Vehicle-activated signs – a large scale evaluation

Prepared for Road Safety Division, Department for Transport

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CONTENTS

Executive Summary

There is a well established, positive relationship between vehicle speeds and road accidents. On rural roads, inappropriate speed for the conditions is more likely to be a factor in accidents than speed in excess of the limit. Assuming that speed limits are chosen correctly, there are safety benefits to be achieved by encouraging drivers to travel at or below the speed limit. Additionally, speed limits are by nature inflexible and there are situations that require drivers to travel below the speed limit, at speeds suitable for the conditions. Encouraging drivers to drive at sensible speeds for the conditions is particularly important, since driver error is the major contributory factor in 95 per cent of road accidents.

A range of rural road safety engineering measures has been developed to encourage drivers to adopt a safe speed on the approach to hazards such as bends and junctions. Ideal safety measures are likely to:

- Be of low cost with low maintenance requirements.
- Be self-enforcing with high compliance.
- Have no long-term diminution in effect, making them less effective.

Vehicle-activated signing corresponds closely to these requirements, and following early trials, a significant number have been installed in the United Kingdom since 1990. The signs display a simple message relating to road conditions (presence of bends, junctions or speed requirements) to specific drivers, i.e. those exceeding a particular threshold speed. Four types of sign have been studied:

- Speed limit roundel (just inside the speed limit terminal signs) - mainly village sites.
- Bend warning.
- Junction warning.
- Safety camera repeater sign (displaying camera logo).

The bend and junction warning signs were normally set up so that vehicles exceeding what was considered a safe speed to negotiate the hazard triggered them.

Following trials of individual sign installations with promising results, a full-scale study of the effectiveness of over 60 installations has been conducted by TRL for the Department for Transport (DfT), and is the subject of this report. The signs are mainly on rural single carriageway roads, and are situated in Norfolk, Kent, West Sussex and Wiltshire.

The main aims of the trial were to assess the effect of the signs on speed and injury accidents, and drivers' understanding of the signs. This information will be used to develop best practice for sign installation.

Monitoring of the signs involved:

- Before and After collection of speed data - the After data collected typically one month and at least one year after sign installation (also after three years at early installations).
- Obtaining accident data (for locations that had been in operation for more than one year) for sections of road appropriate to the type of sign or hazard.

Speed was used as an indicator of the expected changes in accident frequency, because of the long time taken for accident data to accumulate. In general, as the average speed of traffic reduces, there is a corresponding reduction in the number and severity of casualties. Also, the highest speeds contribute most towards the number and severity of casualties; therefore, the ability to identify and analyse the speed distribution in some detail is very important. Using automatic data loggers connected to loop or tube detectors, 1-3 months' data were collected Before and After installation where possible, with 7 days as a minimum requirement.

For Norfolk, where the majority of signs have so far been installed, accident data were also obtained for all urban and rural roads in the county, to compare numbers at the treated sites with the general accident trend in the county.

Results

Effect on speeds and accidents

At the speed limit roundel signs, mean speeds of the traffic as a whole were reduced by between 1mph and 14mph, the higher reductions being where the speed limit had also been reduced by 10mph. The average reduction in mean speed where there had been no change in the speed limit was 4mph (range 1mph to 7mph).

The junction and bend warning signs reduced mean speeds by up to 7mph, and the safety camera repeater signs yielded a reduction of up to 4mph. Speeds exceeding the limit were also reduced, with the reductions tending to be greater at the roundel signs.

There has been a statistically significant one-third reduction in accidents across all of the Norfolk sites combined when compared with the number of accidents that would have been expected without the signs. Safety camera repeater signs appear to give small additional accident reductions over safety cameras alone.

Public opinions

Nearly 450 drivers took part in opinion surveys at three locations in Norfolk and one in Wiltshire. Two locations had a speed limit roundel (20mph and 40mph) and two had a junction sign. Most of these drivers drove regularly past the relevant sign. Opinions were sought about the four sign types, some of which might be thought to be associated with enforcement, by showing photographs of each type of sign. (The roundel signs were pictured with and without a microwave detector head, which could be thought to be a speed enforcement camera.)

There was overwhelming approval of the signs. Most drivers had made the connection between their own speed and the signs being triggered; exceeding the speed limit was thought much more likely to trigger the roundel sign than the other signs. At the locations with the junction

warning sign, nearly all drivers thought that its main purpose was to slow them down or to warn of a hazard.

Over half of drivers believed they would receive a penalty for triggering the safety camera repeater sign.

These surveys suggest that the attitudes, understanding and behaviour of drivers in both Norfolk and Wiltshire are very similar and thus there is no clear regional bias.

Conclusions

- Clearly, drivers can be influenced to reduce speed when they are specifically targeted, with fixed signs alone likely to have less effect.
- Vehicle-activated signs appear to be very effective in reducing speeds; in particular, they are capable of reducing the number of drivers who exceed the speed limit and who contribute disproportionately to the accident risk, without the need for enforcement such as safety cameras.
- Vehicle-activated signs can be operated at thresholds well below normal police enforcement levels.
- There is no evidence that in time, drivers become less responsive to the signs, even over three years.
- Operating costs are also low.
- In this study, a substantial accident reduction has been demonstrated.

1 Introduction

There is a well established, positive relationship between vehicle speeds and road accidents (Taylor *et al*., 2000, 2002). On rural roads, inappropriate speed for the conditions is more likely to be a factor in accidents than speed in excess of the limit. Assuming that the speed limits posted on the highways are chosen correctly, then there are safety benefits to be achieved by encouraging drivers to travel at or below the speed limit. Additionally, speed limits are by nature inflexible and there are occasions and locations along the road network that require drivers to adopt speeds that are below the posted speed, that is, speeds suitable for the local conditions.

Encouraging drivers to make sensible speed choices with regard for local conditions is particularly important, since driver error is the major contributory factor in 95 per cent of road accidents. The DfT's review of speed policy, New Directions in Speed Management (2000), makes the following observations:

> *'It is clear that we need a consistent strategy for managing vehicle speeds on all rural roads.*
>
> *If we could assess the best speeds for these roads, there is still the question of how to bring vehicle speeds in line with it. There is evidence that drivers are confused about the national rural speed limit. The nature and appearance of the road is one of the strongest influences on how fast people drive, and therefore the speeds currently driven on rural roads. If a lower speed limit were imposed without any additional speed management measures, drivers' attitudes would have to change for there to be a general reduction to the new limit.'*

While there appears to be a very small hard core of drivers who refuse to conform both to law and common sense, research suggests that a majority of drivers may be encouraged to change their behaviour with advice that is appropriate, sensible and relevant to them in the prevailing conditions. Driver responsibility, given reasonable help, underlies much road safety policy.

An assessment undertaken on the level of accidents on rural single carriageway roads (Barker *et al*., 1998) suggests that vehicle speed is an important factor. A range of rural road safety engineering measures has been developed to encourage drivers to adopt a safe speed choice on the approach to hazards such as bends and junctions (for example Barker, 1997).

The ideal road safety measure would:

- Have an initial low cost, with small annual recurrent costs.
- Have low maintenance and high durability.
- Be self-enforcing with high compliance.
- Be without long term behavioural adaptation and consequent reduction in effectiveness.

Vehicle-activated signing corresponds closely to these requirements and during the last decade (1990s) the number of installations has been increasing in the United Kingdom. Vehicle-activated signing is a means of delivering a simple message relating to conditions on the highway (presence of bends, junctions or speed requirements) to specific drivers. The sign activates and displays a message when a driver exceeds a particular threshold (normally based on speed).

A number of evaluations of individual vehicle-activated sign installations have previously been undertaken, as described later in this report, with promising results, but a full-scale study of their effectiveness has now been carried out.

This report describes that study, which included 62 installations, mainly on rural single carriageway roads. The trial aimed to assess:

- The effect of the signs on drivers' speed.
- The effect of the signs on injury accidents.
- Drivers' understanding of the signs, and any regional differences.

This information will be used to develop best practice and a technical advice note for installing signs.

Section 2 of this report examines the history and development of vehicle-activated signs. Section 3 catalogues the sites examined in this study and the selection criteria and Section 4 the data sources used in the evaluation. Section 5 summarises the speed and accident changes associated with the vehicle-activated installations. Section 6 summarises the behavioural survey to assess driver attitudes to the signs.

2 Background

2.1 Early work on vehicle-activated signs

TRL carried out research in the late 1970s and early 1980s on automatic signs that gave drivers information that related either to close following or to excessive speed. The signs remained unlit until drivers exceeded a predetermined threshold relating to either the distance from the vehicle in front or the vehicle's speed.

The sign advising drivers to 'MOVE APART' (Plate 1) was constructed using a back-lit message and relied on an overhead infra-red detector to measure the separation of the close following vehicle from the vehicle in front.

Plate 1 Close following sign

The sign advising drivers to ‘SLOW DOWN’ (Plate 2) had a message formed by a number of pinpoints of light individually supplied through fibre-optic cables. The vehicle speed was measured from inductive loops buried in the carriageway. The original ‘SLOW DOWN PLEASE’ message was later amended to ‘SLOW DOWN 30’.

Plate 2 Speed reduction sign

The close following sign was trialled on the A332 at Ascot, Berkshire (Helliar-Symons, 1983) and the speed limit speed warning signs were trialled in Hampshire on the A32 (now B3349) at West Meon and Droxford, where conventional accident countermeasures had not been entirely successful (Helliar-Symons *et al*., 1984).

The speed reductions obtained using these signs were modest but the experiment was possibly more successful than appreciated at the time. It should also be noted that the speed samples were small (around 100 drivers per sample) and that the measurements were made with hand-held radar. The measured speeds at the signs tended to decrease with time after the signs were installed, suggesting that some regular users of the roads had learned to reduce their approach speed and avoid activating the sign. The analysis indicated a halving of accidents within the speed limits following sign installation, but this reduction was not statistically significant; the numbers of accidents associated with the sites were very small.

A few years later, a similar trial of speed warning signs was carried out in Warwickshire (Long Compton) using the legends ‘TOO FAST’ and ‘SLOW DOWN 30’. This time statistically significant reductions in speed occurred that were maintained consistently over 12 months.

The issue of trigger speeds and the corresponding proportion of the target population seemed to be of much concern at the time of this early research. There was a fear that habituation, whereby drivers become immune to the signs and thus cease to respond, would occur if too many activated the signs. This thinking was perhaps based on drivers merely processing and responding to the messages given by the signs rather than on exploring the wider cognitive processes that might be at work. The predominant effect of a vehicle-activated sign was perhaps regarded as really little different from static signing. At West Meon the speed thresholds were actually set at between the 75th and 81st percentile speeds which gave a very small target population. In Warwickshire the initial threshold was around the 20th to 30th percentile speed, thus targeting many more drivers. This produced far more encouraging results.

The results of this early work may be summarised:

For close following:

- The close following sign reduced by about 30% the number of drivers following the vehicle in front with a gap of less than one second.
- The effect was maintained 800m downstream.
- There was no appreciable degradation of the effectiveness of the close following sign over a five-year period.

For speed reduction:

- Measured speeds tended to decrease with time after the sign installation;
- In the village centres of West Meon and Droxford, small reductions in the speeds of the faster vehicles were achieved.

2.2 Further development of vehicle-activated signs

The latest generation of vehicle-activated signs display a message (symbols and words) delineated by either fibre-optic cables (illuminated by quartz halogen lamps) or light emitting diodes (LEDs) mounted on the front panel of the sign. Different parts of the message or symbols can be shown in different colours. The lamp is provided with an automatic dimmer to reduce the intensity during night-time operation. When not activated by a vehicle, the sign remains blank (i.e. blacked out).

The signs used recently have been of two types:

- Speed enforcing
- Warning (for example, of a hazard).

The speed enforcing signs display a speed limit roundel. Vehicles exceeding a pre-set threshold cause the sign to illuminate. The warning signs (used at bends and junctions for example), unlike the speed limit roundels, do not advise the driver to adopt a specific speed but rely upon their good judgement. This pre-supposes that drivers are capable of making an intelligent evaluation of a situation having been warned in advance.

TRL has conducted a number of trials on a range of vehicle-activated signs as follows:

- 30mph and 40mph roundel signs on village approaches in Norfolk (Farmer *et al.*, 1998).
- 20mph roundel sign (village centre).
- Rural bend warning sign (Plate 3).
- Rural junction warning sign (Plate 4).
- Safety camera repeater sign (displaying warning logo).

With the exception of the rural bend sign (Felbrigg, Norfolk) that was activated from a buried inductive loop, the other signs were activated by microwave detector

Plate 3 Felbrigg bend, Norfolk

heads (X-band 10.5Ghz) mounted on the top of the signs. These heads were aligned to detect vehicles at a distance of 100-150m in advance of the signs.

The signs were switched on for 4 seconds when a vehicle exceeding the threshold was detected. This exposure time was calculated to be sufficient for the driver to register and understand the message. As a rule, the distance between the sign and the position at which the vehicle is detected, can be calculated from the distance travelled in 3 seconds at the 85th percentile speed. The time of 3 seconds was chosen because it was found that almost all drivers (99.9%) should be able to read a sign consisting of N words in N/3 + 2 seconds (Moore *et al.*, 1963). This formula was derived from an experiment in which subjects had to identify a specific place name on a sign displaying a number of unrelated names. It was assumed that in the case of meaningful phrases such as speed warning messages, they would be read more quickly, hence the minimum exposure of 3 seconds to the message. The character height was 200mm on all signs (with a warning triangle height of 600mm and a total sign height of 1200mm).

The threshold speed, at which the vehicle-activated warning signs were switched on, was set at the 50th percentile speed detected at the sign location before the sign was installed. This was to avoid excessive exposure to the sign by targeting half of the drivers. The speed roundel signs did not necessarily have a threshold speed set at the actual speed limit, but rather it was based on road conditions.

Plate 4 Felthorpe junction, Norfolk showing the sign on and off

Vehicle-activated roundel signs have achieved reductions in the average speed of vehicles of up to 7.5mph, with the larger speed reductions occurring at locations where speeds were higher initially. Warning signs have also encouraged speed reductions approaching hazards. There is no indication that drivers are habituating to the signs such that their speed begins to increase again over time.

3 Site selection and sign details

3.1 Participating local authorities

Local authorities that had already installed vehicle-activated signs and those anticipating installing signs were invited to participate in the present, full-scale evaluation. In the event, the following took part:

- Norfolk
- Wiltshire
- West Sussex
- Kent

3.2 Site selection criteria

Sites in this study were selected on the basis of either:

- Having a recent history of accidents in which inappropriate speed was a contributory factor, or
- Where excessive speed for the conditions (i.e. approaching junctions or bends) was believed to be a potential problem.

While there are many locations that might be selected on the basis of these criteria, there are other considerations that may rule out the installation of vehicle-activated signs. For example, there are natural features of the highway, such as road geometry and poor sight lines that may reduce the effectiveness of the sign. Sites were rejected if there would have been insufficient time to display the message to drivers due to these constraints.

Before the decision to install vehicle-activated signs was made (taking into account the above considerations), the existing fixed signs and road markings were examined for standard, condition and wear. It is not recommended that vehicle-activated signs are deployed until it has been established that the current signs and markings fully comply with the standards of size, clear visibility distance and siting distance specified in Chapters 4 and 5 of The Traffic Signs Manual (Department of Transport, 1985, 1986).

3.3 Types of sign used

Temporary sign authorisation was applied for through the DfT for the signs used in this study. Every effort was made to produce signs that conform to the current signing standards and avoid non-standard messages. As a result, a limited number of signs have been developed and this evaluation is confined to just four types of sign:

- The speed roundel (Plates 5 and 6).
- Junction warnings (Plate 7).
- Bend warnings (Plate 8).
- Safety camera logo (Plate 9).

The signs used in this evaluation have been deliberately chosen to match the types of static sign in current use on the highway. These signs are both common and familiar to drivers. Signs with additional information such as a speed limit roundel with the words ‘SLOW DOWN’ were not considered suitable, since the roundel is by definition a sign giving an order to obey a maximum speed.

Vehicle-activated speed roundel signs are not repeater signs since they will only operate for drivers exceeding the speed limit. Consequently they do not display to all traffic. Their purpose is to reinforce the posted speed limit. Speed limit roundels were installed between 20 metres and 50 metres beyond the first sign indicating the change in the speed limit. For example, on a section with a 30mph limit, the vehicle-activated sign would be situated within this speed limit, 20-50 metres downstream from the speed limit terminal sign.

At one site there was a specific problem with speeding drivers approaching a two-lane to one-lane merge that is situated on a bend, close to a junction. The measure chosen to treat this problem was a 50mph speed limit roundel.

The junction signs were developed to tackle the problem of speeds that were unsuitable for the conditions. Many collisions at junctions are caused by driver error when entering a junction from the minor arm and failing to estimate the speed of approaching vehicles on the major arm. Approaching vehicles on the major arm of the junction (priority arm) may not have a clear view of the junction and may not be aware of emerging vehicles until it is too late to take appropriate action. The junction signs have been developed to counter this problem and tackle the inappropriate approach speeds of vehicles.

It is not always possible to reduce speed limits over a short distance where there is a hazard related to speed and this highlights the fact that speed limits are often inflexible. The junction warning signs are designed to deal with this particular problem. These signs have been located between 100 metres and 150 metres from the centre of the junction.

A major contributory factor reported by the police in bend accidents is excessive speed for the conditions. The bend signs were developed to deal with the problem of accidents involving loss of control due to excessive speed on the approach to bends. Many of these accidents are also associated with wet roads where tyre adhesion is reduced. This highlights the problem that drivers do not always take into account the prevailing conditions and adapt their behaviour accordingly. It is possible that since many of these accidents occur on minor roads, with a high proportion of local traffic, over-familiarity with the route and lack of concentration may be additional contributory factors. The signs give advance warning of the hazard, to reinforce the potential risk associated with the bend. These signs were located between 50 and 100 metres in advance of the apex of the bend.

Plate 5 30 roundel without flashers (Brisley, Norfolk)

Plate 7 Junction warning sign (Wootton Bassett, Wiltshire)

Plate 6 20 roundel with amber flashers (Horsford, Norfolk)

Plate 8 Bend warning sign (Sells Green, Wiltshire)

Plate 9 Safety camera logo (Poringland, Norfolk (detail inset)

The safety camera signs were developed to provide drivers with information that the route that they are on has had safety cameras installed to enforce the speed limit. Safety cameras do not provide drivers with the immediate feedback that they are offending and the signs were developed to provide this additional information to the driver. These signs were located between 50 and 150 metres inside the speed limit that was being enforced by safety cameras.

The signs in Kent and some in Norfolk were complemented by pairs of flashing amber lights that are triggered at the same time as the sign itself.

In the majority of cases, the trigger threshold for the speed roundels was set at the speed limit. Both the warning signs and the safety camera repeater signs were set to target 50 per cent of the driver population.

The signs cost around £5,000 plus the cost of supplying power.

3.4 Sites selected

Details of the locations, types of sign, and dates of installation are included in Appendix A. The locations in this study cover A-, B- and C-class roads with two-way flows ranging from 10,000 to 60,000 vehicles per week. Sites were selected on the basis of the criteria outlined in Section 3.2 above. All the signs were installed between 1995 and 2000.

Sites in Norfolk, at Fakenham, Horsford and Norwich, have had the speed limit reduced from 30mph to 20mph, reinforcing fixed 20mph roundels with 20mph vehicle-activated signs. In addition sites at Beetley, Blakeney, Horsford[1], South Lopham and Outwell in Norfolk, have had the speed limit reduced from 40mph to 30mph, reinforcing fixed 30mph roundels with 30mph vehicle-activated signs. No physical engineering measures were introduced at the sites to encourage compliance.

3.4.1 Norfolk

At the time of writing, Norfolk County Council has been using vehicle-activated signs for five years. Norfolk has provided most of the data for this study. Some of the 30 signing locations in Norfolk, for example in Horsford village, have multiple installations of vehicle-activated signs (30mph and 20mph speed roundels operating in both directions). The following type and number of signs were installed in Norfolk:

- 20 sections of road with 30mph speed limit[2]. Treated with 30mph speed roundels. (35 signs altogether).
- Three sections of road with 20mph speed limit[2]. Treated with 20mph speed roundels with flashing amber lights, operating in both directions.
- One rural junction (speed limit 60mph). Treated with junction warning signs operating in both directions on the major arm.
- One rural bend (speed limit 30mph). Treated with bend warning sign operating in one direction only.
- Three sections of road with safety cameras (one 60mph site and two 30mph[2] sites). Treated with single safety camera repeater signs.

3.4.2 Wiltshire

Wiltshire County Council provided three sites for the project:

- One urban junction (30mph speed limit). Treated with junction warning signs operating in both directions on the major arms (Plate 7).
- One rural junction (60mph speed limit). Treated with two junction warning signs operating in both directions on the major arms.
- One rural bend (60mph speed limit). Treated with bend warning sign (Plate 8) operating in one direction only.

3.4.3 West Sussex

West Sussex County Council provided four sites:

- One section of road with 40mph speed limit. Treated with 40mph speed roundel.
- One rural bend (50mph speed limit). Treated with a bend warning sign operating in one direction only.
- One dual carriageway with two lanes merging into one (50mph speed limit). Treated with 50mph speed roundel.
- One rural junction. Dual carriageway approaching junction (60mph speed limit). Treated with junction warning signs configured as a gateway.

3.4.4 Kent

Kent County Council provided five sites with five signs, all situated in villages:

- Four sections of road with 30mph speed limit. Treated with 30mph speed roundels (with flashing amber lights).
- Section of road with 40mph speed limit. Treated with 40mph speed roundel (with flashing amber lights).

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[1] Horsford has 20mph and 30mph vehicle-activated signs.

[2] The 20mph and 30mph speed limits are in built-up areas on rural roads.

4 Data collection

The methodology for evaluation of the signs has been refined over the years. Because accident data take a long time to accumulate, speed was used as an indicator of the expected changes in accident frequency. In general, as the average speed of traffic reduces, there is a corresponding reduction in the number and severity of casualties. However, the highest speeds contribute most towards the number and severity of casualties (Taylor *et al.*, 2000). For this reason, the ability to identify and analyse the speed distribution in some detail is very important.

The following were collected by the local authority or by TRL at each site:

- Speed data.
- Accident data (for locations that had been in operation for more than one year).

4.1 Speed data collection periods

Speed data were collected before the installation of the vehicle-activated signs in order to provide the baseline for estimating change, and again immediately after the installation. In Norfolk, the first After data collection was made about one month after the installation became operational. To establish whether any speed changes had been maintained at their original level, further data collections were made after one year, and for the earlier-installed sites an additional collection was made after three years.

A minimum of seven days' continuous data were collected at each site in both the Before and After data collection periods. At the sites monitored by TRL (due to the high memory capacity of the data loggers), between one and three month's Before data, and similar quantities of After data, were collected.

4.2 Sources of speed data

Most of the early (pre-1997) speed data were collected using pneumatic tubes (though at one site - Scole, Norfolk - handheld radar was used before and after sign installation). Tubes were laid close to, or just downstream from, the vehicle-activated signs depending on the suitability of the location (see Section 4.3). Data supplied directly by the participating Local Authorities was of this type. Speed data collected by this method are generally aggregated into 'bins' for hourly periods - for example, all vehicles travelling between 5mph and 15mph between 07:00h and 08:00h will be grouped together and presented as a single value e.g. 200 vehicles/hour. The traffic counters generally have 13 'bins' in which to store data and cover the speed range 0 to 100mph. This method gives a coarse distribution of vehicle speeds and consequently it is not possible to examine particular groups of vehicles in detail. In addition the descriptive statistics (i.e. the mean speed, standard deviation and 85th percentile) cannot be calculated accurately from the binned data.

Where the Local Authority employed TRL to collect the data, either tubes or inductive loops were used, with data loggers capable of collecting individual vehicle records, comprising vehicle speed (accurate to 0.1mph) and the time that the measurement was taken. This data gives a much clearer picture and enables a much more precise evaluation to be made of speeds at the upper end of the distribution.

4.3 Speed monitoring locations

Before and After monitoring was undertaken at the same position. The monitoring position at the speed roundel signs was generally within 100 metres downstream of the sign. At the Kent sites, the monitoring position was adjacent to the signs.

Felbrigg (Norfolk) was the first installation of a bend warning sign and was part of a detailed research study; consequently the site was heavily instrumented. Inductive loops were installed at the following positions:

- On the approach to the sign (70 metres upstream).
- At the entrance to the bend (40 metres downstream of the sign).
- At the apex of the bend (130 metres downstream of the sign).
- At the exit to the bend (50 metres from the apex).

It was not known at the time exactly what the speed profiles of the vehicles negotiating a bend would be and these data provided the information. It was subsequently determined that the most effective location to monitor speeds was on the approach, about 70 metres from the apex of the bend. This is the zone where the driver's speed change is critical for the safe negotiation of the bend (Driving Standards Agency, 1992). Speeds on the apex did not show much change because at that position drivers had adapted their speed to negotiate the bend. The approach speed is of much more importance because the approach is where drivers may be braking late or heavily to adapt their speed to the bend.

Felthorpe (Norfolk) was the first installation of a junction warning sign (installed either side of a crossroads) and was another in-depth research site. It was instrumented to measure junction approach speeds, the monitoring positions either side of the junction, 45-50 metres beyond the sign, 110-120 metres in advance of the junction. The speed reductions were larger than originally expected and consequently the monitoring loops were located further downstream of the sign closer to the junction, because the effect was still measurable. At the other schemes, therefore, loops were placed between 10 and 20 metres from the junction. The advantage of this is that the (very much slower) turning vehicles can be easily identified using the individual vehicle method of monitoring speeds.

The safety camera repeater signs were monitored much further downstream than any of the other signs (i.e. between 200 and 800 metres). This was because the purpose of the signs was to change drivers' speeds over a much greater distance.

Appendix B details the monitoring locations for the Norfolk sites.

4.4 Accident data

Because vehicle-activated signs have been operational in Norfolk for up to five years (at the time of writing), there was sufficient data to show the aggregate effect of the installations on injury accidents. All the Norfolk sites listed in Appendix A were the main source of data, providing the basis for assessing the effect, if any, of the signs on accidents. The period covered was 1990-2000.

For the speed limit reminder signs, all accident data were obtained for the length of road of about 1 km from the start of the speed limit to include the vehicle-activated sign and the two speed monitoring positions. This section would be without junctions, etc, which could generate accidents not influenced by the sign.

For the junction and bend vehicle-activated signs, data were obtained respectively within 50 metres either side of the centre of the junction and within 30 metres either side of the apex of the bend, where accidents tend to cluster.

For the safety camera repeater sign, data were obtained for the whole section of road where the safety camera would be operational (i.e. over about 3 km), since this sign was designed to have an effect over this distance.

In addition to the data obtained directly from Norfolk County Council, data from the STATS 19 national accident database were obtained for all urban and rural roads in Norfolk, in order to compare the treated sites with the general accident trend in the county.

After accident data for one year were obtained for the Wiltshire sites.

5 Results

5.1 Speed changes

Since this study involves an intervention (the vehicle-activated sign), the changes in vehicle speeds above the intervention threshold (trigger speed) are of greatest interest. Vehicles that do not trigger the vehicle-activated sign tend to dominate the speed distribution, because the majority of the vehicles do not switch the sign on and are consequently not affected by it. Therefore the change in average speed is often small. In the results tables below, showing the effects of the sign, the percentage change in the number of drivers exceeding the trigger speed has proved an effective indicator of their benefit.

Speed tabulations are used to show the effects of the different types of sign, as follows:

- The speed roundels (50mph, 40mph, 30mph and 20mph).
- Warning signs.
- Junctions.
- Bends.
- Safety camera repeater signs.

The tabulations show the changes in mean speed and the changes in the percentage of vehicles exceeding the speed limit (except at the bend and junction warning signs in Norfolk) and the sign trigger speed. The Before and After results are for at least one complete week at the site. All changes in mean speed are statistically significant at the 5% level at least. More detailed results are given in Appendix C.

Care should be taken in making comparisons between the speed reductions at different installations, since the speed monitoring locations are not in the same position relative to the sign at each site (see Section 4.3).

5.1.1 Speed roundels

5.1.1.1 30mph sites

Table 1 gives the results for the sites with 30mph roundel signs. The percentages of vehicles exceeding the speed limit (30mph) and the sign trigger speed (35mph) are

Table 1 Speed changes at 30mph sites with 30mph roundels

		Mean speed (mph)		***Change in mean speed (mph)***	*% >30mph*		***Change in % > 30mph****	*% >35mph*		***Change in % > 35mph****
County	*Site*	*Before*	*After*		*Before*	*After*		*Before*	*After*	
Norfolk	B1140 Acle	34.7	27.6	**-7.1**	68	36	**-32**	55	7	**-48**
Kent	A274 Sutton Valence	38.9	32.1	**-6.8**	92	69	**-22**	69	21	**-48**
Kent	B2163 Coxheath	37.3	30.6	**-6.7**	88	56	**-32**	58	15	**-43**
Kent	B2017 Five Oak Green	36.5	30.2	**-6.3**	87	52	**-34**	52	9	**-43**
Kent	A257 Littlebourne	36.5	30.7	**-5.8**	83	57	**-26**	51	14	**-37**
Norfolk	A140 Scole	38.3	32.6	**-5.7**	95	73	**-22**	67	16	**-51**
Norfolk	B1145 Litcham	38.2	33.2	**-5.0**	91	61	**-30**	68	29	**-39**
Norfolk	C162 Costessey	35.3	30.7	**-4.6**	86	60	**-26**	55	15	**-40**
Norfolk	C46 Marham	32.4	28.5	**-3.9**	65	36	**-29**	33	6	**-27**
Norfolk	B1150 Horstead	33.5	29.8	**-3.7**	75	45	**-30**	38	9	**-29**
Norfolk	C480 Hellesdon	33.2	29.7	**-3.5**	79	49	**-30**	36	10	**-26**
Norfolk	B1110 North Elmham	33.5	30.4	**-3.1**	79	56	**-23**	40	11	**-29**
Norfolk	A1122 Outwell	31.8	28.8	**-3.0**	62	44	**-18**	32	10	**-22**
Norfolk	A1151 Wroxham	31.4	28.5	**-2.9**	63	37	**-26**	20	5	**-15**
Norfolk	B1134 Pulham Market	31.1	28.4	**-2.7**	70	42	**-28**	27	4	**-23**
Norfolk	B1145 Billingford	32.5	29.8	**-2.7**	65	43	**-22**	32	13	**-19**
Norfolk	A143 Wells	31.4	28.8	**-2.6**	63	40	**-23**	31	9	**-22**

Changes sorted in decending order of magnitude
** Absolute change (change in percentage points)*

shown, and the results are sorted by the size of the mean speed reduction in descending order.

All the 30mph roundel signs yielded a reduction in the mean speed of between 2.6 and 7.1mph. In general, the signs had the greatest benefit at the sites with higher average Before speeds. However, even at sites where the Before mean speeds were within 2mph of the limit, speed reductions occurred, and in nine cases, the average speed dropped below the posted speed.

The proportion of vehicles exceeding 30mph reduced in every case, the changes ranging between 18 and 34 percentage points. The proportion exceeding 35mph was reduced by between 15 and 51 percentage points. Those sites with the highest percentage of vehicles exceeding the speed limit before sign installation tend to show the greatest benefit.

It is suggested that the largest speed reductions would occur close to the signs, with speed slowly increasing again downstream from the sign. A possible explanation as to why the Kent sites appear to show large changes in mean speed and percentages of vehicles exceeding the speed limit is because the monitoring locations were adjacent to the signs, where the greatest benefits are to be expected.

5.1.1.2 40 mph sites

Table 2 gives the results for the sites with 40mph roundel signs. The percentages of vehicles exceeding the speed limit (40mph) and 5mph above the speed limit are shown, and the results are sorted by the size of the mean speed reduction in descending order.

All the 40mph roundel signs yielded a reduction in the mean speed of between 1.2 and 4.4mph. In general, the signs had the greatest benefit at the sites with higher average Before speeds.

The proportion of vehicles exceeding 40mph reduced in every case, the changes ranging between 7 and 35 percentage points. The proportion exceeding 45mph was reduced by between 1 and 17 percentage points. Those sites with the highest percentage of vehicles exceeding the speed limit before sign installation tend to show the greatest benefit.

5.1.1.3 50 mph site

Table 3 gives the results for the dual carriageway site with the 50mph roundel sign; the percentages of vehicles exceeding the speed limit (50mph) and 5mph above the speed limit are shown.

The mean speed fell by 4.6mph in lane 1 and 3.6mph in lane 2. The proportion of vehicles exceeding 50mph reduced in both lanes, by 26 percentage points in lane 1 and by 22 percentage points in lane 2. The proportion of vehicles exceeding 55mph fell by 31 percentage points in lane 1 and by 10 percentage points in lane 2.

5.1.1.4 Speed limit change from 30mph to 20mph

Table 4 gives the results for sites with 20mph roundel signs where the speed limit had been reduced from 30mph. The results suggested that drivers had difficulty in achieving and maintaining 20mph, therefore the percentages of vehicles exceeding 25mph and 30mph were calculated. The results are sorted by the size of the mean speed reduction in descending order.

All the 20mph roundel signs yielded a reduction in the mean speed of between 4.4 and 7.5mph. In general, the signs had the greatest benefit at the sites with higher average Before speeds.

The proportion of vehicles exceeding 25mph reduced in every case, the changes ranging between 28 and 51

Table 2 Speed changes at 40mph sites with 40mph roundels

		Mean speed (mph)		***Change in mean speed (mph)***	*% >40mph*		***Change in % > 40mph****	*% >45mph*		***Change in % > 45mph****
County	*Site*	*Before*	*After*		*Before*	*After*		*Before*	*After*	
Kent	A28 Hersden	40.7	36.3	**-4.4**	50	15	**-35**	15	3	**-12**
Norfolk	A1085 Swaffham	39.7	35.7	**-4.0**	44	18	**-26**	17	5	**-12**
Norfolk	B1108 Carbrooke	40.7	36.8	**-3.9**	51	20	**-31**	23	6	**-17**
Norfolk	B1145 Mileham	37.4	35.4	**-2.0**	36	24	**-12**	15	7	**-8**
W Sussex	A24 Kingsfold	32.5	31.3	**-1.2**	12	5	**-7**	2	1	**-1**

Changes sorted in decending order of magnitude
** Absolute change (change in percentage points)*

Table 3 Speed changes at 50mph sites with 50mph roundels

			Mean speed (mph)		***Change in mean speed (mph)***	*% >50mph*		***Change in % > 50mph****	*% >55mph*		***Change in % > 55mph****
County	*Site*	*Lane*	*Before*	*After*		*Before*	*After*		*Before*	*After*	
W Sussex	A24 Findon by-pass	1	55.2	50.6	**-4.6**	80	54	**-26**	50	20	**-31**
		2	48.8	45.2	**-3.6**	38	16	**-22**	15	4	**-10**

Changes sorted in decending order of magnitude
** Absolute change (change in percentage points)*

Table 4 Sites where the speed limit was reduced from 30mph to 20mph

County	Site	Lane	Mean speed (mph) Before	Mean speed (mph) After	Change in mean speed (mph)	% >25mph Before	% >25mph After	Change in % > 25mph*	% >30mph Before	% >30mph After	Change in % > 30mph*
Norfolk	B1146 Fakenham	Eastbound	32.5	25.0	**-7.5**	93	42	**-51**	70	12	**-58**
Norfolk	B1149 Horsford	Southbound	32.9	25.6	**-7.3**	92	53	**-39**	73	17	**-56**
Norfolk	B1149 Horsford	Northbound	32.0	25.5	**-6.5**	89	53	**-36**	67	18	**-49**
Norfolk	B1150 Norwich	Southbound	30.7	24.6	**-6.1**	87	47	**-40**	66	16	**-50**
Norfolk	B1146 Fakenham	Westbound	28.5	23.4	**-5.1**	Radar data	28		Radar data	5	
Norfolk	B1150 Norwich	Northbound	29.7	25.3	**-4.4**	82	54	**-28**	55	17	**-38**

Changes sorted in decending order of magnitude
** Absolute change (change in percentage points)*

percentage points. The proportion exceeding 30mph was reduced by between 38 and 56 percentage points. Those sites with the highest percentage of vehicles exceeding the speed limit before sign installation tend to show the greatest benefit.

5.1.1.5 Speed limit change from 40mph to 30mph

Table 5 gives the results for sites with 30mph roundel signs where the speed limit had been reduced from 40mph. The results are sorted by the size of the mean speed reduction in descending order.

All the 30mph roundel signs yielded a reduction in the mean speed of between 6.5 and 13.8mph. In general, the signs had the greatest benefit at the sites with higher average Before speeds.

The proportion of vehicles exceeding 30mph reduced in every case, the changes ranging between 13 and 60 percentage points. The proportion exceeding 35mph was reduced by between 50 and 80 percentage points. Those sites with the highest percentage of vehicles exceeding the speed limit before sign installation tend to show the greatest benefit.

5.1.2 Warning signs

5.1.2.1 Junctions

Table 6 gives the results for sites with junction warning signs. The results are sorted by the size of the mean speed reduction in descending order.

Other than at Bradford Leigh, Wiltshire (eastbound), mean speeds fell at all the vehicle-activated junction warning signs, the reductions ranging between 0.8 and 9.2mph.

The threshold speeds in the right-hand columns of Table 6 are below the speed limit except for the West Sussex site. (Here, as Before mean speeds already exceeded 60mph, threshold speeds within the upper region of the speed distribution were chosen.) The proportion of vehicles exceeding these threshold speeds reduced at all sites.

The Wootton Bassett results also show that drivers not only reduce their speed after they have passed the sign but that they anticipate the sign and reduce their speed a little on the approach towards it.

5.1.2.2 Bends

Table 7 gives the results for sites with bend warning signs. The results are sorted by the size of the mean speed reduction in descending order.

Mean speeds fell at all the vehicle-activated bend warning signs, the reductions ranging between 2.1 and 6.9mph.

The threshold speeds in the right-hand columns of Table 7 are below the speed limit at Sells Green (Wiltshire) but at and 5mph above the speed limit at Kingsfold (West Sussex). The proportion of vehicles exceeding these threshold speeds was reduced at the sites, though data were not available for Felbrigg.

5.1.2.3 Safety camera repeaters

Table 8 gives the results for sites with safety camera repeater signs. Mean speeds fell at all the vehicle-activated safety camera repeater signs, the reductions ranging between 0.5 and 3.7mph. The percentage of vehicles exceeding various threshold speeds at around the speed limit on the section covered by the safety camera also reduced.

Table 5 Sites where the speed limit was reduced from 40mph to 30mph

County	Site	Lane	Mean speed (mph) Before	Mean speed (mph) After	Change in mean speed (mph)	% >30mph Before	% >30mph After	Change in % > 30mph*	% >35mph Before	% >35mph After	Change in % > 35mph*
Norfolk	B1146 Beetley	Southbound	45.1	31.3	**-13.8**	98	65	**-33**	94	14	**-80**
Norfolk	A1066 South Lopham	Westbound	40.7	30.7	**-10.0**	95	47	**-48**	85	17	**-68**
Norfolk	B1146 Beetley	Northbound	37.8	28.0	**-9.8**	91	31	**-60**	71	5	**-66**
Norfolk	A1066 South Lopham	Eastbound	40.5	32.5	**-8.0**	94	64	**-30**	83	23	**-60**
Norfolk	B1149 Horsford	Southbound	37.8	30.5	**-7.3**	93	48	**-45**	76	6	**-70**
Norfolk	A1122 Outwell	Southbound	41.2	34.1	**-7.1**	97	84	**-13**	88	38	**-50**
Norfolk	A149 Blakeney	Eastbound	34.8	28.3	**-6.5**	90	35	**-55**	56	6	**-50**

Changes sorted in decending order of magnitude
** Absolute change (change in percentage points)*

Table 6 Sites where junction warning signs were installed

Site	Direction	Speed limit (mph)	Mean speed (mph) Before	Mean speed (mph) After	**Change in mean speed**	% >50mph Before	% >50mph After	**Change in % > 50 mph***
Norfolk								
Felthorpe	Southbound	60	45.6	42.2	**-3.4**	29	12	**-17**
Felthorpe	Northbound	60	53.2	45.8	**-7.4**	63	25	**-38**

Site	Direction	Speed limit (mph)	Mean speed (mph) Before	Mean speed (mph) After	**Change in mean speed**	% >70mph Before	% >70mph After	**Change in % > 70 mph***	% >75mph Before	% >75mph After	**Change in % > 75 mph***
W Sussex											
A24/B2135 Lane 1	Southbound	70	60.2	55.0	**-5.2**	17	6	**-11**	8	2	**-5**
A24/B2135 Lane 2	Southbound	70	67.2	60.0	**-7.2**	37	12	**-26**	18	4	**-13**

Site	Direction	Speed limit (mph)	Mean speed (mph) Before	Mean speed (mph) After	**Change in mean speed**	% >40mph Before	% >40mph After	**Change in % > 40 mph***	% >45mph Before	% >45mph After	**Change in % > 45 mph***
Wiltshire											
Bradford Leigh	Westbound	60	28.3	27.5	**-0.8**	20	11	**-9**	8	3	**-5**
Bradford Leigh	Eastbound	60	33.0	34.2	**1.2**	27	26	**-1**	9	8	**-1**

Site	Direction	Speed limit (mph)	Mean speed (mph) Before	Mean speed (mph) After	**Change in mean speed**	% >30mph Before	% >30mph After	**Change in % > 30 mph***	% >35mph Before	% >35mph After	**Change in % > 30 mph***
Wiltshire											
Near junction											
Wootton Bassett	Northbound	30	24.9	23.5	**-1.4**	33	23	**-10**	10	4	**-6**
Wootton Bassett	Southbound	30	29.1	26.9	**-2.2**	52	43	**-9**	31	14	**-17**
Approaching sign											
Wootton Bassett	Northbound	30	36.9	27.7	**-9.2**	87	46	**-41**	62	21	**-41**
Wootton Bassett	Southbound	30	31.4	28.0	**-3.4**	67	26	**-41**	25	6	**-19**

** Absolute change (change in percentage points - some rounding errors present)*

Table 7 Sites where bend warning signs were installed

County	Site	Speed limit (mph)	Mean speed (mph) Before	Mean speed (mph) After	**Change in mean speed (mph)**
Norfolk	Felbrigg	30	36.7	29.8	**-6.9**

County	Site	Speed limit (mph)	Mean speed (mph) Before	Mean speed (mph) After	**Change in mean speed (mph)**	% >40mph Before	% >40mph After	**Change in % > 40mph***	% >45mph Before	% >45mph After	**Change in % > 45mph***
Wiltshire	Sells Green	60	38.3	35.3	**-3.0**	36	15	**-20**	13	3	**-10**

County	Site	Speed limit (mph)	Mean speed (mph) Before	Mean speed (mph) After	**Change in mean speed (mph)**	% >50mph Before	% >50mph After	**Change in % > 50mph***	% >55mph Before	% >55mph After	**Change in % > 55mph***
W Sussex	Kingsfold	50	40.9	38.8	**-2.1**	4	2	**-2**	1	0	**-1**

** Absolute change (change in percentage points)*

Table 8 Speed camera repeater signs

County	Site	Speed limit (mph)	Mean speed (mph) Before	Mean speed (mph) After	Change in mean speed (mph)		% > 30mph	% > 35mph	% > 40mph	% > 45mph	% > 60mph	% > 65mph	% > 75mph
Norfolk	Loddon A146	60	49.3	48.7	**-0.6**	Before	n/a	n/a	n/a	n/a	6	3	1
						After	n/a	n/a	n/a	n/a	4	1.5	0.5
						Change in %*					**-2**	**-1.5**	**-0.5**
Norfolk	Poringland B1332	40	35.0	34.5	**-0.5**	Before	87	58	15	3	n/a	n/a	n/a
						After	85	55	13	2	n/a	n/a	n/a
						Change in %*	**-2**	**-3**	**-2**	**-1**			
		40/30	34.5	30.8	**-3.7**	Before	85	55	13	2	n/a	n/a	n/a
						After	59	16	4	1	n/a	n/a	n/a
						Change in %*	**-26**	**-39**	**-9**	**-1**			
Norfolk	Shipdham A1075	30	32.7	31.4	**-1.3**	Before	74	29	8	2	n/a	n/a	n/a
						After	64	18	4	1	n/a	n/a	n/a
						Change in %*	**-10**	**-11**	**-4**	**-1**			

***** *Absolute change (change in percentage points); n/a: not applicable*

5.2 Accident changes

The following sections present the effect of the installation of the vehicle-activated signs on reported injury accidents. Section 5.2.4 summarises a statistical analysis of some of the accident data, which takes account of general accident trends.

5.2.1 Speed roundel signs

Table 9 shows the results for sites with speed roundel signs.

There has been a reduction in accidents at all the speed roundel sites except Costessey and Watton, where the Before accident frequency was relatively low (<1 per year). The reductions range from 16% to 100%, with a 58% reduction across the sites combined. The proportion of accidents involving fatal or serious injury was unchanged.

5.2.2 Warning signs

Table 10 shows the results for sites with junction warning signs.

There has been a reduction in accidents at all the junction warning signs except at Bradford Leigh (Wiltshire) where there has been no change. Otherwise the reductions range from 45% to 100%, with a 26% reduction across the sites combined. The proportion of accidents involving fatal or serious injury was little changed.

Table 9 Accident numbers changes at sites with speed roundel signs

		Before installation				After fibre optic sign installation				
County	Site	PIA	KSI	Years	PIA per year	PIA	KSI	Years	PIA per year	**% change**
Norfolk	B1140 Acle	2	1	5.0	0.4	1	0	5.5	0.2	**-55%**
Norfolk	B1146 Beetley	7	1	5.0	1.4	2	0	1.7	1.2	**-16%**
Norfolk	B1145 Route	32	9	5.0	6.4	5	1	1.5	3.3	**-48%**
Norfolk	A149 Blakeney	10	5	5.0	2.0	2	1	1.7	1.2	**-41%**
Norfolk	C162 Costessey	3	1	5.0	0.6	3	0	3.6	0.8	**39%**
Norfolk	B1146 Fakenham	17	3	5.0	3.4	0	0	0.5	0.0	**-100%**
Norfolk	C480 Hellesdon	13	2	5.0	2.6	1	0	1.1	0.9	**-65%**
Norfolk	B1108 Hingham	11	2	5.0	2.2	3	0	2.7	1.1	**-49%**
Norfolk	B1149 Horsford	21	2	5.0	4.2	2	0	1.7	1.2	**-72%**
Norfolk	B1150 Horstead	7	2	5.0	1.4	5	3	5.5	0.9	**-35%**
Norfolk	C46 Marham	9	1	5.0	1.8	3	1	3.6	0.8	**-54%**
Norfolk	Norwich	24	6	5.0	4.8	1	0	1.0	1.0	**-79%**
Norfolk	A1122 Outwell	15	7	5.0	3.0	3	2	1.7	1.8	**-41%**
Norfolk	B1134 Pulham Market	5	1	5.0	1.0	1	0	1.7	0.6	**-41%**
Norfolk	A1066 South Lopham	9	5	5.0	1.8	3	0	3.6	0.8	**-54%**
Norfolk	A1085 Swaffham	7	0	5.0	1.4	6	2	5.5	1.1	**-22%**
Norfolk	B1108 Hingham	4	2	5.0	0.8	6	2	5.5	1.1	**36%**
Norfolk	A143 Wells	2	0	5.0	0.4	1	0	5.5	0.2	**-55%**
Norfolk	A1151 Wroxham	10	2	5.0	2.0	6	1	5.5	1.1	**-45%**
	All	208	52	95	2.2	54	13	59.1	0.9	**-58%**

PIA: Personal injury accident
KSI: Accidents involving fatal or serious injury
B1145 Route includes villages [Billingford, Brisley, Litcham, Mileham, North Elmham]

Table 10 Accident numbers changes at sites with junction and bend warning signs

		Before installation				After fibre optic sign installation				
County	Site	PIA	KSI	Years	PIA per year	PIA	KSI	Years	PIA per year	**% change**
Norfolk	Felbrigg (Jn)	16	7	5.0	3.2	3*	2	4	0.75	**-77%**
Norfolk	Felthorpe (Bend)	16	5	5.0	3.2	4	2	2.7	1.5	**-54%**
	All	32	12	10	3.2	7	4	6.7	1.0	**-67%**
Wiltshire	Sells Green (Bend)	2	0	3	0.7	0	0	1	0	**-100%**
Wiltshire	Wootton Bassett (Jn)	11	1	3	3.7	2	0	1	2.0	**-45%**
Wiltshire	Bradford Leigh (Jn)	10	2	2.5	4.0	4	1	1	4.0	**0%**
	All	23	3	8.5	2.7	6	1	3	2.0	**-26%**

PIA: Personal injury accident
KSI: Accidents involving fatal or serious injury
**Felbrigg After period: includes two serious accidents recorded whilst sign removed for repair 1998*

5.2.3 Safety camera repeater signs

Table 11 shows the results for sites with safety camera signs.

There has been a reduction in accidents at all these sites, the reductions ranging from 8% to 31%, with a 17% reduction across the sites combined. This adds to any accident reduction attributable to the installation of the safety camera on the section of road. The proportion of accidents involving fatal or serious injury was little changed.

5.2.4 Detailed analysis of accident data

Monthly accident data for 21 Norfolk sites were analysed in more detail to estimate the effect of the vehicle-activated signs on accidents. Eleven years of accident data (1990-2000) were available.

Monthly accident data for the whole of Norfolk were also available for all the urban and rural roads covering the same period. These data were used as 'control' data. Time series 'control' accident models were developed separately for urban and rural roads. These models were used to predict the expected number of accidents ('target' accidents) that would have occurred at the treated sites if the signs had not been installed. A Poisson regression model was assumed, using yearly and monthly factors as explanatory variables. The method employed for estimating the model parameters was the Generalised Linear Modelling (GLM) technique (McCullagh and Nelder, 1989). For estimating the 'target' accidents an 'Empirical Bayes' method was employed (Hauer, 1997).

The prediction method showed that, at the 19 sites with a 30/40mph (urban) speed limit, 92.4 accidents would have been expected to occur overall in the After periods, up to the year 2000, if the signs had not been installed. The actual number of accidents occurring was 61. This difference represents a highly statistically significant reduction of 34% (±8%).

For the two sites with a 60mph rural speed limit, 19.5 accidents were predicted during the After periods and 16 occurred. This represents a 17% (±21%) reduction, which is not statistically significant.

Across all sites together, a highly statistically significant 31% (±8%) reduction in accidents has occurred.

6 Public opinion surveys

It is clear that the vehicle-activated signs are associated with speed reductions in a wide range of circumstances and that there are accident benefits associated with the signs, however, it is not yet clear what the behavioural mechanisms involved are. A roadside survey of 346 drivers was carried out at three locations in Norfolk in February 2000 in order to establish the factors influencing drivers' response to the signs. A further survey of 100 drivers was conducted at one site in Wiltshire in February 2001 to investigate possible regional differences in behavioural response.

Table 11 Accident changes at sites with speed camera signs

		Before installation				*After speed camera installation*					*After fibre optic sign installation*				
County	*Site*	*PIA*	*KSI*	*Years*	*PIA per year*	*PIA*	*KSI*	*Years*	*PIA per year*	***% change***	*PIA*	*KSI*	*Years*	*PIA per year*	***Additional % change***
Norfolk	A146 Loddon	27	8	5.0	5.4	4	1	1.1	3.6	**-33%**	5	4	1.6	3.1	**-14%**
Norfolk	B1332 Poringland	29	7	5.0	5.8	4	0	1.1	3.6	**-37%**	4	0	1.6	2.5	**-31%**
Norfolk	A1075 Shipdham	30	6	5.0	6.0	6	0	1.1	5.5	**-9%**	8	1	1.6	5.0	**-8%**
	All	86	21	15	5.7	14	1	3.3	4.2	**-26%**	17	5	4.8	3.5	**-17%**

PIA: Personal injury accident
KSI: Accidents involving fatal or serious injury

A number of criteria were specified for the interview location:

- The location should be on a vehicle-activated sign route.
- The vehicle-activated sign should be in good working order.
- A safe off-road area should be available to conduct the interviews.
- A discreet location should be available where the sign could be observed (to enable samples to be taken of drivers triggering and not triggering the sign).
- There should be sufficient traffic to allow enough (about 100) drivers to be interviewed each day.

The sites chosen were:

- Felthorpe, Norfolk.
- Horsford, Norfolk.
- Carbrooke, Norfolk.
- Wootton Bassett, Wiltshire.

Opinions were sought about a variety of signs, some of which might be thought to be associated with enforcement, by showing respondents photographs. These signs were:

- The speed roundel (with and without a microwave detector on top).
- Bend warning.
- Junction warning.
- Safety camera repeater.

Drivers were asked specifically about the sign they had just passed (both lit and unlit i.e. visible and blank) and then about other vehicle-activated signs. Drivers were asked about their understanding of the purpose of the signs and the way they operated. They were also asked whether they thought the signs were a good idea and why.

The detail of the questionnaire was modified for the Wiltshire survey to take account of findings from the Norfolk survey, but the main substance of the questions remained the same.

The results from Norfolk and Wiltshire were broadly similar. A summary of the key questions and responses is given in Appendix D, Tables D1 to D4.

About two thirds of respondents at each location were male; very few were under 21 years of age but about a quarter were aged 60 years or over (Table D1). The practical requirement for a large enough sample, which was as evenly as possible split between those who did and did not trigger the sign, did not allow for any further stratification. About 80% of drivers interviewed at each location drove along the road at least once a month and so should have been familiar with the relevant signs.

Most drivers had made the connection between their own speed and the signs being triggered (Table D2), although not surprisingly, at Carbrooke, where the sign was a 40mph roundel, a third thought exceeding the speed limit triggered the sign compared to 5 per cent or less at the other locations. Also at Carbrooke (although nearly two thirds thought the main purpose of the sign was to slow drivers down), almost half thought it was to enforce the speed limit. At the other locations, which had the junction (crossroad) warning sign, about three-quarters of drivers also thought the main purpose was to slow drivers down, but between a third and two thirds thought its purpose was to warn of hazards. (Drivers were encouraged to give more than one answer to the question about the purpose of the sign, which is why these replies add up to more than 100%.) The responses of male and female drivers were broadly similar.

Table D3 shows that most drivers believed they would receive a penalty for triggering the safety camera logo sign, but not the 30 or 40mph roundel signs. Over half of all respondents at all locations believed they would receive a penalty if they triggered the safety camera logo sign. There was some evidence, from additional statements made to the interviewers in the Norfolk survey, that drivers felt more likely to receive a penalty if there was a police presence or a safety camera i.e. some visible level of enforcement. A question was added to the Wiltshire survey asking whether the presence of a safety camera would make the driver more likely to obey the speed limit. Three quarters of drivers said ‘Yes’.

There had been some anecdotal evidence from previous studies that drivers thought the microwave vehicle detectors mounted above the signs were speed enforcement cameras but this was mentioned by only a few drivers in this study. Table D3 shows that the presence of a microwave vehicle detector above the roundel sign made little difference to drivers’ expectation of receiving a penalty if they triggered the sign.

There was overwhelming approval of the signs (Table D4). They were seen principally as an aid to reducing vehicle speeds, but beyond that, there was a lot of enthusiasm for the value of the signs in bringing drivers’ attention back to their speed, or warning of a potential hazard ahead.

The studies conducted in Norfolk and Wiltshire suggest that the attitudes, understanding and behaviour of drivers in both counties are very similar and thus there is no clear regional bias.

7 Summary and conclusions

A full-scale trial of the effectiveness of vehicle-activated signs in reducing speeds and accidents has been undertaken. The signs display a simple message relating to road conditions (presence of bends, junctions or speed requirements) to specific drivers, i.e. those exceeding a particular threshold speed. Four types of sign have been studied:

- speed limit roundel (just inside the speed limit terminal signs) - mainly village sites;
- bend warning;
- junction warning;
- safety camera repeater sign (displaying camera logo);

mainly on rural single carriageway roads, and were situated in Norfolk, Kent, West Sussex and Wiltshire.

7.1 Effect on speeds and accidents

At the speed limit roundel signs, mean speeds of the traffic as a whole were reduced by an average of 3-9mph, the higher reductions being where the speed limit had also been reduced by 10mph (Table 12). The average reduction in mean speed where there had been no change in the speed limit was 4mph.

The junction and bend warning signs reduced mean speeds by up to 7mph, and the safety camera repeater signs yielded a reduction of up to 4mph. Speeds exceeding the limit were also reduced, with the reductions tending to be greater at the roundel signs (Table 13).

There has been a statistically significant one-third reduction in accidents across all of the Norfolk sites combined when compared with the number of accidents that would have been expected without the signs. Safety camera repeater signs appear to give small additional accident reductions over safety cameras alone.

7.2 Public opinion surveys

Nearly 450 drivers took part in opinion surveys at three locations in Norfolk and one in Wiltshire. Two locations had a speed limit roundel (20mph and 40mph) and two had a junction sign. Most of these drivers drove regularly past the relevant sign. Opinions were sought about the four sign types, some of which might be thought to be associated with enforcement, by showing photographs of each type of sign. (The roundel signs were pictured with and without a microwave detector head, which could be thought to be a speed enforcement camera.)

There was overwhelming approval of the signs. Most drivers had made the connection between their own speed and the signs being triggered; exceeding the speed limit was thought much more likely to trigger the roundel sign than the other signs. At the locations with the junction warning sign, nearly all drivers thought that its main purpose was to slow them down or to warn of a hazard.

Over half of drivers believed they would receive a penalty for triggering the safety camera repeater sign.

These surveys suggest that the attitudes, understanding and behaviour of drivers in both Norfolk and Wiltshire are very similar and thus there is no clear regional bias.

Table 13 Summary of speed reductions at warning signs

		Change in mean speed		*Change in percentage of speeders*	
Sign type	*No. of speed measurement locations*	*Maximum (mph)*	*Minimum (mph)*	*Maximum % points*	*Minimum % points*
Junctions	8	-7.4	-0.8	-25	-1
Bends	2	-6.9	-2.1	-10	-1
Camera logo	3	-3.7	-0.5	-15	-0.5

% points: percentage points

7.3 Conclusions

- Clearly, drivers can be influenced to reduce speed when they are specifically targeted, with fixed signs alone likely to have less effect.
- Vehicle-activated signs appear to be very effective in reducing speeds; in particular, they are capable of reducing the number of drivers who exceed the speed limit and who contribute disproportionately to the accident risk, without the need for enforcement such as safety cameras.
- Vehicle-activated signs can be operated at thresholds well below normal police enforcement levels.
- There is no evidence that in time, drivers become less responsive to the signs, even over three years.
- Operating costs are also low.
- In this study, a substantial accident reduction has been demonstrated.

For completeness, guidelines for the use of vehicle-activated signs are given in Appendix E.

8 Acknowledgements

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Table 12 Summary of speed reductions at roundel signs

		Change in mean speed								*Change in percentage of speeders*	
Sign type	*No. of speed measurement Locations*	*Maximum (mph)*	*Minimum (mph)*	*Average change (mph)*	*Std. dev. of change (mph)*	*Av. before speed (mph)*	*Std. dev. before*	*Av. after speed (mph)*	*Std. dev. after*	*Maximum % points*	*Minimum % points*
30mph roundel	17	-7.1	-2.6	-4.5	1.6	34.5	2.7	30.0	1.6	-51	-15
40mph roundel	5	-4.4	-1.2	-3.1	1.4	38.2	3.5	35.1	2.2	-12	-1
30/20mph change	6	-7.5	-4.4	-6.2	1.2	31.1	1.7	24.9	0.8	-58	-38
40/30mph change	7	-13.8	-6.5	-8.9	2.5	39.7	3.3	30.8	2.2	-80	-50
50mph roundel*	1	-4.6	-3.6	-4.1	0.7	52	4.5	47.9	3.8	-51	-15

**Speed measured in two lanes*
% points: percentage points

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Appendix A: Location details of vehicle-activated signs

All locations reported in study

Location	*Road*	*Address*	*Sign type*	*Flashing lights*	*Installation*
Norfolk					
Acle	B1140	South Walsham Road	30 roundel	Yes	Jan-95
Beetley north	B1146	Fakenham Road	30 roundel	Yes	Mar-99
Beetley south	B1146	Fakenham Road	30 roundel	Yes	Mar-99
Billingford east	B1145	The Street	30 roundel	No	May-99
Billingford west	B1145	The Street	30 roundel	No	May-99
Blakeney	A149	Marsham Road	30 roundel	Yes	Dec-98
Brisley west	B1145	Fakenham Road	30 roundel	No	May-99
Brisley east	B1145	Church Street	30 roundel	No	May-99
Costessey	C162	Longwater Lane	30 roundel	Yes	Jan-97
Fakenham west	B1146	Wells Road	30 roundel	Yes	Apr-00
Fakenham west	B1146	Wells Road	20 roundel	Yes	Apr-00
Fakenham east	B1146	Highfield Road	20 roundel	Yes	Apr-00
Fakenham east	B1146	Highfield Road	30 roundel	Yes	Apr-00
Felbrigg	B1436	Near war memorial	Bend	No	Oct-96
Felthorpe north	B1149	Holt Road	Junction	Yes	Feb-98
Felthorpe south	B1149	Holt Road	Junction	Yes	Feb-98
Hellesdon south	C480	Low Road	30 roundel	No	Nov-99
Hellesdon north	C480	Low Road	30 roundel	No	Nov-99
Hingham	B1108	Watton Road	30 roundel	No	Mar-98
Horsford north	B1149	Holt Road	30 roundel	Yes	Mar-99
Horsford north	B1149	Holt Road	20 roundel	Yes	Mar-99
Horsford south	B1149	Holt Road	20 roundel	Yes	Mar-99
Horsford south	B1149	Holt Road	30 roundel	Yes	Mar-99
Horstead	B1150	Norwich Road	30 roundel	Yes	Mar-99
Litcham west	B1145	Lexham Road	30 roundel	No	May-99
Litcham east	B1145	Mileham Road	30 roundel	No	May-99
Loddon	A146	A146 near junction with Beccles Road	Safety camera logo	No	Mar-99
Marham southwest	C46	Burnt House Drove	30 roundel	Yes	Jan-97
Marham northeast	C46	Burnt House Drove	30 roundel	Yes	Jan-97
Mileham west	B1145	Fakenham Road	30 roundel	No	May-99
Mileham east	B1145	Stanfield Road	30 roundel	No	May-99
North Elmham north	B1110	Holt Road	30 roundel	No	May-99
North Elmham south	B1110	Holt Road	30 roundel	No	May-99
Outwell east	A1122	Downham Road	30 roundel	Yes	Feb-99
Outwell west	A1122	Wisbech Road	30 roundel	Yes	Feb-99
Poringland	B1332	The Street	Safety camera logo	No	Mar-99
Pulham Market	B1134	Opposite Sycamore House	30 roundel	Yes	Mar-99
Scole		Old A140 - village now bypassed	30 roundel	Yes	1992-1996
Shipdham	A1075	Chapel Street	Safety camera logo	No	Mar-99
South Lopham west	A1066	Thetford Road	30 roundel	Yes	Jan-97
South Lopham east	A1066	Thetford Road	30 roundel	Yes	Jan-97
Swaffham	A1065	Brandon Road	40 roundel	Yes	Jan-95
Watton	B1108	Norwich Road	40 roundel	Yes	Jan-95
Wells next the Sea	A149	Mill Road	30 roundel	Yes	Jan-95
Wroxham	A1151	Norwich Road	30 roundel	Yes	Jan-95
Norwich City north	B1150	Constitution Hill	20 roundel	Yes	Feb-00
Norwich City south	B1150	Constitution Hill	20 roundel	Yes	Feb-00
West Sussex					
Kingsfold	A24	In village	40 roundel	Yes	Sep-00
Kingsfold	A24	1600m south of Kingsfold	Bend	Yes	Sep-00
Findon by-pass	A24	Southern end of bypass	50 roundel	Yes	Sep-00
West Grinstead	A24	Junction with B2135	Junction	Yes	Sep-00
Wiltshire					
Sells Green	A365	West of village (near drive to Broad Lane Farm)	Bend	No	Dec-99
Bradford Leigh	B3105	West of B3109 crossroads	Junction	No	Dec-99
Bradford Leigh	B3105	East of B3109 crossroads	Junction	No	Dec-99
Wootton Bassett	B3102	North of Whitehill Lane/New Road crossroads	Junction	No	Dec-99
Wootton Bassett	B3102	South of Whitehill Lane/New Road crossroads	Junction	No	Dec-99
Kent					
Littlebourne	A257	Canterbury Road (west of village centre)	30 roundel	Yes	Jun-00
Hersden	A28	East end of village (Upstreet End)	40 roundel	Yes	Jun-00
Sutton Valence	A274	North end of village (North Street)	30 roundel	Yes	Jun-00
Coxheath	B2163	West end of village (Heath Road)	30 roundel	Yes	Jun-00
Five Oak Green	B2017	West end of village (Five Oak Street)	30 roundel	Yes	Jun-00

Appendix B: Monitoring loop locations (Norfolk)

Site	*Road*	*Sign type*	*Road type in vicinity of sign*	*Remarks*	*Distance to loop/tube 1*
Acle	B1140	30 roundel	Rural road, quiet, wide verge	On a slight curve	29m south east
Beetley north	B1146	30 roundel	Rural road	Very good visibility for 1km	At sign
Beetley south	B1146	30 roundel	Rural road	Sign nr sharp bend	At sign
Billingford east	B1145	30 roundel	Village approach	Good forward visibility	At sign
Blakeney	A149	30 roundel	Village approach	Good forward visibility	At sign
Brisley west	B1145	30 roundel	Village approach	Right hand bend approaching junction	
Brisley east	B1145	30 roundel	Village	Curved alignment within village	
Costessey	C162	30 roundel	Urban residential, 'rat run'	Downhill; good forward visibilty	At sign
Fakenham west	B1146	30 roundel	Urban, wide approach to sign	Good visibility, narrowing at sign	30m west
Fakenham west	B1146	20 roundel	Urban, narrow	Bend approaching sign	340m west
Fakenham east	B1146	20 roundel	Urban with wide verges	Slow bend at sign position	At sign
Fakenham east	B1146	30 roundel	Urban, tree-lined	Straight with cycle lanes	At sign
Felbrigg	B1436	Bend	Rural link road avoiding Cromer	Sharp left-hand bend	26m north
Felthorpe north	B1149	Junction	Rural road	Good forward visibility	95m north
Felthorpe south	B1149	Junction	Rural road	Woodland either side	95m south
Hellesdon south	C480	30 roundel	Urban 'rat run' (near Norwich)	Busy with on-road parking	230m north
Hellesdon north	C480	30 roundel	Urban 'rat run' (near Norwich)	Narrow with tree-lined bends	140m south
Hingham	B1108	30 roundel	Village (outer)	Just inside built-up area	
Horsford north	B1149	30 roundel	Village (outer)	Wide, good visibility, residential	At sign
Horsford north	B1149	20 roundel	Village (inner)	Wide, good visibility, residential	85m south
Horsford south	B1149	20 roundel	Village (inner)	Cluttered, parked cars outside Post Office	85m north
Horsford south	B1149	30 roundel	Village (outer)	Good forward visibility; downhill	705m north
Horstead	B1150	30 roundel	Village	Straight approach with side road	At sign
Litcham west	B1145	30 roundel	Village (small)	Approach to sign after bend	650m south west
Litcham east	B1145	30 roundel	Village (small)	Long straight approach to sign	At sign
Loddon	A146	Safety camera logo	Village bypass, busy	Good visibility on straight past sign	775m east
Marham southwest	C46	30 roundel	Village	Approach to housing estate	At sign
Marham northeast	C46	30 roundel	Village approach	Rural straight to housing estate	Not measured
Mileham west	B1145	20 roundel	Village approach	Good visibility on approach to sign	88m north east
Mileham east	B1145	20 roundel	Village approach	Sign near S-bend	1.6km east
North Elmham north	B1110	30 roundel	Village	Sharp S-bends ahead of sign	90m south
North Elmham south	B1110	30 roundel	Village, past community centre	Parking outside village shop, etc	1.6km east
Outwell east	A1122	30 roundel	Village, large, busy road	Bendy road with unguarded river	At sign
Outwell west	A1122	30 roundel	Village, large, busy road	Frequent heavy vehicles, good visibility	At sign
Poringland	B1332	Safety camera logo	Village, large, side road junctions	Gentle curve to right	573m north
Pulham Market	B1134	30 roundel	Village	Good visibility on approach to sign	At sign
Shipdham	A1075	Safety camera logo	Village	Narrow with parked cars	226m north east
South Lopham west	A1066	30 roundel	Village approach, busy	Fast rural approach to sign, bends after	At sign
South Lopham east	A1066	30 roundel	Village approach, busy	Fast rural approach to sign, bends after	At sign
Swaffham	A1065	40 roundel	Semi-urban, town approach	Straight approach past houses on one side	At sign
Watton	B1108	40 roundel	Semi-urban, town approach	Tree-lined, wide, straight	At sign
Wells next the Sea	A149	30 roundel	Bypasses town centre, tourist route	Straight and fast, houses after sign	20m east
Wroxham	A1151	30 roundel	Urban, tourist route	Cluttered, slight bend, trees, parking	At sign

Appendix C: Detailed site results

Table C1 30mph roundel signs in Norfolk

Direction: towards sign		Mean speed	Std. Dev.	Vehicles exceeding speed (mph)	
Site	Period	(mph)	(mph)	% > 30mph	% > 35mph
Speed limit 30mph					
Acle	Before	34.7	11.0	68	55
B1140	After 1	29.1	5.6		
Type I sign	After 2	27.6	7.6	36	7
	Diff. A2-B	-7.1	-3.4		
Billingford	Before	32.5	7.2	65	32
B1145	After 1	29.1	5.6		
Type II sign	After 2	29.8	6.1	43	13
	Diff. A2-B	-2.7	-1.1		
Costessey	Before	35.3	6.4	86	55
C162	After 1	30.7	4.8	60	15
Type I sign	Diff. A2-B	-4.6	-1.6		
Hellesdon	Before	33.2	5.5	79	36
C480	After 1	29.7	4.8	49	10
Type II sign	Diff. A2-B	-3.5	-0.7		
Horstead	Before	33.5	6.2	75	38
B1150	After 1	29.5	5.1		
Type I sign	After 2	28.3	4.9	30	7
	Diff A2-B	-5.2	-1.3		
	After 3 (>5 years)	29.8	4.9	45	9
	Diff. A2-B	-3.7	-1.3		
Litcham	Before	38.2	7.0	91	68
B1145	After 1	32.7	6.3		
Type II sign	After 2	33.2	6.8	61	29
	Diff A2-B	-5.0	-0.2		
Marham	Before	32.4	6.8	65	33
C46	After 1	28.5	5.0	36	6
Type I sign	Diff. A2-B	-3.9	-1.8		
North Elmham	Before	33.5	5.8	79	40
B1110	After 1	30.5	4.4		
Type II sign	After 2	30.4	4.4	56	11
	Diff. A2-B	-3.1	-1.4		
Outwell	Before	31.8	7.1	62	32
A1122 (site 1)	After 1	28.8	5.5	44	10
Type I sign	Diff. A2-B	-3.0	-1.6		
Pulham Market	Before	31.1	6.7	70	27
B1134	After 1	28.4	5.2	42	4
Type I sign	Diff. A2-B	-2.7	-1.5		
Scole	Before	38.3	5.9	95	67
A140	After 1	32.0	3.8		
Type I sign	After 2	32.6	3.5	73	16
	Diff A2-B	-5.7	-2.4	radar measurement	
Wells	Before	31.4	7.1	63	31
A143	After 1	28.0	5.4		
Type I sign	After 2	28.8	5.0	40	9
	Diff A2-B	-2.6	-2.1		
Wroxham	Before	31.4	4.9	63	20
A1151	After 1	30.7	4.7		
Type I sign	After 2	28.5	4.9	37	5
	Diff A2-B	-2.9	0.0		

Type I sign: 300mm roundel with flashing amber lights.
Type II sign: 400mm roundel without *flashing amber lights.*
After 1 is typically 1 month after; After 2 is typically 1 year after (long term).
After 3 is very long term at selected sites.

Table C2 30mph roundel signs in Kent

Direction: towards sign		Mean speed	Std. Dev.	Vehicles exceeding speed (mph)	
Site	Period	(mph)	(mph)	% > 30mph	% > 35mph
Speed limit 30mph					
Five Oak Green	Before	36.5	6.7	86.6	52.3
B2017	After 1	30.1	4.2	50.3	8.9
	After 2	30.1	4.5	51.5	9.6
	After 3	30.2	4.3	52.1	9.1
	Diff. A3-B	-6.3	-2.4		
Coxheath	Before	37.3	6.7	88.1	57.6
B2163	After 1	31.3	6.0	59.9	16.4
	After 2	30.6	5.3	55.8	14.9
	After 3	32.6	10.4	59.3	20.4
	Diff. A3-B	-4.7	3.7		
Littlebourne	Before	36.5	6.9	82.9	51.1
A257	After 1	30.5	4.8	55.1	13.2
	After 2	30.7	4.9	57.1	14.9
	After 3	30.7	4.7	56.8	14.1
	Diff. A3-B	-5.8	-2.2		
Sutton Valence	Before	38.9	7.1	91.6	68.7
A274	After 1	31.7	4.7	65.3	19.1
	After 2	32.2	4.8	68.8	21.9
	After 3	32.1	4.7	69.1	21.0
	Diff. A3-B	-6.8	-2.4		
Speed limit 40mph					
Hersden	Before	40.7	7.1	49.5	15.5
A28	After 1	35.9	5.0	15.1	2.3
	After 2	36.5	4.8	17.9	2.8
	After 3	36.3	5.0	17.5	2.9
	Diff. A3-B	-4.4			

After 1, After 2 and After 3 are typically 1 month, 6 weeks and 2 months after respectively.

Table C3 40mph roundel signs, Norfolk

Direction: towards sign		Mean speed	Std. Dev.	Vehicles exceeding speed (mph)	
Site	Period	(mph)	(mph)	% > 40mph	% > 45mph
Speed limit = 40mph					
Carbrooke	Before	40.7	6.8	51	23
B1108	After 1	38.2	5.7		
Type I sign	After 2	36.8	4.8	20	6
	Diff. A2-B	-3.9	-2.0		
Mileham	Before	37.4	8.4	36	15
B1145	After 1	34.8	7.0		
Type II sign	After 2	35.4	7.9	24	7
	Diff. A2-B	-2.0	-0.5		
Swaffham	Before	39.7	6.0	44	17
A1085	After 1	35.6	5.8		
Type I sign	After 2	35.7	5.4	18	5
	Diff. A2-B	-4.0	-0.6		

Type I sign: 300mm roundel with flashing amber lights.
Type II sign: 400mm roundel without flashing amber lights.
After 1 is typically 1 month after, After 2 is typically 1 year after (long term).
After 3 is very long term at selected sites.

Table C4 40mph roundel signs, West Sussex and Kent

Direction: towards sign		Mean speed	Std. Dev.	Vehicles exceeding speed (mph)	
Site	Period	(mph)	(mph)	% > 40mph	% > 45mph
Speed limit = 40mph					
Kingsfold	Before	32.5	7.4	12.1	2.3
A24	After 1	31.8	6.6	4.9	0.7
(West Sussex)	After 2	31.3	6.5	4.7	0.6
	Diff. A2-B	-1.2	-0.9		
Hersden	Before	40.7	7.1	49.5	15.5
A28	After 1	35.9	5.0	15.1	2.3
(Kent)	After 2	36.5	4.8	17.9	2.8
	After 3	36.3	5.0	17.5	2.9
	Diff. A2-B	-4.2	-2.3		

Kingsfold: After 1 and After 2 are respectively 1 month and 3 months after respectively.
Hersden: After 1, After 2 and After 3 are typically 1 month, 6 weeks and 2 months after respectively.

Table C5 50mph roundel signs, West Sussex

Direction: towards sign		Mean speed	Std. Dev.	Vehicles exceeding speed (mph)	
Site	Period	(mph)	(mph)	% > 50mph	% > 55mph
Speed limit = 50mph					
Findon bypass	Before	48.8	6.5	38.1	14.5
(S end)	After 1	45.5	5.6	16.5	4.6
A24 lane 1	After 2	45.2	5.7	14.8	4.1
	Diff. A2-B	-3.6	-0.8		
Findon bypass	Before	55.2	6.8	79.7	50.2
(S end)	After 1	50.5	5.8	51.1	19.0
A24 lane 2	After 2	50.6	5.9	40.4	14.1
	Diff. A2-B	-4.6	-0.9		

After 1 and After 2 are respectively 1 month and 3 months after respectively.

Table C6 20mph roundel signs (formerly 30mph sites), Norfolk

Direction: towards sign		Mean speed	Std. Dev.	Vehicles exceeding speed (mph)	
Site	Period	(mph)	(mph)	% > 30mph	% > 35mph
Speed limit 20mph					
Fakenham (site 1)	Before	32.5	6.2	93	70
B1146	After 1				
	(5 months)	25.0	4.4	42	12
Type III sign	Diff. A1-B	-7.5	-1.8		
Fakenham (site 2)	Before	28.5	3.6	% not available	
B1146	After 1			(radar)	
	(5 months)	23.4	3.7	28	5
Type III sign	Diff. A1-B	-5.1	0.1		
Horsford (site 1a)	Before	32.0	6.2	89	67
B1149	After 1	24.6	5.0	44	15
Type I sign	After 2				
	(20 months)	25.5	5.8	53	18
	Diff. A2-B	-6.5	-0.4		
Horsford (site 1b)	Before	32.9	6.1	92	73
B1149	After 1	24.3	5.1	43	13
Type I sign	After 2				
	(20 months)	25.6	5.3	53	17
	Diff. A2-B	-7.3	-0.8		
Norwich (site 1a)	Before	30.7	8.0	87	66
B	After 1	23.4	6.5	37	10
Type III sign	After 2	24.6	6.4	47	16
	Diff. A2-B	-6.1	-1.6		
Norwich (site 1b)	Before	29.7	6.8	82	55
B	After 1	23.9	5.4	41	10
Type III sign	After 2	25.3	5.7	54	17
	diff A2-B	-4.4	-1.1		

Type I sign: 300mm roundel with flashing amber lights.
Type III sign: 450mm roundel with flashing amber lights.
After 1 is typically 1 month after; After 2 is typically 1 year after (long term).
After 3 is very long term at selected sites.
Data collection downstream from signs.

Table C7 30mph roundel signs (formerly 40mph sites), Norfolk

Direction: towards sign		*Mean speed*	*Std. Dev.*	*Vehicles exceeding speed (mph)*	
Site	*Period*	*(mph)*	*(mph)*	*% > 30mph*	*% > 35mph*
Speed limit 30mph					
Beetley	Before	45.1	7.6	98	94
B1146 (site 1)	After 1	31.3	3.6	65	14
Type I sign	Diff. A1-B	-13.8	-4.0		
Beetley	Before	37.8	6.5	91	71
B1146 (site 2)	After 1	28.0	5.0	31	5
Type I sign	Diff. A1-B	-9.8	-1.5		
Blakeney	Before	34.8	4.2	90	56
A149	After 1	28.3	5.1	35	6
Type I sign	Diff. A1-B	-6.5	0.9		
Horsford	Before	37.8	6.0	93	76
B1149	After 1	30.6	4.8	58	13
Type I sign	After 2	30.5	5.1	48	6
	Diff. A1-B	-7.2	-1.2		
Outwell	Before	41.2	6.5	97	88
A1122 (site 2)	After 1	34.1	5.0	84	38
Type I sign	Diff. A1-B	-7.1	-1.5		
South Lopham	Before	40.5	7.5	94	83
A1066 (site 1)	After 1	32.5	5.1	64	23
Type I sign	diff A2-B	-8.0	-2.4		
South Lopham	Before	40.7	6.4	95	85
A1066 (site 2)	After 1	29.5	5.3		
Type I sign	After 2	30.7	5.5	46	19
	Diff. A2-B	-10.0	-0.9		
	After 3 (>5 years)	30.7	5.4	47	17
	Diff. A3-B	-10.0	-1.0		

After 1 is typically 1 month after; After 2 is typically 1 year after (long term). After 3 is very long term at selected sites.

Table C8 Junction warning signs

Norfolk: Felthorpe junction

Direction: towards sign		Mean speed	Std. Dev.	Vehicles exceeding speed (mph) % > 50mph
Site	Period	(mph)	(mph)	
Speed limit = 50mph				
Site 1,	Before	42.5	8.6	17.4
southbound	Before	45.6	9.0	29.2
(approaching	Before	45.3	9.2	28.1
sign)	Before	44.8	8.7	26.8
	After 1	41.1	6.8	7.7
	After 2*	42.2	7.7	12.2
Site 2,	Before	53.2	9.6	62.6
northbound	Before	53.5	9.7	64.1
(approaching	Before	52.1	9.8	57.8
sign)	Before	49.2	8.7	45.1
	After 1	45.3	7.4	21.3
	After 2*	45.8	7.8	24.8

Site 1 is 110m north of crossroads.
Site 2 is 120m south of crossroads.
**31 months after.*

West Sussex: A24 junction with B2135 (dual carriageway)

Direction: towards sign		Mean speed	Std. Dev.	Vehicles exceeding speed (mph) % > 70mph	% > 75mph
Site	Period	(mph)	(mph)		
Speed limit = 70mph					
A24 lane 1	Before	60.2	9.9	17.0	7.5
	After 1	56.1	9.5	8.4	3.3
	After 2	55.0	9.1	6.4	2.5
	Diff. A2-B	-5.2	-0.8		
A24 lane 2	Before	67.2	9.0	37.3	17.6
	After 1	61.5	9.2	17.9	7.4
	After 2	60.0	8.4	11.6	4.1
	Diff. A2-B	-7.2	-0.6		

After 1 and After 2 are respectively 1 month after and 3 months after respectively.

Wiltshire: Bradford Leigh (crossroads)

Direction: towards sign		Mean speed	Std. Dev.	Vehicles exceeding speed (mph) % > 40mph	% > 45mph
Site	Period	(mph)	(mph)		
Speed limit = 40mph					
Westbound	Before	38.7	7.8	43.1	19.3
approaching sign	After 1	35.8	8.1	30.7	11.8
	After 2	37.9	7.3	37.2	13.9
	Diff. A2-B	-0.8	-0.5		
Westbound	Before	28.3	10.7	19.6	7.6
near junction	After 1	27.5	9.5	10.8	2.9
	After 2	31.5	10.5	24.6	8.1
	Diff. A2-B	3.2	-0.2		
Eastbound	Before	38.2	7.3	41.0	15.5
approaching	After 1	39.3	6.7	46.2	17.1
sign	After 2	39.7	6.6	49.5	18.2
	Diff. A2-B	1.5	-0.7		
Eastbound	Before	33.0	10.5	27.2	9.5
near junction	After 1	34.2	9.2	26.3	8.0
	After 2	no data			
	Diff. A1-B	1.2	-1.3		

After 1 is 1 month after and After 2 is 8 months after.

Wiltshire: Wootton Bassett (crossroads)

Direction: towards sign		Mean speed	Std. Dev.	Vehicles exceeding speed (mph) % > 30mph	% > 35mph
Site	Period	(mph)	(mph)		
Speed limit = 30mph					
Northbound	Before	36.9	7.3	86.9	62.3
Approaching	After 1	29.4	5.6	47.5	11.2
sign	After 2	27.7	8.7	46.1	21.2
	Diff. A2-B	-9.2	1.4		
Northbound	Before	24.9	8.5	34.4	10.0
Near junction	After 1	23.5	7.9	23.3	3.7
	After 2	no data			
	Diff. A1-B	-1.4	-0.6		
Southbound	Before	31.4	6.0	66.6	24.9
Approaching	After 1	28.9	5.8	45.1	11.2
sign	After 2	28.0	4.5	25.9	5.7
	Diff. A2-B	-3.4	-1.5		
Southbound	Before	29.1	9.8	51.6	31.4
near junction	After 1	28.0	9.2	47.7	24.6
	After 2	26.9	9.3	43.1	14.1
	Diff. A2-B	-2.2	-0.5		

After 1 is 1 month after and After 2 is 8 months after.

Table C9 Bend warning signs in Wiltshire and West Sussex

Site	Period	Mean speed (mph)	Std. Dev. (mph)	Vehicles exceeding speed (mph) % > 40mph	% > 45mph
Speed limit 40mph					
Sells Green	Before	50.2	8.0	92.9	76.9
(Wiltshire)	After 1	48.3	8.2	86.4	64.3
Northbound	After 2	46.7	8.3	80.6	56.2
approaching	Diff. A2-B	-3.5	+0.3		
sign					
Sells Green	Before	38.3	6.0	35.6	12.9
(Wiltshire)	After 1	37.9	6.3	33.8	13.3
Northbound	After 2	35.3	4.8	15.2	3.2
past sign	Diff. A2-B	-3.0	-1.2		

After 1 is 1 month after and After 2 is 8 months after.

.				Vehicles exceeding speed (mph) % > 50mph	% > 55mph
Speed limit 50mph					
1 mile south	Before	41.6	5.6	5.4	1.3
of Kingsfold					
(West Sussex)	After 1	38.6	5.0	1.8	0.5
Northbound	After 2	38.0	4.7	1.0	0.2
20m after sign	Diff. A2-B	-3.6	-0.9		

After 1 is 1 month after; After 2 is 3 months after (long term).

Table C10 Speed camera repeater signs, Norfolk

Site	Speed limit (mph)	Period	Mean speed (mph)	Std. dev. (mph)	Vehicles exceeding speed (mph) %> 30mph	%> 35mph	%> 40mph	%> 45mph	%> 60mph	%> 65mph	%> 75mph
Loddon	60	Before	49.3	8.0	n/a	n/a	n/a	n/a	6	3	1
A146		After 1	48.7	7.6	n/a	n/a	n/a	n/a	4	1.5	0.5
		Diff. A1-B	-0.6	-0.4							
Poringland	40/30	Before	35.0	6.4	87	58	15	3	n/a	n/a	n/a
B1332		After 1	34.5	6.4	85	55	13	2	n/a	n/a	n/a
		After 2	30.8	5.2	59	16	4	1	n/a	n/a	n/a
		Diff. A2-B	-4.2	-1.2							
Shipdham	30	Before	32.7	5.5	74	29	8	2	n/a	n/a	n/a
A1075		After 1	31.4	5.6	64	18	4	1	n/a	n/a	n/a
		Diff. A1-B	-1.3	0.1							

After 1 is typically 1 month after; After 2 is 18 months after (NB speed limit reduced at Poringland Autumn 1999).
n/a - not applicable.

Appendix D: Public opinion surveys

Table D1 Some basic details of respondents

	Felthorpe		*Horsford*		*Carbrooke*		*Wootton Bassett*	
Gender of respondents	*Frequency*	*Percentage of col. total*	*Frequency*	*Percentage of col. total*	*Frequency*	*Percentage of col. total*	*Frequency*	*Percentage of col. total*
Male	47	66%	51	62%	134	69%	76	76%
Female	23	32%	31	38%	57	30%	24	24%
Not known	1	1%	0	0%	2	1%	0	0%
Age of respondents								
<21 years	1	1%	3	4%	3	2%	4	4%
21 to 59 years	53	75%	61	74%	140	73%	72	72%
>59 years	17	24%	17	21%	48	25%	21	21%
Not known	0	0%	1	1%	2	1%	3	3%
How often do you drive down this road?								
At least:								
Once a day	22	31%	33	40%	55	28%	41	41%
Once a week	18	25%	22	27%	67	35%	31	31%
Once a month	18	25%	9	11%	36	19%	12	12%
Or:								
Less than once a month	13	18%	12	15%	29	15%	11	11%
First time	0	0%	6	7%	5	3%	5	5%
Not known	0	0%	0	0%	1	1%	0	0%
Was the sign triggered?								
Yes	39	55%	55	67%	56	29%	52	52%
No	32	45%	27	33%	136	70%	48	48%
Not known	0	0%	0	0%	1	1%	0	0%
Total number of drivers		71		82		193		100

Table D2 What triggers the sign and what is its purpose?

	Felthorpe		*Horsford*		*Carbrooke*		*Wootton Bassett*	
	Frequency	*Percentage of col. total**	*Frequency*	*Percentage of col. total**	*Frequency*	*Percentage of col. total**	*Frequency*	*Percentage of col. total**
What do you think triggers the sign to light up like this? **								
Speed of vehicle	68	96%	64	78%	111	58%	77	77%
Exceed speed limit	2	3%	4	5%	66	34%	2	2%
Don't know	1	1%	5	6%	11	6%	3	3%
Other reasons	0	0%	9	11%	6	3%	13	13%
What do you think the purpose of this sign is? (lit sign) **								
Make people slow down	57	80%	60	73%	118	61%	71	71%
Warn of hazards	47	66%	36	44%	17	9%	34	34%
Enforce speed limit	1	1%	1	1%	91	47%	18	18%
Alert drivers	1	1%	1	1%	10	5%	5	5%
Reduce accidents	6	8%	4	5%	8	4%	4	4%
Other reasons	0	0%	2	2%	2	1%	1	1%
Total number of drivers		71		82		193		100

 # The sign at Felthorpe, Horsford and Wootton Bassett was a junction (crossroads) warning, that at Carbrooke was a 40mph roundel.
** The percentages are calculated from the total number of drivers, not the number of responses, and thus may not add up to 100%.*
*** Drivers were encouraged to give more than one response and these have been aggregated in this table.*

Table D3 If this sign lit up for you, would you expect to receive a penalty?

	Felthorpe		Horsford		Carbrooke		Wootton Bassett		All sites combined	
	Frequency	*Percentage of col. total*	Frequency	*Percentage of col. total*	Frequency	*Percentage of col. total*	Frequency	*Percentage of col. total*	Frequency	*Percentage of col. total*
Junction warning sign										
Yes	4	6%	20	24%	37	19%	23	23%	84	19%
No	63	89%	53	65%	136	70%	59	59%	311	70%
Sometimes	1	1%	1	1%	2	1%	7	7%	11	2%
Don't know	3	4%	8	10%	18	9%	11	11%	40	9%
Bend warning sign										
Yes	5	7%	9	11%	20	10%	14	14%	48	11%
No	61	86%	63	77%	159	82%	73	73%	356	80%
Sometimes	1	1%	0	0%	0	0%	3	3%	4	1%
Don't know	4	6%	10	12%	14	7%	10	10%	38	9%
30mph sign without microwave detector										
Yes	22	31%	29	35%	63	33%	35	35%	149	33%
No	41	58%	42	51%	101	52%	48	48%	232	52%
Sometimes	3	4%	4	5%	5	3%	2	2%	14	3%
Don't know	5	7%	7	9%	24	12%	15	15%	51	11%
Speed camera logo										
Yes	39	55%	43	52%	107	55%	52	52%	241	54%
No	15	21%	23	28%	62	32%	30	30%	130	29%
Sometimes	4	6%	4	5%	1	1%	4	4%	13	3%
Don't know	13	18%	12	15%	23	12%	14	14%	62	14%
30/40mph sign with microwave detector										
Yes	29	41%	32	39%	62	32%	52	52%	175	39%
No	32	45%	31	38%	107	55%	29	29%	199	45%
Sometimes	3	4%	4	5%	5	3%	3	3%	15	3%
Don't know	7	10%	15	18%	19	10%	16	16%	57	13%
Total number of drivers		71		82		193		100		446

Table D4 Are the signs a good idea and why?

	Felthorpe		*Horsford*		*Carbrooke*		*Wootton Bassett*	
	Frequency	*Percentage of col. total**	*Frequency*	*Percentage of col. total**	*Frequency*	*Percentage of col. total**	*Frequency*	*Percentage of col. total**
Are the signs a good idea?								
Yes	66	93%	81	99%	190	98%	92	92%
No	5	7%	1	1%	3	2%	8	8%
Why do you think the signs are a good/bad idea?**								
Slow vehicles down	24	34%	31	38%	66	34%	27	27%
Warn of hazards	12	17%	5	6%	25	13%	14	14%
Obey/more aware of speed limits	4	6%	11	13%	40	21%	7	7%
Alert drivers	10	14%	14	17%	30	16%	22	22%
Draw attention to own speed	17	24%	19	23%	42	22%	34	34%
More noticeable because they light up	11	15%	8	10%	41	21%	11	11%
Total number of drivers	71		82		193		100	

** The percentages are calculated from the total number of drivers, not the number of responses, and thus may not add up to 100%.*

*** Drivers were encouraged to give more than one response and these have been aggregated in this table.*

Appendix E: Guidelines for using vehicle-activated signs

Before the decision to install vehicle-activated signs is made, it is important to undertake an audit of existing furniture, fixed signs, road condition and road markings to assess their standard, condition and wear. It is not recommended that vehicle-activated signs are deployed until it has been established that the current markings fully comply with the standards of size, clear visibility and siting distance specified in Chapters 4 and 5 of The Traffic Signs Manual (Department of Transport, 1985, 1986). It should also be noted that vehicle-activated signs are not an alternative or substitute for standard fixed signs.

Site selection should also take into consideration the number of speed-related accidents and excessive speed for the conditions, for example, on the approaches to bends and junctions. Speed profiles using the individual vehicle speed data collection method should be obtained in order to confirm that a speeding problem exists.

It is suggested that a detailed accident investigation is undertaken to identify the major accident contributory factors and confirm that vehicle-activated signs are an appropriate remedial measure.

The cost of running mains power to the installation should be investigated at an early stage of planning in order to make contingencies for an alternative power source (solar panels) if the costs are too high. However, it is possible in remote and heavily wooded locations (in the absence of mains power supplies) that there may be insufficient power from a solar re-charger to run the sign.

Sites should be chosen such that there is a clear sight line between the driver and the sign, so that the driver can be detected by the microwave speed sensor and exposed to the sign message for at least three seconds. At some locations, for example where there is a footway immediately beside the road, the sign will be located much further away from the carriageway so as not to obstruct pedestrians. This will also result in the microwave detector being positioned at a greater angle to the carriageway. Under these circumstances, the detection window (i.e. the distance over which the vehicle can be detected) is much reduced because of the geometry.

Where signs are designed to draw attention to a hazard, they should be installed 100-150 metres in advance of that hazard, to give the driver time to respond. If the sign is too far from the hazard, it is possible that the association between the sign and the hazard will not be made. If it is too close it leaves a very short response time.

Having confirmed the suitability of the location for treatment with vehicle-activated signs, it is necessary to decide upon the information that will be conveyed to the driver. Signs should not contain non-standard pictograms or messages (i.e. those not prescribed in the Traffic Signs Regulations and General Directions (Department for Transport, 2002)), to avoid causing ambiguity and confusion to drivers.

The collection of speed data prior to the installation of the vehicle-activated sign should enable the estimation of a suitable threshold speed for the sign to display the message. The speed limit signs should be set to display at a threshold equal to the speed limit, and speed thresholds for warning signs should be set at the 50th percentile speed measured before sign installation.

It is critical that the speed monitoring detectors are installed as accurately as possible to minimise errors in speed measurement. If tubes are used, they are normally installed in pairs with a separation of 1 metre, perpendicular to the direction of the traffic flow. An installation error of 1cm will create a 1% error in the speed measurements. If the tubes have not been installed accurately for both the Before and After data collection, the errors are multiplied.

It is, however, recommended that buried inductive loops are used for Before and After data collection. While the cost of a single data collection using the tube sensor method is lower than that for inductive loops (due to the relatively high initial installation costs), for long term evaluation and repeat collections, the marginal costs are much lower, and inductive loops become very cost effective. An additional advantage of using loops is that their geometry is fixed for the duration of the study and consequently the errors in measurement are constant for each data collection. Loops are less visually intrusive and are thus difficult to see by the driver. Surface mounted tubes are vulnerable to damage (often by vehicles braking heavily) and they may influence drivers' speed since they could be mistaken for an enforcement device.

Many of the early vehicle-activated installations used flashing amber lamps ('wig-wags') to enhance the signs, but there has been little evidence to suggest that this makes the sign more effective.

At remote locations where mains electrical power is not readily or cheaply available, due to installation costs, an alternative battery power source using solar panel recharging has been developed. Although the signs are relatively low power (400mA with the display off and 1.5A with the display on), the microwave vehicle detector is always actively sensing even when the message is not being displayed. At high vehicle flow locations where the sign is being triggered frequently, this may pose a problem with the consumption rate exceeding the charge rate. The daily power consumption may be calculated from the degree to which the sign is triggered - since the vehicle flow, the trigger speed and the display time are known, it is possible to calculate the daily duration of the sign 'on' time and hence the power consumption. LED signs are expected to use even less power than the quartz halogen illuminated signs.

An advantage of using solar power recharging is that it simplifies the installation, removing the cost of running mains power to the site and extending the use of the vehicle-activated signs to remote locations. With solar powered sites, however, theft of the panels could pose a risk.

Inductive loops (rather than a microwave detector) were used to detect vehicles at the Felbrigg (Norfolk) bend site. This was an early experimental location where loops were used to trigger the sign (i.e. when a set threshold speed was exceeded) and for connection to the data loggers.

There are advantages in using loops for vehicle detection, such as the ability to accurately set the distance from the sign at which the vehicle is detected, and the very low power required by the loop detector circuit. However, the initial costs (loop cutting and running cables from the detector to the sign) are high.

There is no evidence to show that in time, drivers become less responsive to the signs. The longer-term evaluation of the Norfolk sites would suggest that, to the contrary, compliance is maintained.

Abstract

There is an established, positive relationship between vehicle speeds and road accidents. On rural roads, driving too fast for the conditions is more likely to be a factor in accidents than exceeding the speed limit. Encouraging drivers to drive at suitable speeds for the conditions is particularly important, since driver error is the major contributory factor in 95 per cent of accidents.

A range of rural road safety engineering measures, in particular vehicle-activated signing, has been developed to encourage drivers to approach hazards such as bends and junctions at a safe speed, and to encourage them to comply with the speed limit, e.g. through villages. The signs display a message relating to road conditions such as these to just those drivers exceeding a set threshold speed.

A study of the effectiveness of over 60 installations on rural roads in Norfolk, Kent, West Sussex and Wiltshire has been conducted by TRL for the Department for Transport (DfT). The trial aimed to assess the effect of the signs on speed and injury accidents, and drivers' understanding of the signs. The results will be used to develop best practice for sign installation.

The signs appear to be very effective in reducing speeds, particularly those of the faster drivers who contribute disproportionately to the accident risk, without the need for enforcement such as safety cameras. In this study, a substantial accident reduction has been demonstrated.

Related publications

TRL511 *The relationship between speed and accidents on rural single-carriageway roads* by M C Taylor, A Baruya and J V Kennedy. 2002 (price £25, code AX)

TRL421 *The effects of drivers' speed on the frequency of road accidents* by M C Taylor, D A Lynam and A Baruya. 2000 (price £35, code H)

TRL401 *Interactive fibre optic signing at a rural crossroad (B1149 Felthorpe, Norfolk CC)* by M A Winnett, E Woodgate and N Mayhew. 1999 (price £35, code H)

TRL304 *Injury accidents on rural single-carriageway roads, 1994-95: an analysis of STATS 19 data* by J Barker, S Farmer and D Nicholls. 1998 (price £25, code E)

TRL202 *Trials of rural road safety engineering measures* by J Barker. 1997 (price £35, code H)

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