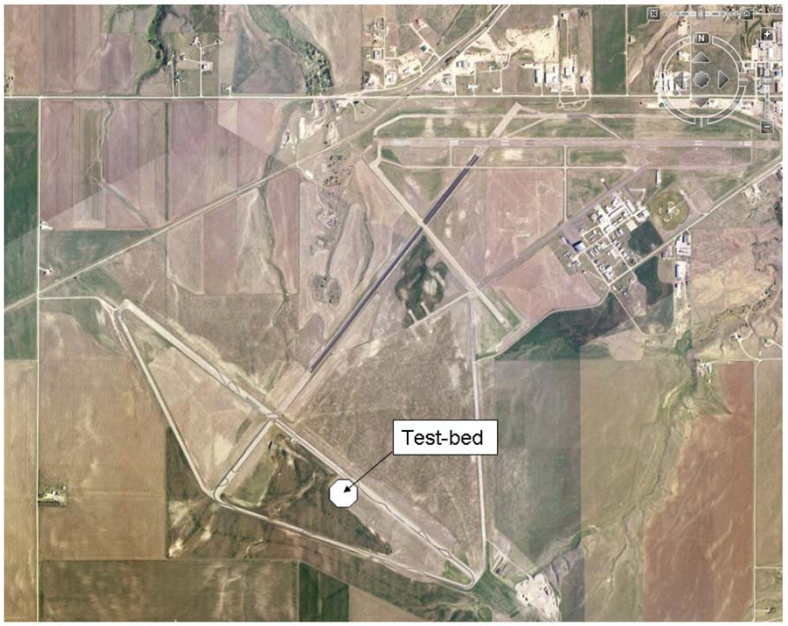
US Hwy 160 between Durango and Bayfield, Colorado, USA.

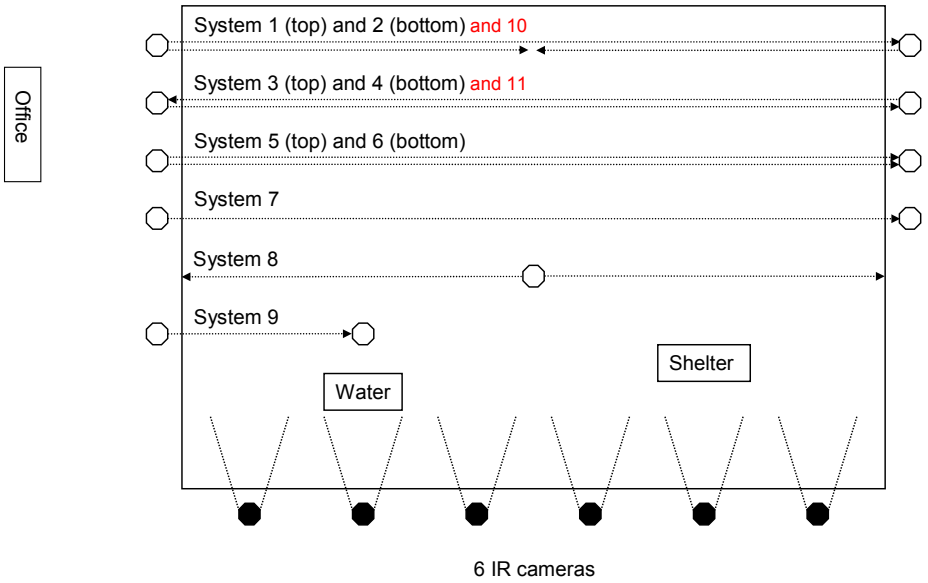
Icx Radar Systems (STS III)

Hwy 3 (Ft. Jones Rd.) near Ft Jones, CA, USA

Animal Detection System
Test Bed Lewistown, MT

- Test bed completed in Sep 2006
- 11 systems from 6 vendors
- IR camera system
- Horses/llamas/sheep





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Systems and Manufacturers

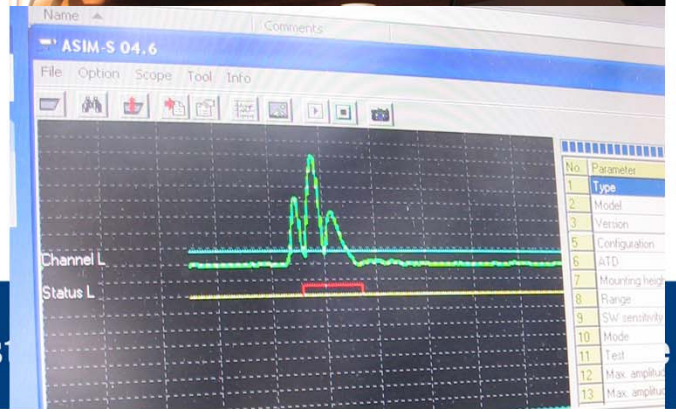
System #	Manufacturer and system name	ID #	System type	Signal type	Maximum range	Installation date
1	Xtralis (ADPRO)	7	Area cover	Passive IR	500 ft (152 m)	21 Sep 2006
2	Xtralis (ADPRO)	5-6	Area cover	Passive IR	200 ft (61 m) (one detector on each side)	21 Sep 2006
3	STS (ICx radar systems) (RADS I)	1	Break-the-Beam	Microwave radio (± 35.5 GHz)	¼ mi (402 m)	19 Oct 2006
4	STS (RADS II)	2	Break-the-beam	Microwave radio (± 35.5 GHz)	Well over ¼ mi (402 m)	19 Jul 2007
5	Calstrom GmbH CAR92,LS-WS -WE 45	1	Break-the beam	Laser	984 (built-up areas) -1148 ft (open areas) (300-350 m)	21-22 Sep 2006
6	Calstrom GmbH (CAR92,IR-204-319/M3	2	Area cover	Passive IR	328 ft (100 m)	21-22 Sep 2006
7	Camrix (A.L.E.R.T.)		Area cover	Passive IR	300 ft (91 m)	19-31 Oct 2006
8	Xtralis (ADPRO)	1-2	Area cover	Passive IR	200 ft (61 m) (2 detectors, one facing each way)	8 Aug 2006
9	Goodson		Break-the-beam	Active IR	90 ft (27 m)	Dec 2006
10	Magal Senstar Perimitrax		Buried cable	Electromagnetic field	About 0.1 mi (161 m)	11/12 Aug 2009
11	STS (RADS III)	3	Break-the-beam	Microwave radio (± 35.5 GHz)	About 1/2 mi (804 m)	16 Dec 2009

Horses, Llamas, and Sheep

- Model for

  deer, pronghorn, elk, moose
- Caretaker

Reliability tests

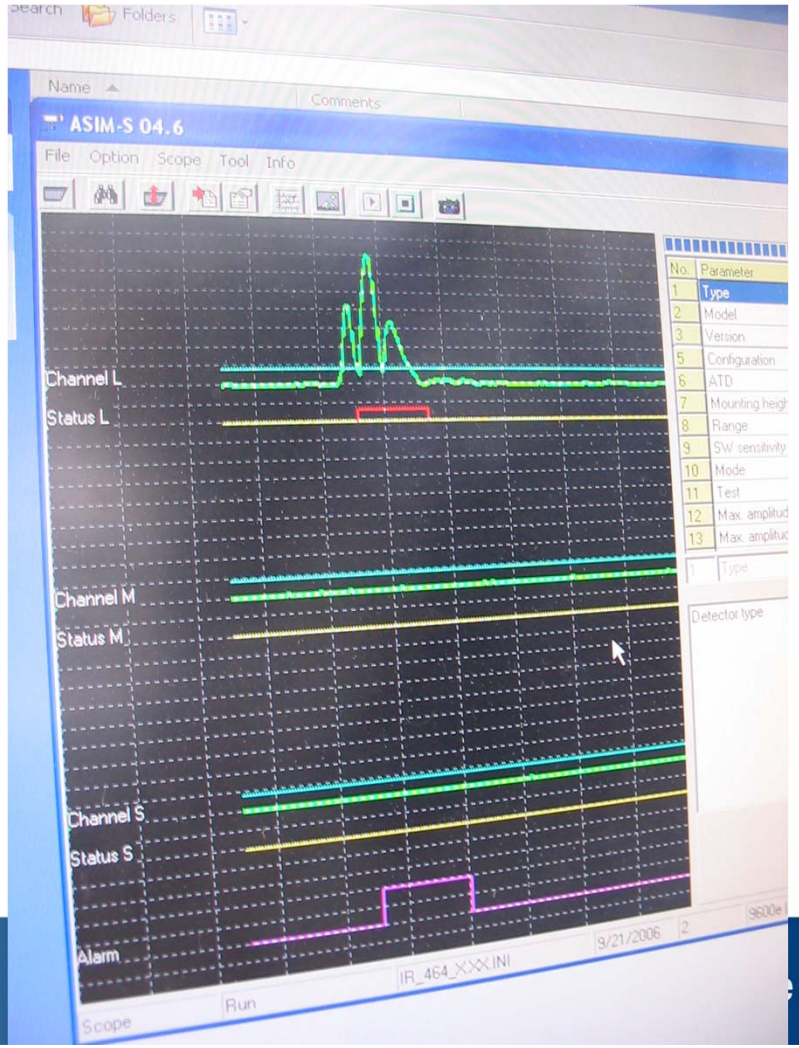


Data Collection

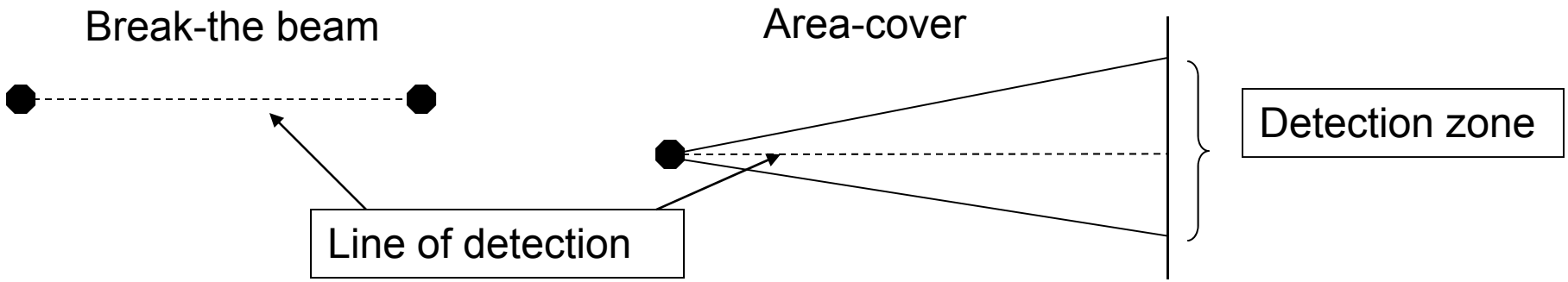
- Detection data logs
- IR camera images

- 10 day test periods (24/7)
- 10 periods Jan ’07 - Dec ’07
- 4 periods Dec ‘09 – Jan ‘10
- Each test day: 3 randomly selected hrs analyzed
- “Chosen” periods, with and without animals

Data Collection

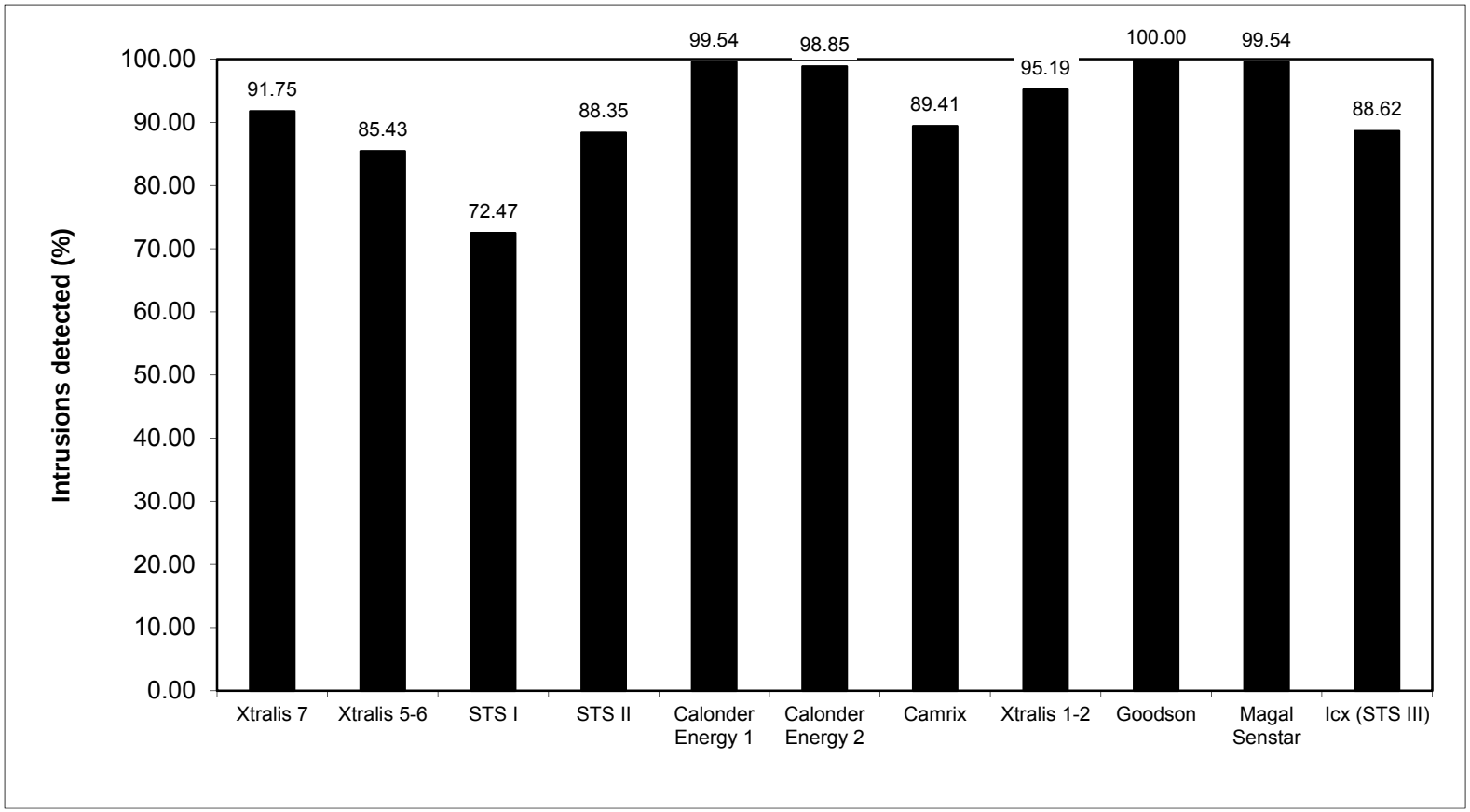


Dependent Variables

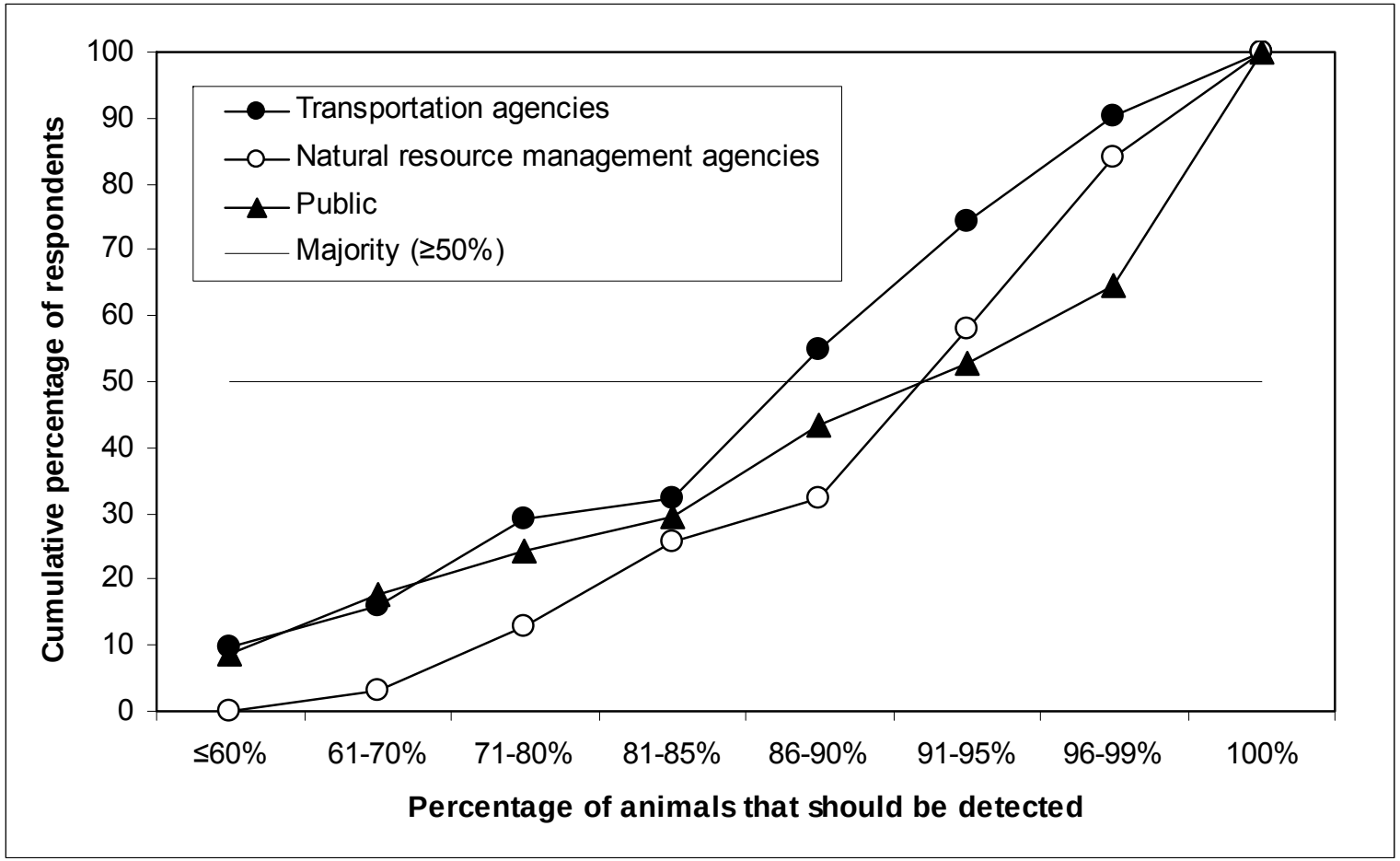


- *Correct detection:* Detection and animal present in detection area
- *False positives:* Detection but no animal present in detection area
- *False negatives:* Animal passes line of detection but no detection
- *False negatives 1:* Animal lingers in the detection zone before passing through the line of detection but no detection
- *False negatives 2:* Animal(s) lingered in the detection zone and other animal(s) passed through the line of detection but no detection

Intrusions detected (%)



Suggested norms reliability



Meet the minimum norms?

Table 8.2: The reliability of each system in relation to the recommended minimum norms. The percentage of intrusions detected is similar, though not exactly the same as the inverse of the percentage of false negatives (see chapter 4) (*1alternative calculation: 81.2%; *2alternative calculation: 81.8%; *3alternative calculation: 75.5%).

System number (Figure 3.2)	Manufacturer and system name	ID number	False positives (%)	False negatives (all types combined) (%)	Intrusions detected (%)	Meets recommended norms (yes/no)
1	Xtralis (ADPRO)	7	0.00	10.29	91.75	Yes
2	Xtralis (ADPRO)	5-6	0.00	20.88	85.43	No
3	STS (RADS I)	1	0.00	30.91	72.47	No
4	STS (RADS II)	2	0.00	15.94	88.35	No
5	Calonder Energy (CAL 92, LS-WS-WE 45)	1	0.60	0.48	99.54	Yes
6	Calonder Energy (CAL 92, IR-204-319/M3)	2	0.00	1.16	98.85	Yes
7	Camrix (A.L.E.R.T.)	Overall Before mod. After mod.	0.07 0.07 0.00	30.21 30.41 27.00	89.41*1 89.33*2 90.20*3	No No No
8	Xtralis (ADPRO)	1-2	0.97	6.53	95.19	Yes
9	Goodson		0.82	0.00	100.00	Yes
10	Magal Senstar		0.33	1.88	99.54	Yes
11	ICx		0.41	16.76	88.62	No

Explanatory Variables

- Wind Speed
- High Wind (winds over 15 mph)
- Wind Gust (present/ absent)
- Wind direction (split into 4 categories for N, E, S or W)
- Temperature
- Day or night
- Visibility (10 or not)
- Relative Humidity
- Precipitation (presence/ absent)
- Animal (none, horse or llama)
- System modifications (e.g. threshold settings)

Data analyses

- Multinomial logistic regression model
- Akaike's An Information Criterion (AIC)
- Stepwise model selection procedure for each system

- Effect and direction of effect was investigated for each type of FN or FP relative to correct detections

- System modifications and animal species were forced into the models

Variable included in model

Significant effects (P≤0.05):

FN = False Negative

FP = False Positive

+ = Increase in error rate

- = decrease in error rate

Huijser et al., 2009

	Excluded	System modifications (aft./bef.)	Wind speed (mi/h)	High wind (> 15 / ≤ 15 mi/h)	Wind gust (present/absent)	Wind direction (N,W,S / E)	Temperature (°C)	Day or night (N/D)	Visibility (excellent/not excel.)	Relative humidity (%)	Precipitation (present/absent)	Animal (llama/horse)
Xtralis 7			+FN				+FN					
			+FN1									+FN1
			+FN2				+FN2			-FN2		
	FP											
Xtralis 5-6			+FN				+FN	-FN		+FN		+FN
						+FN1 (N/E)		-FN1				+FN1
			+FN2			-FN2 (N/E)	+FN2					+FN2
	FP											
STS 1							+FN	-FN		+FN		
								-FN1				
	FP											
STS 2												+FN
						+FN1 (S/E)	+FN1					
							+FN2			+FN2		+FN2
	FP											
Calonder Energy 1	FN											
	FN1											
	FN2											
					+FP		+FP		-FP	+FP		
Camtix			+FN					+FN				
							-FN1	+FN1				
		-FN2						+FN2	+FN2			
			-FP			+FP (N/E)	-FP			+FP		
Xtralis 1-2							+FN			+FN		+FN
						-FN1 (N/E)		-FN1				+FN1
												+FN2
										-FP		
Goodson	FN											
	FN1											
	FN2											
					-FP	+FP (N+W+S/E)	-FP			-FP		

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Animal detection systems or wildlife crossing structures?

?

Positive

- Wider crossing areas (without fences)
- Less expensive?

Negative

- Large animals only
- Avoidance open areas / pavement
- Human safety (animals, posts)

Conclusions

- Some systems are very reliable
- 6 out of the 11 systems tested met reliability norms
- Reliability is dependent on environmental conditions
- Not “one system fits all”; variety technologies needed

Work to be Done!

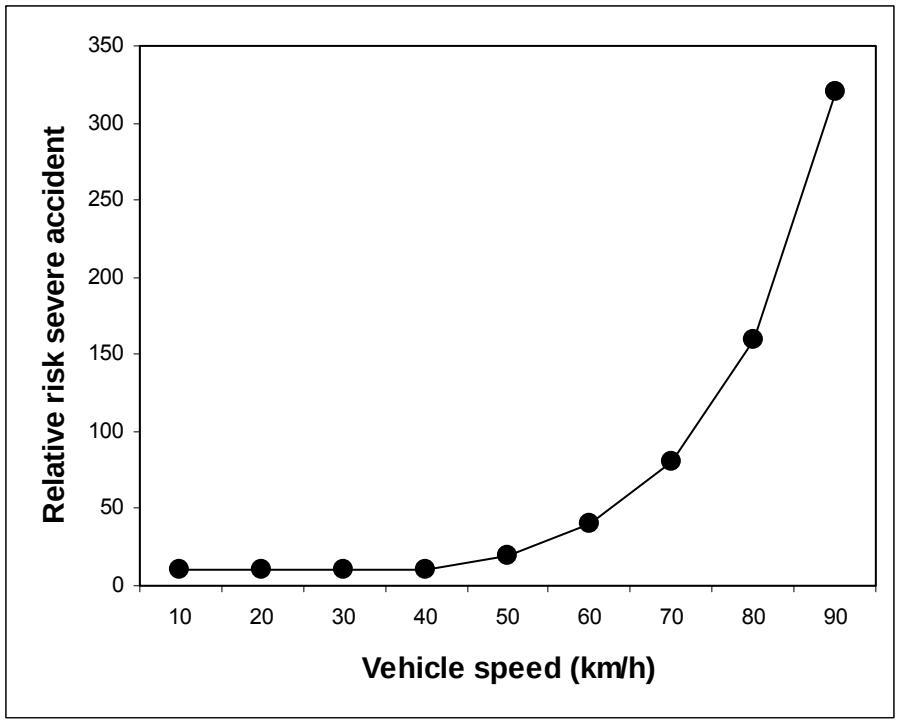
Researchers
Suggest norms for system reliability (ongoing)
Investigate effective warning signs; message, spacing (driving simulator study)
Investigate system effectiveness further (dependent on study sites)
Communicate, share data for meta-analyses

Vendors
More robust systems (less maintenance)
Increase reliability (detecting 91-95% animals)
Smaller systems
Further integration with other ITS systems

DOTs/FHWA
Discuss and adopt norms system reliability
Require tests before installation
Standardize warning signs (type, spacing)
Develop further standards for ITS integration (car – roadside communication)
Implement systems and monitor effectiveness
Communicate, share data for meta-analyses

Effectiveness: speed reduction

Conceptual relationship



After Kloeden et al., 1997

Exponential relationship

At high speed, small reductions in speed lead to disproportionate decrease in risk of severe accident

At high vehicle speed, small reductions in speed do matter!

Systems: break the beam

Microwave radio signals

Effectiveness: driver alertness

- Potential reduction in reaction time:
  1.5-0.7= 0.8 s (Green, 2000)
- Potential reduction in stopping distance:
  0.8 s at 55 mi/h = 68 ft

Detection Lines and Zones

Animal Detection System Test Bed Lewistown, MT

Status

- Test bed completed in Sep 2006
- 11 systems from 6 vendors
- IR camera system
- Horses, llamas and sheep as models for wildlife

Focus

- Reliability systems
- Reliability standards