An Investigation of impacts VMS on safety on Scottish Trunk Roads

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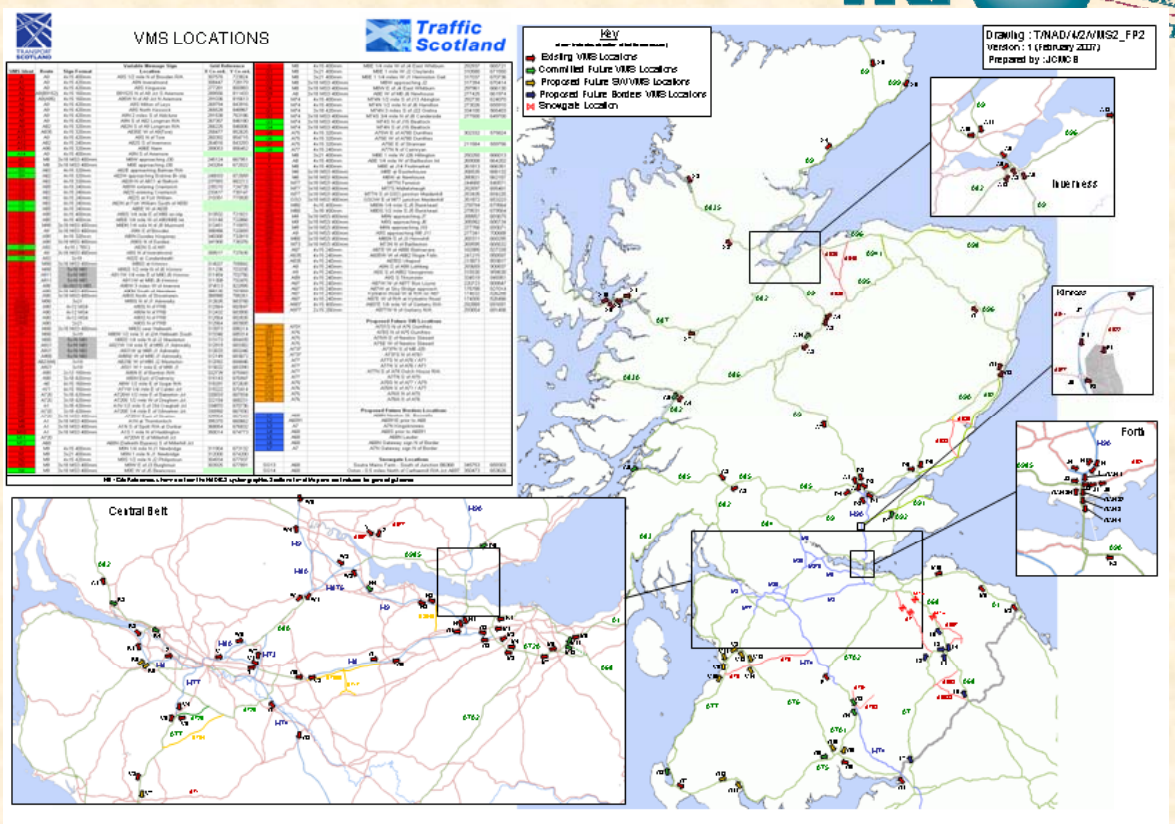
Contents

Introduction to VMS

- To inform drivers of dangers ahead (e.g., adverse weather, accidents)
- To inform motorists of congestion, roadworks, or speed limits ahead, etc.



Literature

- VMS for Speed reduction information and unexpected events

- a 30% - 48% reduction of accident rates
- effective in diverting motorists
- a reduction in speed in upstream but an increase downstream

Research Gap

- **Results re accidents reductions are not conclusive**
- **Overall reduction in accidents do not mean resulting from VMS**
- **The effect of VMS on accident severity?**
- The interaction effects of other factors with VMS?

Therefore…

- A review of the literature suggest that while consistent conclusions have been suggesting that a reduction of speed was observed as a result of a sign that urges a reduced speed, there was a concern for an increase in speed downstream
- The net safety effects of such message systems were rather inconclusive in the literature

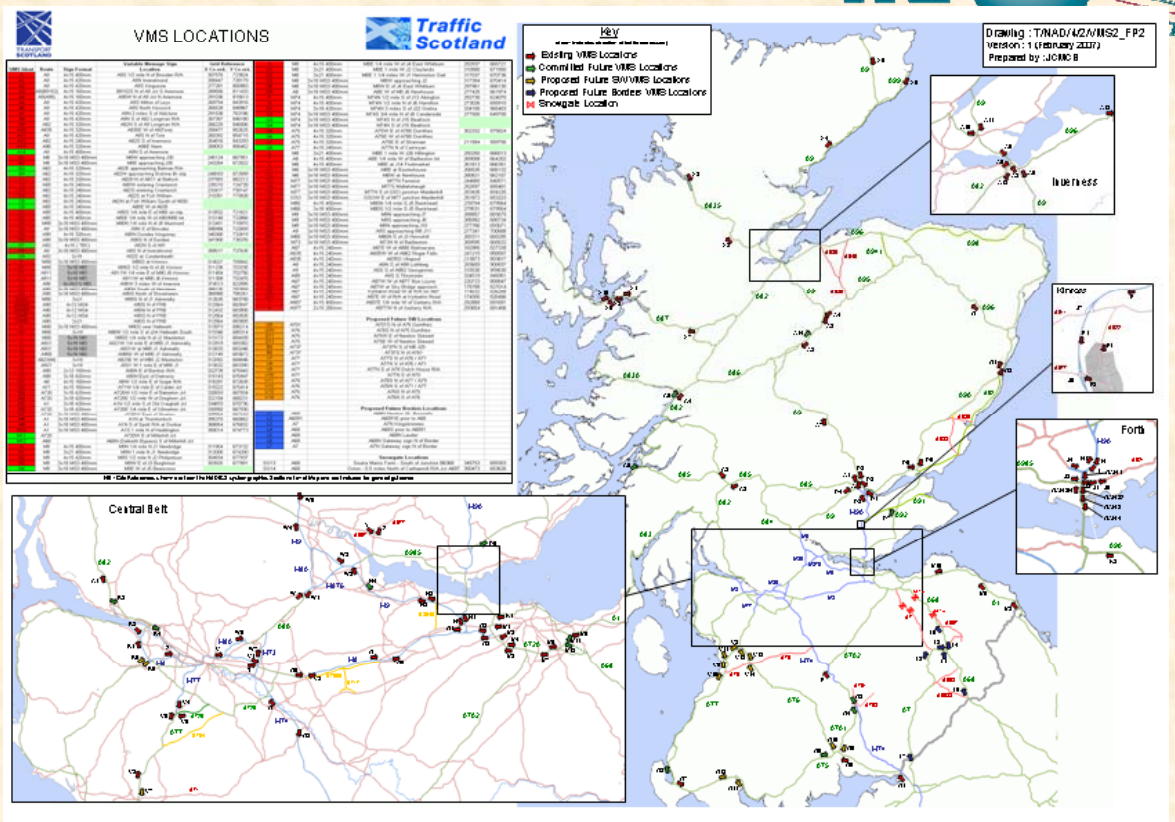
Research objectives

- To investigate the impacts of VMS on accident rates and severity on Scottish trunk roads

- A before-and-after analysis of accidents at 14 selected VMS sites in Central and North-East Scotland is presented.

Data source

- The number and locations of accidents at 14 selected VMS sites
- NADICS website
- Glasgow ITS department of the Faber Maunsell Engineering Consultancy
- Other factors that affect accident rates and severity:
- The UK Stats19 accident injury database



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Analysis of accident rates

- Accident rates

$$\hat{k} = \frac{X}{TLQ} \qquad \text{st. error}(\hat{k}) = \sqrt{\frac{\hat{k}}{TLQ}} = \frac{\sqrt{X}}{TLQ}$$

Where $\hat{k}$ represents accident rates; X = number of accidents, T = time (in years in this case), L = length (km) of the road in question and Q = flow on the road over the entire year (thus is typically calculated by multiplying the AADT (Annual Average Daily Traffic) by 365 (days in a year))

Effect of VMS on accident rate

- Effectiveness of VMS

$$\theta = \frac{Y_A T_B Q_B}{Y_B T_A Q_A}$$

Where Y_B = Accidents Before, Y_A = Accidents After
T_B = Time Before (years), T_A = Time After (years)
Q_B = Flow Before, Q_A = Flow After

Overall accident rate (k) 2000-2006

ROAD	VMS CODE	*X* ACCIDENTS	*Q* (AV.)	*L* (KM)	*T* (YEAR)	*K* (ACCS/10^8VEH-KM)	SE (ACCS/10^8VEH-KM)
M9	N3	6	17515	2	7	6.70	2.74
	W2	5	18006	2	7	5.43	2.43
	W3	2	18857	2	7	2.08	1.47
	W4	2	18088	2	7	2.16	1.53
A720	M7	9	30401	2	7	5.79	1.93
M8	O3	69	31066	2	7	43.47	5.23
	O6	10	26476	2	7	7.39	2.34
	O	7	25442	2	7	5.38	2.04
	V2	10	26377	2	7	7.42	2.35
	O9	18	25036	2	7	14.07	3.32
	V1	13	36582	2	7	6.95	1.93
A90	G1	11	12285	2	7	17.52	5.28
	G2	4	10871	2	7	7.20	3.60
	D6	14	12756	2	7	21.48	5.74

Accidents data before and after installing VMS

ROAD	VMS CODE	*ACCIDENT DATA (BEFORE)*				*ACCIDENT DATA (AFTER)*				*K* BEFORE VMS (ACCS/100 M VEH-KMS)	*K* AFTER VMS (ACCS/100 M VEH-KMS)	BEFORE AND AFTER % DIFFERENCE
		X Accidents	*Q* Average	*L (km)*	*T* (yr)	*X* Accidents	*Q* Average	*L (km)*	*T* (yr)			
M9	N3	4	17139	2	5	2	18455	2	2	6.39	7.42	16.09%
	W2	4	16571	2	5	1	21592	2	2	6.61	3.17	-52.03%
	W3	2	17764	2	5	0	21590	2	2	***3.08***	***0.00***	***-100.00%***
	W4	2	17206	2	4	0	19263	2	3	***3.98***	***0.00***	***-100.00%***
A720	M7	4	30042	2	4	5	30881	2	3	4.56	7.39	62.14%
M8	O3	46	30436	2	4	23	31905	2	3	51.76	32.92	-36.40%

Percentage effectiveness of VMS including the control zone information

VMS	Y_B Accs before	Y_A Accs after	X_B Accs before	X_A Accs after	VMS % EFFECT	EFFECT RANGE	
N3	4	2	5	2	25.00%	-88.20%	1224.07%
W2	4	1	5	2	-37.50%	-95.95%	865.03%
W3	2	0	5	2	-100.00%	0.00%	0.00%
W4	2	0	4	3	-100.00%	0.00%	0.00%
M7	5	4	4	3	6.67%	-85.45%	682.20%
O3	46	23	76	50	-24.00%	-84.32%	268.40%
O6	6	4	5	2	66.67%	-78.99%	1222.36%
O	3	4	4	3	77.78%	-78.60%	1376.72%
V2	7	3	7	3	0.00%	-86.70%	651.94%
O9	10	8	9	1	620.00%	9.31%	4642.50%
V1	7	6	7	3	100.00%	-68.62%	1174.54%
G1	8	3	9	1	237.50%	-59.06%	2682.30%
G2	1	3	4	3	300.00%	-73.48%	5932.77%
D6	10	4	15	5	20.00%	-81.94%	697.14%

Percentage effectiveness of VMS

VMS		ESTIMATE % VMS EFFECT			EFFECT RANGE	
N3	1.160896	16.09%	0.213	6.338	-78.74%	533.82%
W2	0.479663	-52.03%	0.054	4.292	-94.64%	329.17%
W3	0	-100.00%	0.000	0.000	0.000	0.000
W4	0	-100.00%	0.000	0.000	0.000	0.000
M7	1.037703	3.77%	0.279	3.864	-72.13%	286.44%
O3	0.635975	-36.40%	0.386	1.049	-61.45%	4.91%
O6	1.489406	48.94%	0.420	5.278	-57.97%	427.80%
O	1.637746	63.77%	0.367	7.318	-63.35%	631.77%
V2	0.304464	-69.55%	0.079	1.177	-92.13%	17.74%
O9	1.827277	82.73%	0.721	4.630	-27.88%	362.99%
V1	0.577838	-42.22%	0.194	1.719	-80.58%	71.94%

Chi-squared results for the 14 VMS

VMS	OBSERVED		ACCIDENTS PER YEAR	EXPECTED		X^2 $=\sum(O-E)^2/E$
	Accs before	Accs after		Accs before	Accs after	
N3	4	2	0.857	4.286	1.714	*0.07*
W2	4	1	0.714	3.571	1.429	*0.18*
W3	2	0	0.286	1.429	0.571	*0.80*
W4	2	0	0.286	1.143	0.857	*1.50*
M7	5	4	1.286	5.143	3.857	*0.01*
O3	46	23	9.857	39.429	29.571	*2.56*
O6	6	4	1.429	7.143	2.857	*0.64*
O	3	4	1.000	4.000	3.000	*0.58*
V2	7	3	1.429	4.286	5.714	*3.01*
O9	10	8	2.571	12.857	5.143	*2.22*
V1	7	6	1.857	5.571	7.429	*0.64*
G1	8	3	1.571	7.857	3.143	*0.01*
G2	1	3	0.571	2.286	1.714	*1.69*
D6	10	4	2.000	8.000	6.000	*1.17*

Analysis of accident severity

- Two binary logit models (KSI vs non KSI accident) were estimated
- the overall binary logit model
- the binary logit model conditioned on the absence of VMS (interaction effects of absence of VMS with other variables)

The overall binary logit model

VARIABLE	CATEGORIES OF EACH VARIABLE	FREQUENCY	COEFFICIENT (P-VALUE)	O.R.
Intercept: -1.876 (0.217)				
Gender of rider	1. male	136 (76%)	0.044 (0.943)	1.045
	2. female	43 (24%)	R	R
Age of rider	1. up to 20	19 (10.6%)	-0.456 (0.661)	0.634
	2. 21~59	143 (79.9%)	-1.017 (0.206)	0.362
	3. 60 or above	17 (9.5%)	R	R
Vehicle type	1. car (private car/taxi)	143 (79.9%)	-0.835 (0.150)	0.434
	2. heavier veh (bus/HGV)	36 (20.1%)	R	R
Accident month	1. spring/summer (Mar-Aug)	84 (46.9%)	0.533 (0.025)	3.237
	2. autumn/winter (Sep-Feb)	95 (53.1%)	0.325 (0.006)	1.384
VMS measure	1. no VMS	113 (63.1%)	0.749 (0.186)	2.116
	2. automatic signal	66 (36.9%)	R	R
Weather condition	1. fine	118 (65.9%)	-0.319 (0.720)	0.727
	2. wet	44 (24.6%)	-0.602 (0.544)	0.548
	3. extreme	17 (9.5%)	R	R
Accident time	1. rush hours (1600-1859; 0700-0959)	69 (38.5%)	0.533 (0.359)	1.705
	2. late night/morning (0000-0659)	10 (5.6%)	1.446 (0.105)	4.246
	3. evening (1900-2359)	21 (11.7%)	0.176 (0.849)	1.185
	4. late morning/afternoon (1000-1559)	79 (44.1%)	R	R
Traffic flow	1. 10000-19999	42 (23.5%)	0.261 (0.688)	1.298
	2. 2000-29999	65 (36.3%)	0.079 (0.245)	1.317
	3. 30000-39999	72 (40.2%)	R	R
Dependent variable	1. KSI	22 (12.3%)		
	2. slight injury	157 (87.7%)		
Classification accuracy	1. the number of KSI that was correctly predicted: 1 (0.6%)			
	2. the number of Slight injury that was correctly predicted: 156 (99.4%)			
Observations: 179				
McFadden Pseudo R-Square: 0.103				
Likelihood ratio χ^2 : 139.761 (with 115 D.F., p=0.058)				

Interaction binary logit model

VARIABLE	CATEGORIES OF EACH VARIABLE	FREQUENCY	COEFFICIENT (P-VALUE)	O.R.
Intercept: -0.573 (0.784)				
Gender of driver	1. male	85 (75.26%)	-00814 (0.913)	0.923
	2. female	28 (24.8%)	R	R
Age of driver	1. up to 20	11 (9.7%)	-0.752 (0.628)	0.472
	2. 21~59	93 (82.3%)	-0.986 (0.339)	0.373
	3. 60 or above	9 (8.0%)	R	R
Vehicle type	1. car (private car/taxi)	92 (81.4%)	-1.616 (0.029)	0.199
	2. heavier veh (bus/HGV)	21 (18.6%)	R	R
Accident month	1. spring/summer (Mar-Aug)	54 (47.8%)	1.607 (0.019)	4.987
	2. autumn/winter (Sep-Feb)	59 (52.2%)	R	R
Weather condition	1. fine	748 (65.5%)	-0.715 (0.580)	0.489
	2. wet	32 (28.3%)	-0.552 (0.668)	0.576
	3. extreme	7 (6.2%)	R	R
Accident time	1. rush hours (1600-1859; 0700-0959)	39 (34.54%)	0.809 (0.253)	2.245
	2. late night/morning (0000-0659)	5 (4.4%)	0.946 (0.458)	2.576
	3. evening (1900-2359)	11 (9.7%)	1.049 (0.297)	2.856
	4. late morning/afternoon (1000-1559)	58 (51.3%)	R	R
Traffic flow	1. 10000-19999	29 (25.7%)	-0.269 (0.747)	0.764
	2. 2000-29999	45 (39.8%)	0.372 (0.598)	1.450
	3. 30000-39999	39 (34.5%)	R	R
Dependent variable	1. KSI	16 (14.2%)		
	2. slight injury	97 (85.8%)		
Classification accuracy	1. the number of KSI that was correctly predicted: 2 (1.8%)			
	2. the number of slight injury that was correctly predicted: 95 (84.1%)			
Observations: 113				
McFadden Pseudo R-Square: 0.149				
Likelihood ratio χ^2 : 13.698 (with 12 D.F., p=0.320)				

Summary and conclusions

- Installation of VMS resulted in a reduced accident rate (16.9% in general).
- However, when the control sites were taken into account, installation of VMS might have resulted in an increase in accident rates on the roads upon which they were placed.
- The presence of VMS reduced accident severity at the considered sites.

Further work

- Analysis of accident rates and severity with larger data and wider area coverage