TRANSPORT RESEARCH LABORATORY

Interactive fibre optic signing at a rural crossroad (B1149 Felthorpe, Norfolk CC)

Prepared for Chief Scientist's Unit, Department of the Environment, Transport and the Regions

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Executive Summary

TRL studies have shown that between 22% and 32% of road accidents have excessive speed as a contributory factor. This study aims to make a major contribution as part of the ongoing Government strategy for tackling the problem of excessive speed on our roads (initiated by *Killing Speed and Saving Lives*. Department of Transport. 1992).

This study evaluates the effectiveness of a Fibre Optic sign in reducing speeds at the approach to a rural cross roads. The objective of the new system is to reduce speeds consistently, and in particular those of motorists at the top end of the speed distribution.

The hypothesis of this study is that drivers' speeds can be influenced by a sign that deliberately gives no information on a suitable speed for the conditions but simply warns of a hazardous situation. For drivers whose attention is for some reason distracted, it will refocus them upon the circumstances. This presupposes that drivers are capable of making an intelligent evaluation of a situation having been warned in advance. This assumption of driver responsibility, given reasonable help, underlies much road safety policy.

This report examines the effect of Fibre Optic signs at a single carriageway cross road junction in rural Norfolk. The site at Felthorpe junction is situated on the B1149 running north from Norwich, just past the village of Horsford. The national speed limit (60mph) applies to the main road and the minor road speed is posted at 50mph. Thirty one personal injury accidents have occurred in 10 years, with most accidents caused by vehicle restarts at the junction subsequently being struck by southbound traffic.

The signs showing a pictogram image of the standard crossroad warning sign with the message 'SLOW DOWN', were switched on when vehicles approaching the junction exceeded 46mph. Although the drivers were not given an advisory speed, they did slow down, resulting in a safer approach speed to the junction. Results obtained from the regression analysis show reductions in mean speed to be highly significant at both sites and in both directions beyond the 0.01% confidence level. Additionally, time headways have increased (avoiding tailgating).

The results are encouraging and summarised below:

- Reduction in the number of high end speeders by as much as 70%.
- Speed reductions occur across the whole range of speeds.
- Reduction in the number of close following vehicles.
- Speed reductions below the posted speed.
- Speed reductions for vehicles on the exit from the junction.
- Speed reductions without enforcement.
- Predicted accident reductions of 20%.
- An immediate effect on driver behaviour.
- Sign in continuous operation.
- Low recurrent annual costs.

1 Introduction

The Felthorpe junction (Figure 1) lies on the B1149 running north from Norwich, just past the village of Horsford. The main road speed is the national speed limit (60mph) and the minor road speed is posted at 50mph.

A local safety scheme was completed in 1995 at a cost of £60,000, comprising visibility improvements to the North (viewed from the south side, Plate 1) and improved static signing. This has had little effect and there were a further 7 accidents up to November 1997.

Plates 2 and 3 illustrate the view from the minor arm in the eastbound and westbound direction.

There have been 31 personal injury accidents in 10 years (1987 to 1989), with most accidents caused by restarts at the junction subsequently being struck by southbound traffic. The distribution of accidents by hour of the day and time of year is shown in Figure 2.

The purpose of the study was to evaluate the effect of fibre optic warning signs (Figure 3) on the main road (B1149) using the hypothesis that the accident problem was not simply due to the emerging vehicles, excess speed

Plate 1 B1149 looking north towards junction

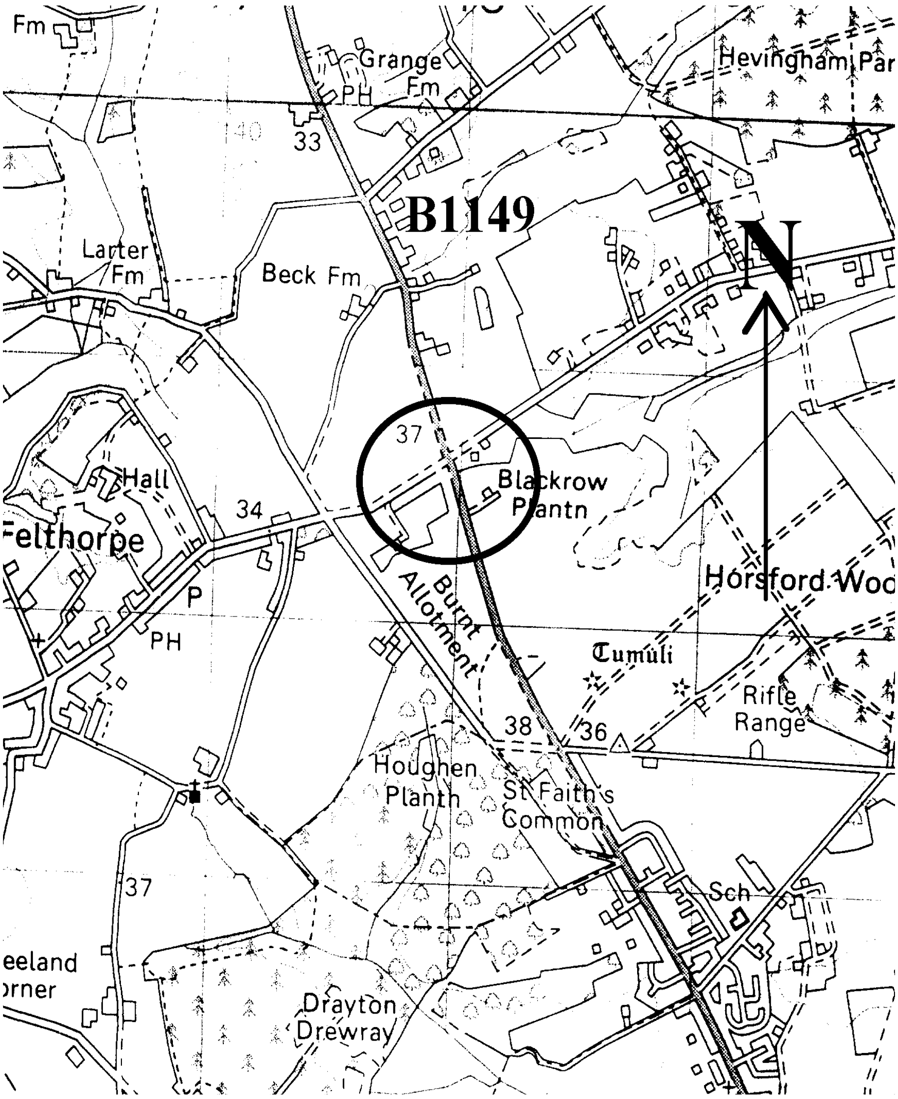

Figure 1 Felthorpe junction (circled)

Plate 2 Minor arm looking west

Plate 3 Minor arm looking east

and inattention from drivers on the main road being a major contributory factor, particularly with regard to accident severity. The sign was intended to reduce the speed on the approach to the junction by targeting high speeders and hence improve the safety margin for emerging vehicles.

The project was a joint venture with the Norfolk County Council, who provided and installed the radar triggered fibre optic signs (manufactured by Forest City Signs). TRL provided the inductive loops, speed monitoring equipment and data analysis. Data collection was a joint exercise with Norfolk CC.

There is also an environmental benefit in as much as these signs when non-operational are less intrusive than conventional fixed message signs.

2 Background

Research has shown the need to target high end speeders and a recent study of T-junctions by Baruya (1996) indicates that for every 1mph reduction in the mean speed *of the speeders* will yield an 18 per cent reduction in vehicle accident frequency.

TRL studies have shown that between 22% and 32% of road accidents have excessive speed as a contributory factor. This seedcorn research study aims to make a major contribution as part of the ongoing Government strategy for tackling the problem of excessive speed on our roads (initiated by *Killing Speed and Saving Lives*. Department of Transport. 1992). The change in accident risk is assessed by the speed reductions achieved and their sustainability over time.

Past research on *fixed* signs advising motorists of the speed to enter a bend safely has shown little effect on actual speeds. Since accidents often cluster at bends, and

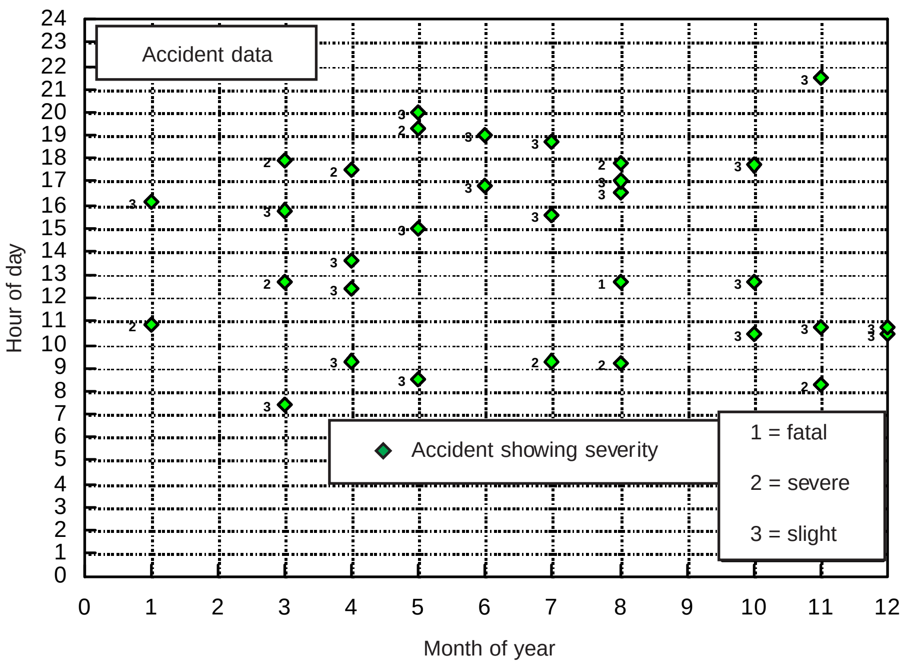

Figure 2 Junction accidents at Felthorpe showing casualty severity

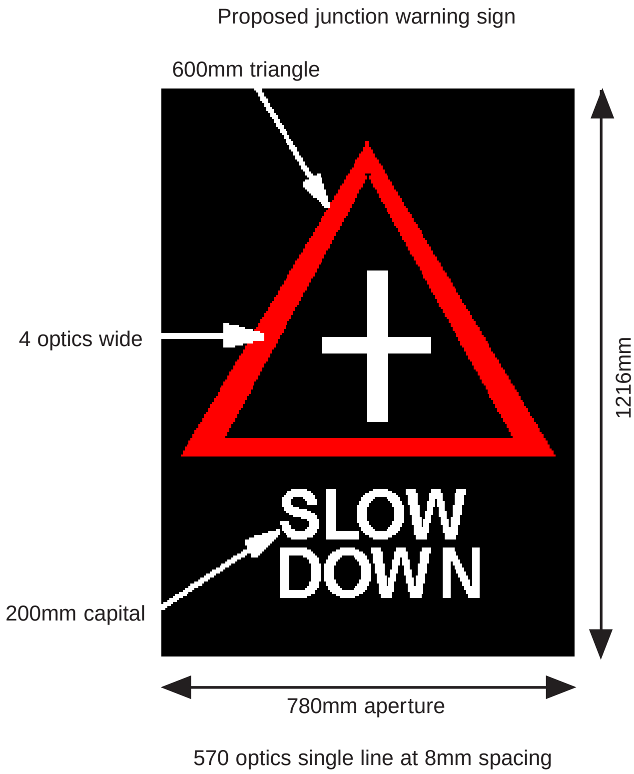

Figure 3 Sign layout

indeed bends are, or should be, moderating influences on speed, this failure of simple signing is a disappointment. A recent trial in Norfolk (Winnett and Woodgate. 1997) using a *responsive* fibre-optic sign that displayed only when drivers exceeded a preset threshold speed showed that this was extremely effective, and sustained reductions in average speeds, over a year were measured. This was the case even though many drivers were regular users of the road.

The sign turns 'on' if certain criteria are met, such as a driver exceeding a predetermined speed threshold, but does not give specific advice on a suitable speed, leaving that to the judgement of the driver. Initial research, limited but very promising, has shown that a significant speed reduction can be achieved with this technology and that it may be possible to reduce the speed even further.

The junction-approach sign developed for this study advised drivers on the major arm that they were approaching the junction too fast. The major arm (with the priority) was selected for treatment since the higher speeds (and consequently the higher kinetic energy of the vehicles) was the major contribution to injury.

This project builds on current research into improving safety on rural roads through the application of intelligent fibre optic signs. The findings from studies (Winnett and Woodgate 1997, Barker and Mackie 1997) suggest that:

- Permanent advisory warning signs appear to have little effect on traffic speeds in these circumstances.
- Drivers respond well to a sign that targets individuals who are exceeding a predetermined speed threshold by slowing down.
- It is possible to control the traffic speed by varying the threshold.
- Drivers respond to the warning 'SLOW DOWN' without instruction to conform to a specific speed.
- Avoiding over-prescriptive information encourages drivers to make a sensible speed choice.
- Drivers who regularly use a route attempt to avoid triggering the sign by slowing in advance of the sign.

3 Objectives

The immediate objective of the new signs was to reduce speeds consistently, and in particular target those drivers at the top end of the speed distribution. The longer term policy objective of reducing accidents cannot be directly monitored in the timescale of this project. The system developed here would ultimately need to be tested in larger trials stage before full implementation, and it would be at that stage that the accident performance could be investigated.

The general aims were to measure:

- The magnitude of the effect at junctions.
- The length of carriageway that can be affected by this technology.
- The effectiveness of the message.
- An estimate of accident benefit.

A further longer term objective would be to assess the rate at which drivers might habituate to the sign and the consequent effect on long term speed reductions.

4 Methodology

This trial attempted to measure whether drivers' speeds can be influenced by a sign that deliberately gives no information on a suitable speed for the conditions but simply warns of a hazardous situation. For drivers whose attention is for some reason distracted, it will refocus them upon the circumstances. This presupposes that drivers can make an intelligent evaluation of a situation having been warned in advance. This assumption of driver responsibility, given reasonable help, underlies much road safety policy.

A reason why no specific (numerical) advice was given on speed was that experience has shown that drivers will sometimes 'test' the advice (ie 'maximum speed 30mph'). If found to be inappropriate for the driver ability or vehicle performance, then the advice will probably be disregarded in future.

4.1 Data collection.

TRL originally developed a data logger for monitoring speeds on the Laboratory site as part of the Safety '91 exhibition. Historically, data logging of traffic speed has employed a 'binning' method for storing traffic data. Vehicle speeds are grouped into 'bins' of preset width, usually in 5mph bands, so that, for example, all vehicles travelling between 5mph and 10mph are clustered into a single 'bin'.

The industry has adopted a 13 bin structure[1] to cover a range of speeds from 0mph to 70mph. The 13 bin structure was advantageous in the early days of data collection because data storage was limited. The development of cheaper and larger memory modules has enabled more information to be collected and because of this TRL developed a data logger that can record the speed of every vehicle travelling along the carriageway and the time that the vehicle passed over the detector. This method of collection is called Per Vehicle Record (PVR) or Vehicle By Vehicle (VBV) recording.

The original TRL instrument was programmed to operate from either inductive loop detectors or pneumatic tube detectors, methods that have been tried and tested for over 30 years. Inductive loop detectors use the principle of detecting the change in inductance of a coil of wire in the carriageway when a vehicle passes over the loop. The pneumatic tube acts as an air switch that records the presence of a vehicle passing over a hollow rubber tube. The loops or tubes are laid in pairs of a known separation, so that the speed can be calculated from the time difference it takes the vehicle to register its presence between detectors.

The TRL data logger has a capacity of 420,000 vehicles. The data is analysed using a TRL developed software suite (Vehicle Software Analysis Package: VSAP) which produces speed distributions by time of day, vehicle headways, flow by time of day, and 85th percentiles.

The PVR method of data collection facilitates an evaluation of traffic data at a microscopic level, which was not possible with ‘binned’ data. Details such as flow breakdown, due to queuing or accidents can be easily identified. Additionally, vehicle separation (headway) can be precisely analysed. When a series of data loggers are installed along the highway it is also possible to track individual vehicles to produce acceleration and speed profiles. This method of data collection also allows the opportunity of replaying the traffic history of the road in the laboratory.

4.2 Signs

The fibre optic signs were manufactured by Forest City Signs. The pictogram (the standard cross-road warning triangle and the words ‘SLOW DOWN’) were produced by fibre optic cables illuminated by quartz halogen lamps. Microwave detector heads (X-band 10.5Ghz) mounted on the top of the signs were aligned to detect vehicles at a distance of 100m approaching the signs.

Vehicles exceeding a preset threshold (46mph for this study) caused the sign to illuminate and advise the drivers to reduce speed. The threshold of 46mph was chosen to ensure vehicles travelling above 50mph triggered the sign (allowing for a 10% error margin on the detector).

The signs were illuminated for 4 seconds when a vehicle exceeding the threshold was detected. This was calculated as sufficient to generate a warning that the driver would register.

Plate 4 Southern site (2) looking north. Sign off

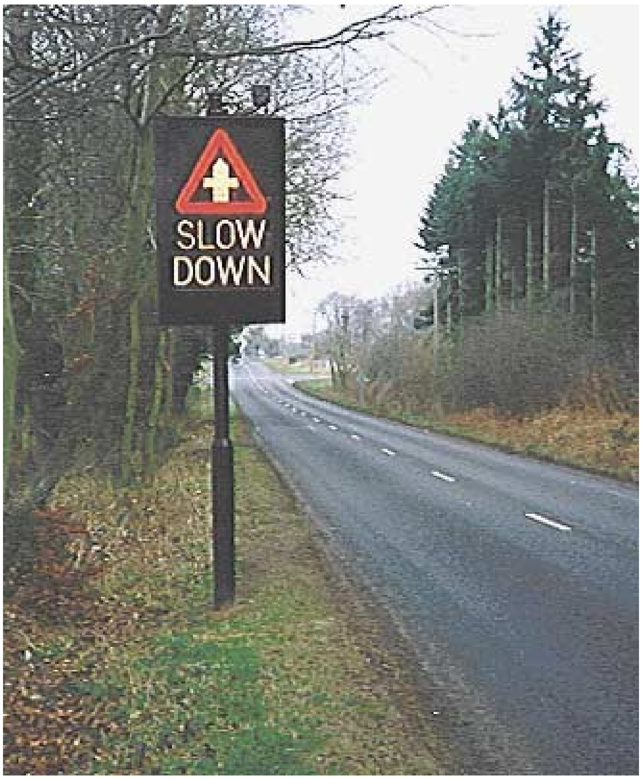

Plate 5 Southern site (2) looking north. Sign active

A series of inductive loops were installed along the carriageway to monitor the vehicle approach speeds, and the speed change, immediately after the sign at a distance of 50 metres from the sign (Figure 4).

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[1] *The 13 bin structure appears to have been used because vehicle classification already used 13 vehicle types.*

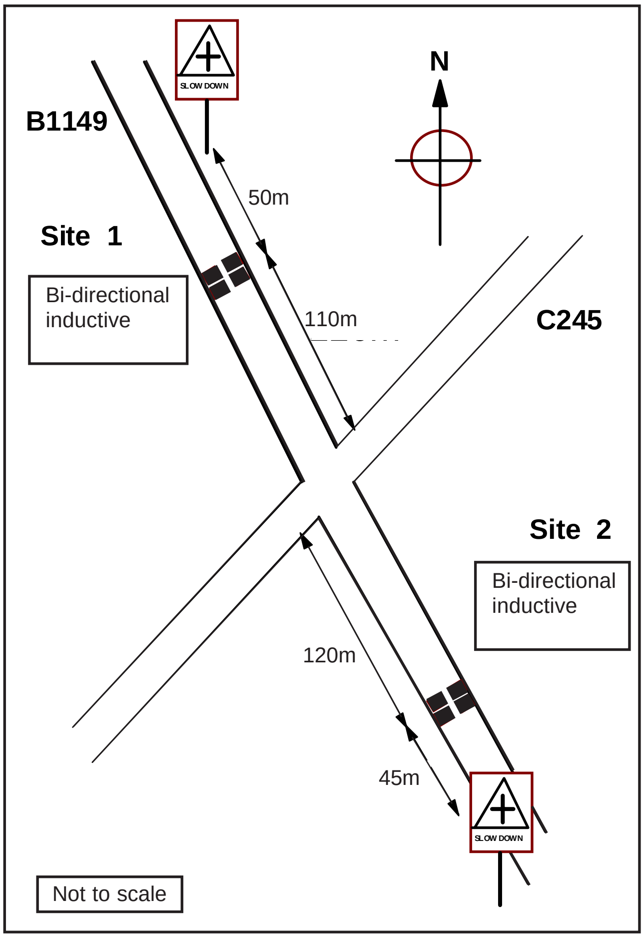

Figure 4 Schematic of site installation

5 Results

5.1 Flow

The 'before' data were collected during:

October/November 1997 (1st set)
January 1998 (2nd set)

with the 'after' data collected in February 1998.

The results are based on comparisons between complete 7 day periods observing flows containing 16,000 vehicles. A typical single weekday flow distribution is shown in Figure 5.

The flows were reasonably consistent for all of the collection periods (Table 1 and Table 2)

Table 1 Flow at Northern site (1)

Period			*Site 1*	
From	*To*		*Northbound*	*Southbound Sign*
31-Oct-97	06-Nov-97	Before	16714	16517
07-Nov-97	13-Nov-97	Before	16814	16729
14-Nov-97	20-Nov-97	Before	17101	15440
23-Jan-98	29-Jan-98	Before	15686	15218
03-Feb-98	09-Feb-98	After	16589	16194
12-Feb-98	18-Feb-98	After	16972	16572
19-Feb-98	25-Feb-98	After	17144	16950
05-Mar-98	11-Mar-98	After	14353	14160
12-Mar-98	18-Mar-98	After	17205	17179
19-Mar-98	25-Mar-98	After	17083	17117
26-Mar-98	01-Apr-98	After	16844	17056

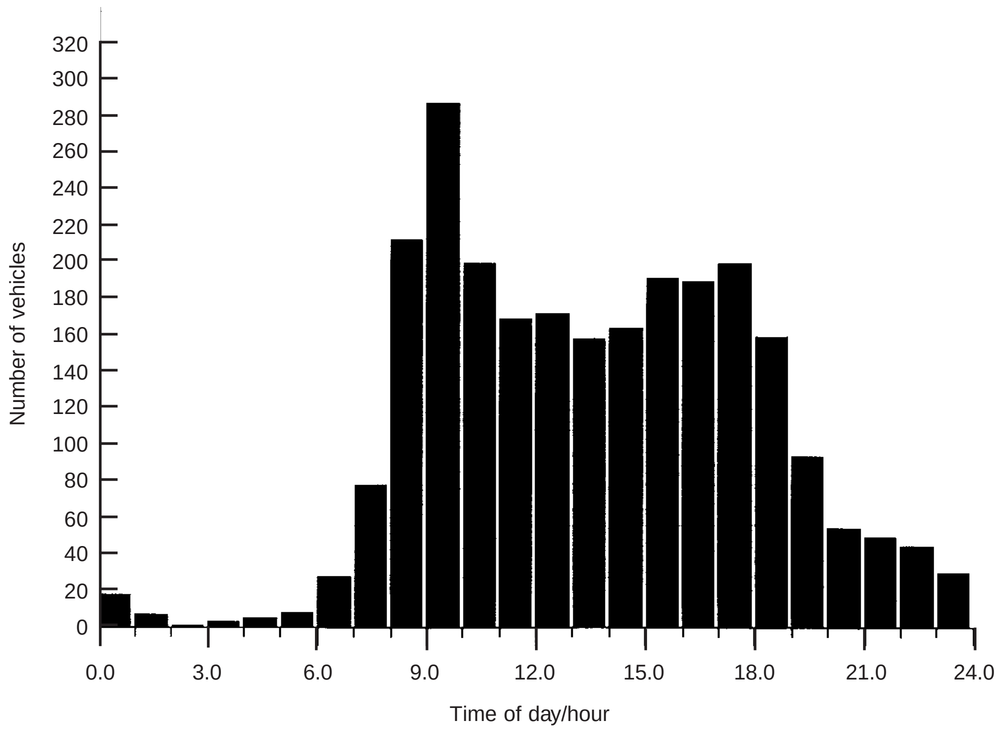

Figure 5 Flow distribution for Wednesday 12th November 1997

Table 2 Flow at Southern site (2)

Period			*Site 2*	
From	*To*		*Northbound Sign*	*Southbound*
31-Oct-97	06-Nov-97	Before	16330	16062
07-Nov-97	13-Nov-97	Before	16348	16157
14-Nov-97	20-Nov-97	Before	16690	—
15-Jan-98	21-Jan-98	Before	15308	14849
05-Feb-98	11-Feb-98	After	16454	15850
12-Feb-98	18-Feb-98	After	16666	15929
19-Feb-98	25-Feb-98	After	16808	16272
05-Mar-98	11-Mar-98	After	14378	13900
12-Mar-98	18-Mar-98	After	17323	16695
19-Mar-98	25-Mar-98	After	17149	16468
26-Mar-98	01-Apr-98	After	17097	16605

5.2 Speeds

The statistics that are usually adopted to illustrate speed and consequent speed changes along the highway are the mean speed and the 85th percentile. These statistics do not individually describe the nature of the changes that may occur due to the introduction of safety measures. For example it is possible to have a mean speed ‘after’ that is the same as the mean speed ‘before’, yet with a significant change in the speed behaviour due to a change in the variance of the distribution.

The following data shows the change in means speed, 85th percentiles and the Standard Deviations.

5.2.1 Means

The mean speeds before the installation of the sign (Tables 3 and 4) are reasonably consistent with the exception of site 1 southbound (31/10/97 to 06/11/97). There appears to have been some obstruction up stream of the site for this period which reduced the speeds.

5.2.2 85th percentiles

The 85th percentile speeds are given in Tables 5 and 6.

Table 3 Mean speeds at Northern site (1)

Period			*Site 1*	
From	*To*		*Northbound*	*Southbound Sign*
31-Oct-97	06-Nov-97	Before	45.3	42.5
07-Nov-97	13-Nov-97	Before	45.6	45.6
14-Nov-97	20-Nov-97	Before	44.9	45.3
23-Jan-98	29-Jan-98	Before	46.2	44.8
03-Feb-98	09-Feb-98	After	43.6	41.1
12-Feb-98	18-Feb-98	After	43.6	41.9
19-Feb-98	25-Feb-98	After	43.8	42.4
05-Mar-98	11-Mar-98	After	44.1	42.6
12-Mar-98	18-Mar-98	After	44.3	43.1
19-Mar-98	25-Mar-98	After	44.2	43.0
26-Mar-98	01-Apr-98	After	44.6	43.1

Table 4 Mean speeds at Southern site (2)

Period			*Site 2*	
From	*To*		*Northbound Sign*	*Southbound*
31-Oct-97	06-Nov-97	Before	53.2	47.4
07-Nov-97	13-Nov-97	Before	53.5	47.2
14-Nov-97	20-Nov-97	Before	52.1	-
15-Jan-98	21-Jan-98	Before	49.2	47.3
05-Feb-98	11-Feb-98	After	45.3	45.6
12-Feb-98	18-Feb-98	After	45.5	45.6
19-Feb-98	25-Feb-98	After	45.7	45.9
05-Mar-98	11-Mar-98	After	45.9	46.0
12-Mar-98	18-Mar-98	After	46.1	46.5
19-Mar-98	25-Mar-98	After	45.9	46.2
26-Mar-98	01-Apr-98	After	46.5	46.4

Table 5 85th percentiles at Northern site (1)

Period			*Site 1*	
From	*To*		*Northbound*	*Southbound Sign*
31-Oct-97	06-Nov-97	Before	55.9	50.8
07-Nov-97	13-Nov-97	Before	55.9	54.3
14-Nov-97	20-Nov-97	Before	55.0	54.1
23-Jan-98	29-Jan-98	Before	56.4	53.5
03-Feb-98	09-Feb-98	After	52.1	47.2
12-Feb-98	18-Feb-98	After	52.0	48.0
19-Feb-98	25-Feb-98	After	52.3	48.5
05-Mar-98	11-Mar-98	After	52.5	48.6
12-Mar-98	18-Mar-98	After	53.0	49.4
19-Mar-98	25-Mar-98	After	53.0	49.2
26-Mar-98	01-Apr-98	After	53.4	49.2

Table 6 85th percentiles at Southern site (2)

Period			*Site 2*	
From	*To*		*Northbound Sign*	*Southbound*
31-Oct-97	06-Nov-97	Before	62.6	57.3
07-Nov-97	13-Nov-97	Before	63.0	56.9
14-Nov-97	20-Nov-97	Before	61.6	-
15-Jan-98	21-Jan-98	Before	57.6	56.8
05-Feb-98	11-Feb-98	After	52.0	53.2
12-Feb-98	18-Feb-98	After	52.1	53.4
19-Feb-98	25-Feb-98	After	52.5	53.7
05-Mar-98	11-Mar-98	After	52.5	53.7
12-Mar-98	18-Mar-98	After	53.0	54.6
19-Mar-98	25-Mar-98	After	53.2	54.3
26-Mar-98	01-Apr-98	After	53.5	54.5

5.2.3 Standard deviation

Table 7 Standard deviation of speed at Northern site (1)

Period			*Site 1*	
From	*To*		*Northbound*	*Southbound Sign*
31-Oct-97	06-Nov-97	Before	10.6	8.6
07-Nov-97	13-Nov-97	Before	10.6	9.0
14-Nov-97	20-Nov-97	Before	10.3	9.2
23-Jan-98	29-Jan-98	Before	10.4	8.7
03-Feb-98	09-Feb-98	After	8.9	6.8
12-Feb-98	18-Feb-98	After	9.0	7.0
19-Feb-98	25-Feb-98	After	9.1	7.0
05-Mar-98	11-Mar-98	After	8.8	7.1
12-Mar-98	18-Mar-98	After	9.2	7.4
19-Mar-98	25-Mar-98	After	9.2	7.3
26-Mar-98	01-Apr-98	After	9.4	7.3

Table 8 Standard deviation of speed at Southern site (2)

Period			*Site 2*	
From	*To*		*Northbound Sign*	*Southbound*
31-Oct-97	06-Nov-97	Before	9.6	10.0
07-Nov-97	13-Nov-97	Before	9.7	9.8
14-Nov-97	20-Nov-97	Before	9.8	-
15-Jan-98	21-Jan-98	Before	8.7	9.6
05-Feb-98	11-Feb-98	After	7.4	8.2
12-Feb-98	18-Feb-98	After	7.2	8.3
19-Feb-98	25-Feb-98	After	7.5	8.5
05-Mar-98	11-Mar-98	After	7.3	8.5
12-Mar-98	18-Mar-98	After	7.5	8.8
19-Mar-98	25-Mar-98	After	8.0	8.8
26-Mar-98	01-Apr-98	After	7.8	8.9

5.3 Percentage exceeding 50mph

Tables 9 and 10 show vehicles exceeding 50mph as a percentage of the total flow.

The four week period immediately before the signs were installed was compared with the four week period 5-8 weeks after to examine the longer term effectiveness of the signs in reducing the percentages of vehicles exceeding 50mph. Results are shown in Table 11.

Table 9 Percentage of vehicles exceeding 50mph Northern site (1)

Period			*Site 1*	
From	*To*		*Northbound*	*Southbound Sign*
31-Oct-97	06-Nov-97	Before	33.0	17.4
07-Nov-97	13-Nov-97	Before	33.9	29.2
14-Nov-97	20-Nov-97	Before	30.6	28.1
23-Jan-98	29-Jan-98	Before	36.7	26.8
03-Feb-98	09-Feb-98	After	21.8	7.7
12-Feb-98	18-Feb-98	After	12.4	9.5
19-Feb-98	25-Feb-98	After	22.3	10.5
05-Mar-98	11-Mar-98	After	23.4	11.4
12-Mar-98	18-Mar-98	After	24.5	13.3
19-Mar-98	25-Mar-98	After	24.6	12.7
26-Mar-98	01-Apr-98	After	26.2	13.2

Table 10 Percentage of vehicles exceeding 50mph Southern site (2)

Period			*Site 2*	
From	*To*		*Northbound Sign*	*Southbound*
31-Oct-97	06-Nov-97	Before	62.6	40.2
07-Nov-97	13-Nov-97	Before	64.1	39.2
14-Nov-97	20-Nov-97	Before	57.8	-
15-Jan-98	21-Jan-98	Before	45.1	39.8
05-Feb-98	11-Feb-98	After	21.3	29.0
12-Feb-98	18-Feb-98	After	21.6	29.1
19-Feb-98	25-Feb-98	After	22.4	30.8
05-Mar-98	11-Mar-98	After	23.1	31.9
12-Mar-98	18-Mar-98	After	24.3	34.2
19-Mar-98	25-Mar-98	After	24.7	33.1
26-Mar-98	01-Apr-98	After	26.4	33.7

Table 11 Percentages of vehicles exceeding 50mph (before and after signing compared)

Site	*Dir*	*Percentage of vehicles exceeding 50 mph no Sign*	*Percentage of vehicles exceeding 50 mph with Sign*	*Percentage reduction of vehicles previously exceeding 50 mph*
1	1	33.5	24.7	26.4
1	2	28.0	12.6	54.9
2	1	57.5	24.6	57.2
2	2	39.7	33.2	16.4

The weeks during which installation of the signs was carried out and the three week period immediately after were excluded as we wished to separate the short term effect from the longer term effect to determine whether reductions in speeders would be maintained.

The percentage reduction is expressed as a percentage of those vehicles previously exceeding 50mph. The percentage reductions were all very good. Regression analysis was carried out and all the results were found to be highly significant to 1% level. This indicates that percentages of vehicles over 50mph have been reduced in the longer term due to signing.

Table 12 shows the percentage change in the number of vehicles exceeding 50mph as a percentage of those vehicles normally exceeding 50mph. The percentage change for vehicles exceeding 45mph has also been included as these were also affected.

Table 12 The reduction in speed to below the target speed, as a percentage of those originally exceeding 45mph and 50mph

	% > 45mph	*% > 50mph*
Site1		
SBND (with sign)	44.7	71.4
NBND	20.4	40.7
Site2		
SBND	6.5	27.2
NBND (with sign)	29.1	52.7

5.4 Headway changes

Since the signs cause the drivers to reduce speeds it was possible that this would increase tailgating or close following, increasing the risk of rear end collisions. The results (Tables 13 and 14) show that this is not the case at this site and that there is a reduction in the number of vehicles following closely.

Table 13 0–1 second headway

Period			Site 1	
From	*To*		*Northbound*	*Southbound Sign*
31-Oct-97	06-Nov-97	Before	50	34
07-Nov-97	13-Nov-97	Before	48	49
14-Nov-97	20-Nov-97	Before	22	31
23-Jan-98	29-Jan-98	Before	9	14
03-Feb-98	09-Feb-98	After	6	2
12-Feb-98	18-Feb-98	After	9	4
19-Feb-98	25-Feb-98	After	9	6
05-Mar-98	11-Mar-98	After	5	1
12-Mar-98	18-Mar-98	After	10	9
19-Mar-98	25-Mar-98	After	3	5
26-Mar-98	01-Apr-98	After	7	5

Period			Site 2	
From	*To*		*Northbound Sign*	*Southbound*
31-Oct-97	06-Nov-97	Before	106	100
07-Nov-97	13-Nov-97	Before	115	96
14-Nov-97	20-Nov-97	Before	55	-
15-Jan-98	21-Jan-98	Before	10	28
05-Feb-98	11-Feb-98	After	6	15
12-Feb-98	18-Feb-98	After	3	22
19-Feb-98	25-Feb-98	After	2	33
05-Mar-98	11-Mar-98	After	3	13
12-Mar-98	18-Mar-98	After	11	35
19-Mar-98	25-Mar-98	After	7	36
26-Mar-98	01-Apr-98	After	9	32

Table 14 0–2 second headway

Period			Site 1	
From	*To*		*Northbound*	*Southbound Sign*
31-Oct-97	06-Nov-97	Before	358	230
07-Nov-97	13-Nov-97	Before	377	432
14-Nov-97	20-Nov-97	Before	319	371
23-Jan-98	29-Jan-98	Before	242	211
03-Feb-98	09-Feb-98	After	112	24
12-Feb-98	18-Feb-98	After	124	53
19-Feb-98	25-Feb-98	After	125	60
05-Mar-98	11-Mar-98	After	107	44
12-Mar-98	18-Mar-98	After	165	91
19-Mar-98	25-Mar-98	After	156	69
26-Mar-98	01-Apr-98	After	171	86

Period			Site 2	
From	*To*		*Northbound Sign*	*Southbound*
31-Oct-97	06-Nov-97	Before	897	867
07-Nov-97	13-Nov-97	Before	963	755
14-Nov-97	20-Nov-97	Before	763	-
15-Jan-98	21-Jan-98	Before	265	394
05-Feb-98	11-Feb-98	After	78	327
12-Feb-98	18-Feb-98	After	101	316
19-Feb-98	25-Feb-98	After	86	357
05-Mar-98	11-Mar-98	After	85	295
12-Mar-98	18-Mar-98	After	147	460
19-Mar-98	25-Mar-98	After	124	457
26-Mar-98	01-Apr-98	After	161	425

6 Discussion

6.1 Change in driver behaviour.

The change in driver behaviour can be clearly illustrated by looking at the distribution of speeds along the road in the examples below, ‘before’ (Figure 6, November 1997) and ‘after’ (Figure 7, February 1998) with the sign trigger threshold 46mph drawn over them. The figures show the speed of each vehicle travelling along the road, by time of day, for a period of one week.

The change in speeds and the shape of the speed distribution are shown in Figures 8 and 9 as directly influenced by the sign. The speeds have been adjusted to compensate for changes in flow.

Not only has the mean speed reduced but the distribution is narrower (a reduction in the standard deviation). An unexpected finding is that the changes are not just limited to the high end of the distribution but impact across the whole range of speed.

These effects are not however just limited to the direction in which the sign is facing. There is an effect on the opposite side of the road after vehicles have crossed the junction (Figures 10 and 11).

This result suggests that a fibre optic sign can influence speed over a distance of at least 300 metres and act over 500 metres.

6.2 Statistical analysis

Speed Distributions, Mean Speeds and Vehicles exceeding 50mph have changed after the installation of the vehicle activated sign.

6.2.1 Speed distributions

As can be seen in Figures 8, 9, 10 and 11 the numbers of vehicles in the higher speed bins have decreased and those in the lower speed bins have increased. A χ^2 test was performed to determine whether the speed distribution for all before data was significantly different from the speed distribution of all after data. The results for both sites in both directions were highly significant, beyond the 0.01% confidence level. The explanation of this difference was therefore investigated further.

6.2.2 Standard deviations

Tables 7 and 8 show the reductions in the standard deviations. Regression analysis was performed on this data to test the significance of these results. Results for Site 2 in both directions were significant at the 0.5% confidence level and for Site 1 highly significant in both directions at the 0.1% confidence level.

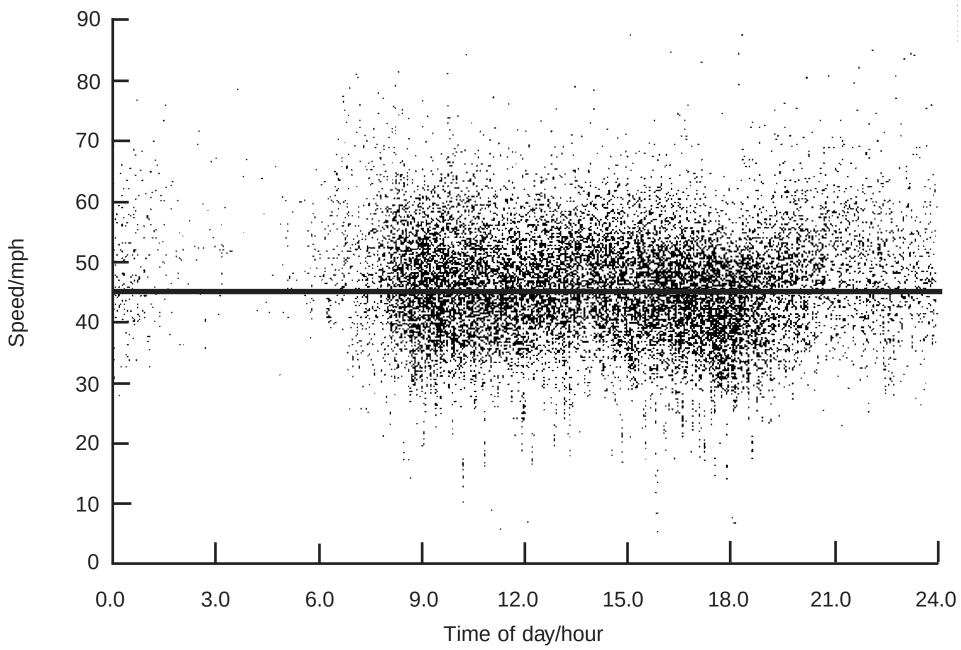

Figure 6 Site 1 southbound (period 7th to 13th November 1997). Before sign installed

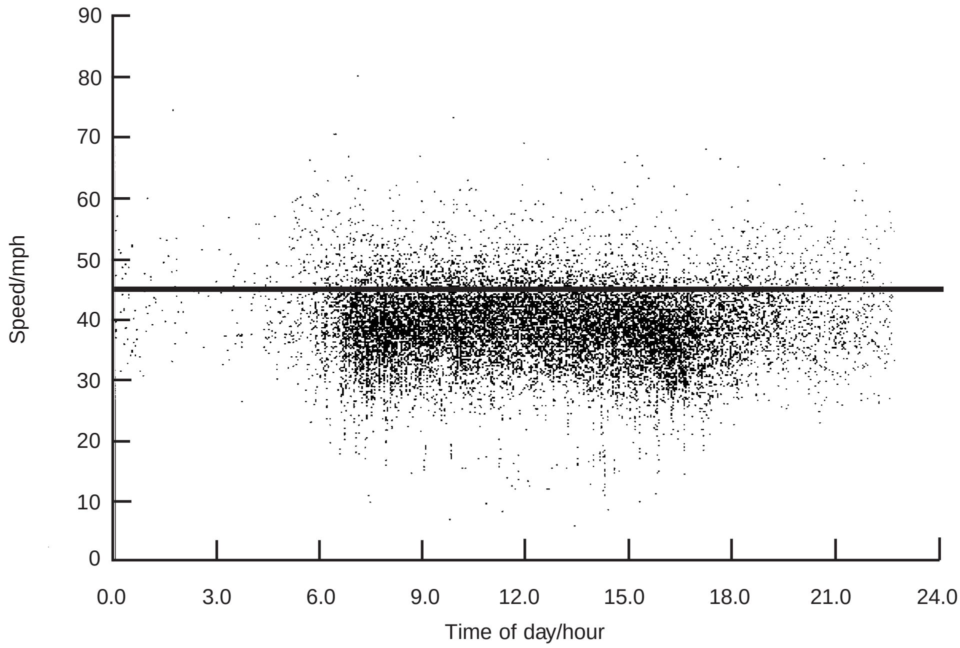

Figure 7 Site 1 southbound (period 3rd to 9th February 1998). After sign installed

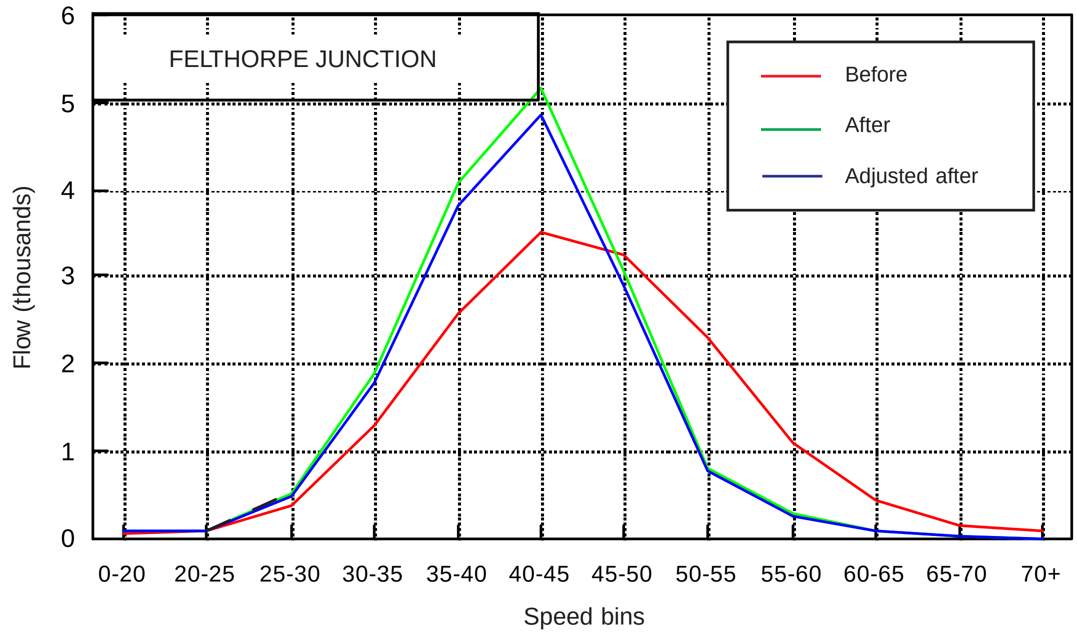

Figure 8 The change in speed distribution at Site 1 (influenced directly by the sign)

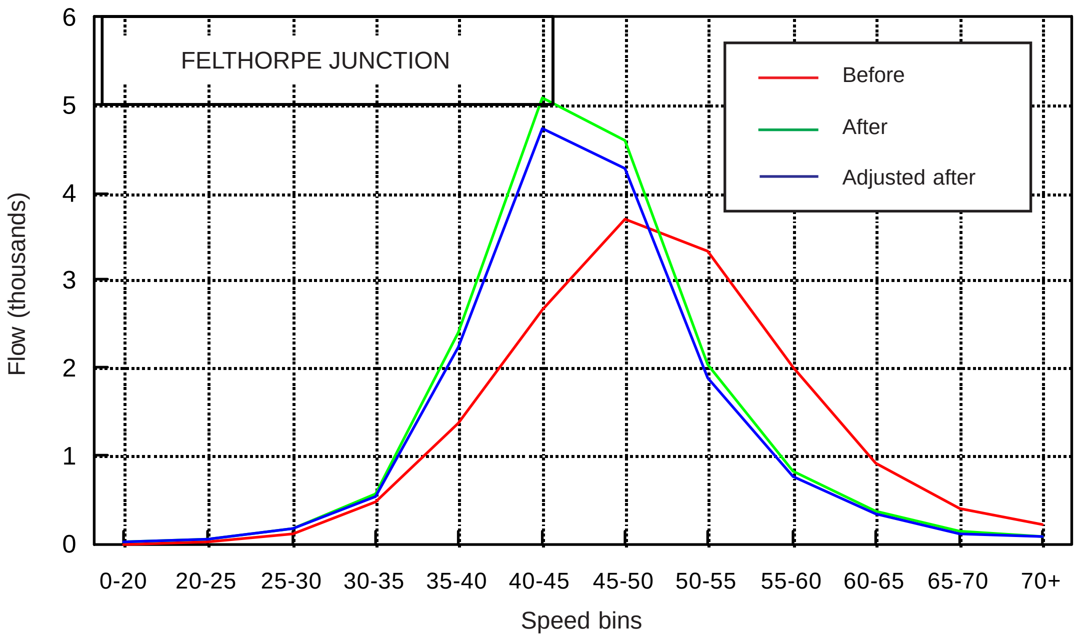

Figure 9 The change in speed distribution at Site 2 (influenced directly by the sign)

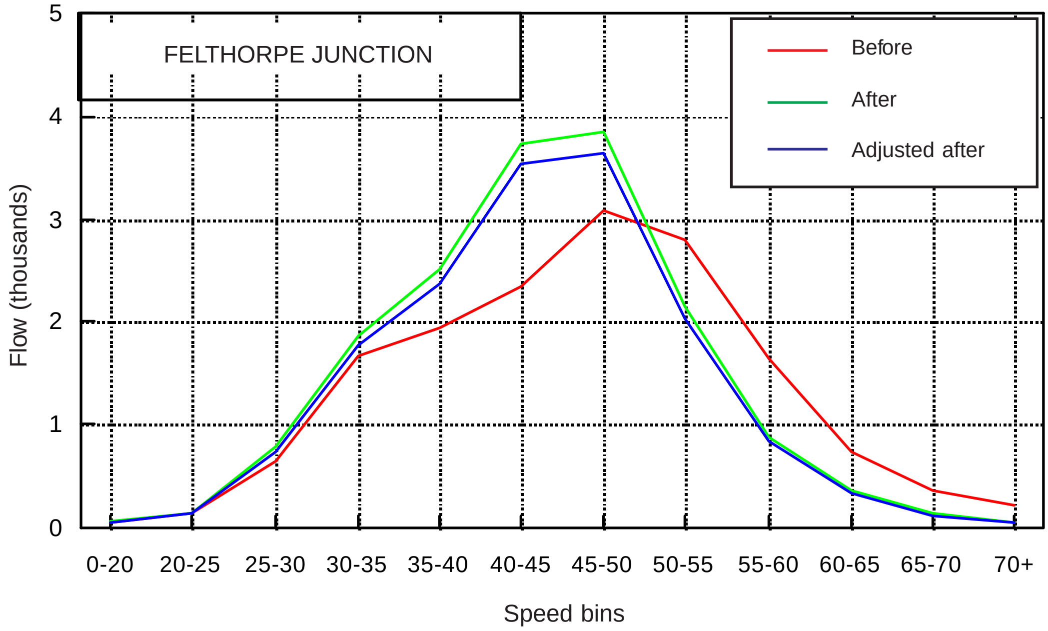

Figure 10 The change in speed distribution at Site 1 (northbound)

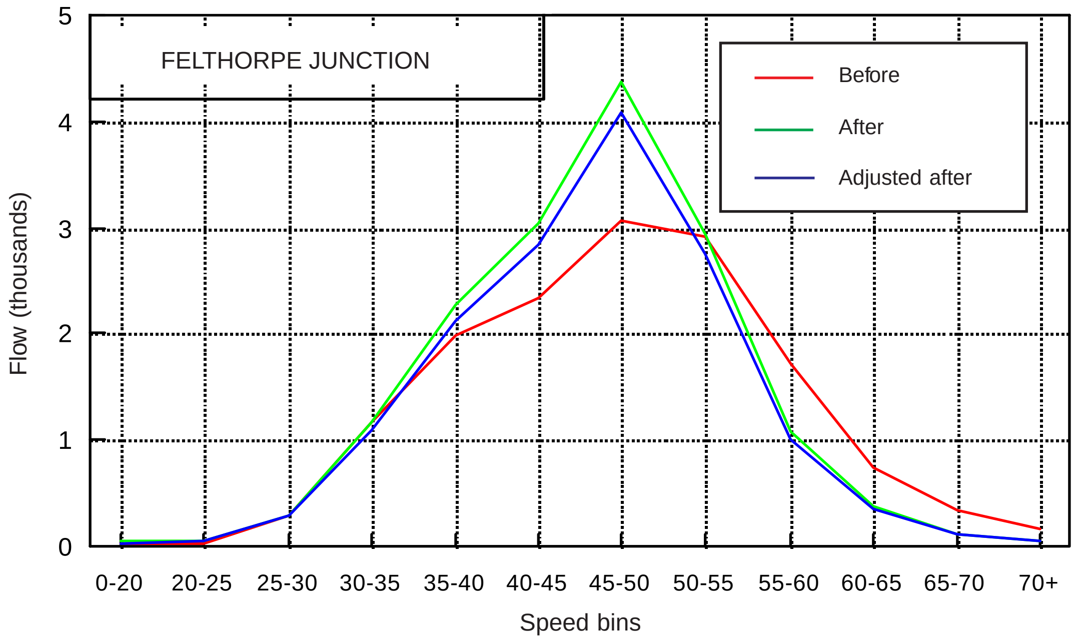

Figure 11 The change in speed distributin at Site 2 (southbound)

6.2.3 Percentages of vehicles exceeding 50mph

Tables 9, 10 and 11 show that percentages of vehicles exceeding 50mph appear to be reduced after the installation of the vehicle activated sign. Regression analysis performed on this data showed these results to be significant for both sites in both directions at the 0.5% confidence level.

6.2.4 Means

From Tables 3 and 4 it appears that a reduction in mean speed was achieved by the installation of the vehicle activated sign. As mean speeds vary from day to day it was necessary to collect daily means and ensure the same combination of weekdays to avoid bias when performing the regression analysis. Results obtained from the regression analysis show these reductions in mean speed to be highly significant at both sites and in both directions beyond the 0.01% confidence level. The change in the daily mean speeds is summarised in Table 15.

Table 15 Change in daily mean speeds

Site	*Mean before (mph)*	*Mean after (mph)*	*Reduction in mean speed (mph)*
1 Northbound	45.38	43.54	1.84
1 Southbound	44.33	41.42	2.91
2 Northbound	51.41	45.31	6.10
2 Southbound	47.00	45.58	1.42

After the installation of the vehicle activated sign:

- The standard deviation has been reduced.
- The number of vehicles exceeding 50mph has been reduced.
- The mean speed has been reduced.
- The change in the speed distribution illustrates these changes.

6.3 Accident benefits.

Since the location where the speed changes have been measured (Figure 4) are only 50m downstream from the sign and 100m from the junction, it is possible that speeds at the junction have been reduced even more, if the vehicles were decelerating as they passed over the inductive loops.

From the speed/accident modelling work of Baruya and Finch (PTRC 1994) the accidents on a road may be predicted from:

$$A_b = k\, V_b^{1.57}\, e^{4.43\, Cvb}$$

where:

A	is the number of accidents
k	is a constant for the road
V	is the Velocity
Cv	is the coefficient of variation (ie mean speed/standard deviation).
subscript 'b'	indicates the before condition and 'a' the after condition.

The change in accidents will be:

$$A_a / A_b = (V_a^{1.57} / V_b^{1.57})\, e^{4.43\,(Cva - Cvb)}$$

where:

A_b	is the number of before accidents
A_a	is the number of after accidents

Using this expression an estimate of accident benefit can be made (Table 16) from the changes in mean speed and standard deviation, before and after.

Table 16 The predicted percentage accident reduction at the measuring loops

Sites	*Percentage accident reduction*
Site 1	
SBND (with sign)	24.3
NBND	16.7
Site 2	
SBND	16.4
NBND (with sign)	27.0

7 Conclusions

The information that influences driver speed choice should be realistic but where a sign advising on a speed is not realistic for the perceived conditions, compliance may be poor. Signs that target hazards may increase compliance because they are perceived as reasonable.

It is clear that drivers can be influenced to reduce their speed when they are specifically targeted. Fixed signs do not have the same magnitude of effect.

Drivers' speeds can be reduced as a direct effect of a sign illuminating asking them to slow down, yet without any information about a suitable speed.

This effect highlights important differences between Speed Enforcement using Speed Cameras and Fibre Optic signs.

a The Speed Camera operates well above the posted speed threshold. At Felthorpe, the Association of Chief Police Officers (ACPO) guideline for enforcement of speed (Posted speed +10% +2mph) for this 60mph road, would suggest a minimum enforcement at 68mph and this therefore would have little influence on the traffic. The Fibre Optic can influence speed below the posted speed and reduce it further.

b Offenders are not always aware that they have triggered a speed camera and consequently their behaviour is not affected immediately. They remain a hazard to other road users. The Fibre Optic sign creates an immediate response and there is no additional cost involved (issuing penalties).

c Whereas Speed Cameras are operational for short periods, the Fibre Optic sign is in continuous operation.

The speed camera therefore enforces speed limits, whereas the Fibre Optic sign encourages drivers to adopt appropriate speeds for conditions.

There are safety benefits from the use of Fibre Optic signs, such as accident reductions due to speed change and a reduction in close following. The speed reductions at the high end of the distribution are consistent with the theoretical model as a predictor of improved safety.

Speed reductions at the junction are likely to be even higher than those measured at the loops since vehicles appear to be reducing speed, rather than travelling at a constant speed. This reasoning is based on observations of vehicles braking as they pass the sign.

The question remains why drivers respond to these warning signs. In order to discover why these signs are effective it is proposed that a driver survey is conducted. This additional study would enable the identification of those factors that have a permanent influence and those that are likely to be transient. For example, if the drivers consider the signs to be part of an enforcement strategy, and it is subsequently discovered through public knowledge (press and media) that they are not, speeds may increase as drivers habituate and the signs will become ineffective. If however, the signs act to remind drivers of potential accident risk (to which they reasonably respond) or change their behaviour because they are observed by other road users to be acting contrary to public safety, then the benefit may be sustained.

Such an understanding will provide valuable information in the development of new countermeasures that are effective and site specific. These measures will not be require costly human resources (such as operating speed cameras sites) and will have a small recurrent cost (the annual cost of maintaining the measure).

The First Year Rate of Return (FYRR) for sites with one ‘slight’ category accident will justify the installation of fibre optic signing (average injury accident cost in rural areas is taken as £80,770 per accident).

The potential application of this technology would be (at least) across the stock of rural single carriageway roads where 41% of all fatal accidents happen (1355 per annum) and 18% of all accidents occur (41,302) and where the available means of speed reduction are extremely limited.

The signs developed for this study required electrical power supplies and were not free standing devices. In order to reduce the cost of the installations it may be possible to develop solar rechargeable units, independent of mains supply, since the duty cycle (power is required for 4 seconds in a 5 minute period) is low.

Summary of benefits:

- Reduction in the number of high end speeders by as much as 70%.
- Speed reductions occur across the whole range of speeds.
- Reduction in the number of close following vehicles.
- Speed reductions below the posted speed.
- Speed reductions for vehicles on the exit from the junction.
- Speed reductions without enforcement.
- Predicted accident reductions of 20%.
- An immediate effect on driver behaviour.
- Sign in continuous operation.
- Low recurrent annual costs.

8 Acknowledgements

Thanks are due to the Norfolk County Council for their enthusiastic support and collaboration during the study, to Counters and Accessories Ltd. for their prompt response in setting up the monitoring sites and developing the data monitoring equipment, and to Forest City Signs for their co-operation in the manufacture and development of the Fibre Optic Signs.

Gratitude is also due to the TRL consultant statistician Dr Babul Baruya for his advice on the statistical analysis and to Mrs Elaine Woodgate (Traffic and Transport Project Support Unit, TRL) for her valuable contribution to the data analysis.

9 References

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Abstract

This report evaluates Fibre Optic technology applied to the problem of high speed vehicles approaching a rural cross road.

The site chosen at Felthorpe in Norfolk had a history of 31 recorded personal injury accidents in a ten year period. Engineering remedial measures had been carried out but with little affect upon the accident problem, principally collisions between vehicles emerging from the minor arm with high speed vehicles on the major arm.

The signs showing the standard crossroad symbol with the message ‘SLOW DOWN’, were switched on when vehicles approaching the junction exceeded 46mph. Although the drivers’ were not given an advisory speed, they did slow down, resulting in a safer approach speed to the junction. Additionally, time headways have increased (avoiding tailgating).

This method of controlling speed can reduce speeds below the posted speed for the highway.

Related publications

TRL364 *A traffic calming scheme at Costessey, Norfolk* by A Wheeler, G Harris, L Chinn, M Taylor and P Abbott. 1998 (price £35, code J)

TRL217 *Traffic congestion incident detection* by D J Bowers, R D Bretherton, G T Bowen, G T Wall. 1996 (price £25, code E)

CT58.2 Driver information systems update (1996-98). *Current Topics in Transport: selected abstracts from TRL Library's database* (price £20)

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