DRAFT PROJECT REPORT RPN 2819

Interim Report: Offside Sign Removal On-Road Trials
1S4a1, Two offside lanes closed on a three lane motorway

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Contents amendment record

This report has been amended and issued as follows:

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Description</th>
<th>Editor</th>
<th>Technical Referee</th>
</tr>
</thead>
<tbody>
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<td>06/12/13</td>
<td>First Draft</td>
<td>MJP</td>
<td>SH</td>
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<td>06/03/14</td>
<td>Edits from TR</td>
<td>MJP</td>
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<tr>
<td>1.2</td>
<td>13/03/14</td>
<td>Final draft</td>
<td>MJP/SC</td>
<td>SH</td>
</tr>
</tbody>
</table>
Executive Summary

Delivery Matrix

1 Introduction

2 Current Signing and OSSR Alternative
   2.1 Control layout
   2.2 Experimental layout

3 Trials Methodology, Planning and Implementation
   3.1 Measurement method
   3.2 Data capture criteria
   3.3 Site selection criteria
   3.4 Provision of resources
      3.4.1 Connect Plus resource
      3.4.2 TRL monitoring resource

4 Data Analysis
   4.1 Video analysis criteria
   4.2 Incidents, dangerous occurrences and taper running
   4.3 Statistical analysis
      4.3.1 Key question
      4.3.2 Method
      4.3.3 Results
      4.3.4 Traffic flows
      4.3.5 Day of the week
      4.3.6 Count of HGVs
      4.3.7 Site selection
      4.3.8 Conclusions

5 Conclusions and recommendations
   5.1 Recommendations
Executive Summary

One of the highest risk activities for traffic management (TM) operatives is exposure to live traffic while deploying and removing temporary traffic management (TTM) signs, particularly when placing signs on the offside (i.e. in the central reservation) due to the need for the road workers to carry equipment across the carriageway. The Highways Agency (HA) has set out its overarching Aiming for Zero (AfZ) Strategy (Highways Agency, 2009) seeking to completely eliminate, by 2016, the requirement for road workers to be on foot on a live carriageway during routine maintenance operations. The elimination of the need for offside signs is consistent with this aim and would enable road works to be completed more quickly, reducing on-road time and related congestion.

Previous research (Clark et al., 2011) led to the release of Interim Advice Note (IAN) 150/12, Guidance for Alternative Temporary Traffic Management Techniques for Relaxation Schemes on Dual Carriageways (Highways Agency, 2012), since updated with IAN 150/14 (Highways Agency, 2014) which permits the nearside only lane closure and signing technique to be safely applied in the approach and lane change zones of these relaxation schemes, for a single nearside closure, or closure of the two nearside lanes. The current trial was conducted using a well-established methodology, and extended this technique to a closure of two offside lanes on a three lane carriageway. It sought to test whether removal of offside signs from the approach to a lane 3 and 2 (offside) closure on a dual carriageway / motorway with three lanes would cause a significant change in driver behaviour and lane choice.

The statistical analyses of the trial results showed that the pattern of vehicles moving across lanes at four different sign points (800yds, 600yds, 400yds and 200yds) varied slightly between the control and experimental conditions. Therefore on-road monitored trials showed that there is some statistical evidence to suggest that omission of offside signing for a lane 3 and 2 closure on a three lane carriageway results in a difference in the lane movement of vehicles when compared with the control condition (a Plan DZA3 relaxation scheme approach zone and Plan DZB7 relaxation scheme lane change zone). However when the analysis was re-run balancing for vehicle flow and day of the week the differences in movement across lanes at four different sign points became statistically non-significant. Nonetheless, small increases in the proportion of vehicles in lane 3, and possible increases in taper running, both associated with the experimental layout, suggest that the monitoring of vehicles in lane 3 under operational conditions (particularly at 200m and nearer to the taper) be given consideration.

Taking all findings into account, the use of the OSSR advanced signing does not substantially change driver behaviour and lane choice from the relaxation signing layout typically used for the closure of lanes 3 and 2 on three lane dual carriageways / motorways with hard shoulder. In addition, the OSSR signing layout substantially reduces road workers’ exposure to risk from crossing live carriageways. Therefore it is recommended that this layout be permitted for implementation.

However, since it has been identified in previous work that a major advanced warning for drivers in the offside lane (lane 3 approaching the taper) is likely to be the taper itself (assuming it is equipped with sequential flashing road danger lamps), it is considered essential that any traffic management deployed using the OSSR technique for a lane 3 closure should meet the following requirements:
- Sequential flashing road danger lamps, specified in Chapter 8 Section D3.12.2, should always be used
- Any works should meet all of the visibility requirements specified in Chapter 8 Section D1.6.3.
Delivery Matrix

The Highways Agency requested that TRL undertake appropriate monitoring activity in order to determine whether removal of offside ‘wicket’ signs from the current Chapter 8 (Department for Transport/Highways Agency, 2009) ‘relaxation scheme’ traffic management layout on the approach to a lane 3 and 2 closure of a three-lane dual carriageway would cause a significant change in driver behaviour and lane choice.

The main objectives of the work programme were to:

1. Provide support to the on-road trial of omitting offside advance warning signs for two-lane offside lane closures at relaxation scheme road works.
2. Design and implement a methodology to monitor driver behaviour and reaction to the conventional signing layout.
3. Design and implement a methodology to monitor driver behaviour and reaction to the reduced signing layout.
4. Compare the safety performance of both sets of road works for both road users and road workers.
5. Report the key findings to the Highways Agency, including any limitations of the offside omission technique for relaxation road works signing.

These objectives are delivered in the following sections within this report:

<table>
<thead>
<tr>
<th>Objectives:</th>
<th>Objective is met by:</th>
<th>Within:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Provide support for the on-road trial of omitting offside advance warning signs for two-lane offside lane closures at relaxation scheme road works</td>
<td>Provide assistance to Connect Plus to gain permissions from the Highways Agency, engage with the HA ‘Aiming for Zero’ programme team and comply with HA internal governance</td>
<td>Section 3.4</td>
</tr>
<tr>
<td>Provide support for on-road trials</td>
<td>Methodology designed using proven techniques used in previous road worker safety sign simplification trial</td>
<td>Section 3.1</td>
</tr>
<tr>
<td>2/3: Design and implement a methodology to monitor driver behaviour and reaction to conventionally signed road works and to the offside omission method used in the on-road trials</td>
<td>Methodology implemented by Connect Plus (with TRL support)</td>
<td>Section 2.2</td>
</tr>
<tr>
<td></td>
<td>4: Compare the safety performance of both sets of road works for both road users and road workers</td>
<td></td>
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<td>----------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analyse safety performance data</td>
<td>Data from monitoring exercise analysed for erratic driver behaviour, and dangerous occurrences</td>
</tr>
<tr>
<td></td>
<td>Undertake statistical analysis of traffic lane occupancy data</td>
<td>Statistical analysis of lane occupancy data at each data measurement point carried out</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>5: Report the key findings to the Highways Agency, including any limitations of the offside omission technique for relaxation road works signing</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Analysis of the results obtained from the on-road evaluations</td>
</tr>
<tr>
<td></td>
<td>Review of the effect of both the current Chapter 8 TTM configuration and the offside omission configuration on lane merging behaviour and lane choice</td>
</tr>
<tr>
<td></td>
<td>An indication as to whether the data and conclusions of the study are robust to the point of being used to amend current Chapter 8 practices</td>
</tr>
</tbody>
</table>
1 Introduction

Figure 1: Traffic Management Operative carrying assembled ‘wicket’ sign across carriageway

One of the highest risk activities for traffic management (TM) operatives is exposure to live traffic whilst deploying and removing temporary traffic management (TTM) signs. The current guidance provided in the Traffic Signs Manual, Chapter 8, Part 1: Design (Department for Transport/Highways Agency, 2009), requires the use of ‘wicket’ signs to indicate lanes open or closed ahead to traffic. On dual carriageway roads and motorways, Chapter 8 requires that these signs be placed on both sides of the carriageway, except on 5 and 6 lane carriageways where offside signing may be omitted within relaxation scheme works. Previous research of a monitored roll-out of a single-lane nearside closure with offside signs removed (Clark et al., 2011), and other subsequent research, led to the release of Interim Advice Note (IAN) 150/12, Guidance for Alternative Temporary Traffic Management Techniques for Relaxation Schemes on Dual Carriageways (Highways Agency, 2012), since updated with IAN 150/14 (Highways Agency, 2014) which permits the nearside only lane closure and signing technique to be safely applied in the approach and lane change zones of these relaxation schemes, for a single nearside closure, or closure of the two nearside lanes.

There is a small risk associated with placing signs on the nearside of the carriageway but the risk of placing signs on the offside is much greater due to the need for road workers to carry the equipment needed across the carriageway to the central reservation. This often requires a minimum of two or three return trips across the carriageway per location for the sign face, sign frame, illumination, stability bars and sandbags.

Carriageway crossings should be carried out in accordance with the advice given in the HSE Construction Information Sheet 53 (CIS53), ‘Crossing high-speed roads on foot during temporary traffic-management works’. Research by the HSE and others suggests that carrying out carriageway crossings in accordance with CIS53 is becoming increasingly difficult as traffic volumes increase. Even where the advice given in CIS53 is followed, crossing live carriageways remains a high risk activity. This is evident in the unfortunate fatality of a TM operative involved in crossing the carriageway to set out advance signing on the A24 in August 2013.

The Highways Agency (HA) has set out its overarching Aiming for Zero (AfZ) Strategy (Highways Agency, 2009). The AfZ Road Worker Safety Strategy has an overall aim of significantly reducing health and safety risks to road workers, through the elimination of road worker fatalities and serious injuries and the significant reduction of personal injury.
accidents to road workers. The Safety Strategy also seeks to completely eliminate the requirement for road workers to be on foot on a live carriageway during routine maintenance operations by 2016 (Exposure:Zero). The approach of eliminating offside signs described in this report is completely consistent with this aim and would also enable road works to be completed more quickly thus reducing on-road time and related congestion.

Paragraph D6.13.11 of Chapter 8 (Department for Transport/Highways Agency, 2009) currently permits offside wicket signing and the advance “road works 1 mile” to be omitted; however this is only applicable for the closure of a single nearside lane within relaxation scheme road works on 5 and 6 lane carriageways. As noted, previous work (Clark et al., 2011) has led to IAN150/12 and IAN 150/14 which extend this approach to relaxation schemes for a single nearside closure, or closure of the two nearside lanes.

This report will cover the work undertaken to trial the Offside Sign Removal technique for closure of lanes 3 and 2 (offised closures) on three lane dual carriageway with hard shoulder.

Within this report:

- Section 2 explains the current signing requirements and the alternative used during the trials.
- Section 3 details the methodology, design and implementation of the on-road trials.
- Section 4 covers the data collected and analysis undertaken.
- Section 5 discusses the statistical findings in the context of the on-road situation, and gives recommendations.
2 Current Signing and OSSR Alternative

The key requirement within the on-road trials of the offside signs relaxation technique was identifying whether risk to road users and road workers changed with the removal of the offside advance signs for a lanes 3 and 2 relaxation lane closure. This was achieved by monitoring the use of the technique and comparing the results with those from the current Chapter 8 relaxation scheme traffic management. This approach allowed the evaluation of the difference in road user behaviour and lane distribution of traffic between the two conditions.

2.1 Control layout

Current signing for relaxation road works is shown in Figure 2. This signing layout was used for the trial’s control condition. This comprised a Plan DZA3\(^1\) relaxation scheme approach zone and Plan DZB7 relaxation scheme lane change zone. The alternative taper (as per IAN163/12) is permitted for this signing layout.

![Diagram of control layout with Chapter 8 relaxation signing, using principles of DZA3 & DZB7](image)

*Figure 2: Control layout with Chapter 8 relaxation signing, using principles of DZA3 & DZB7*

\(^1\) Plan numbers refer to the plans within the Traffic Signs Manual Chapter 8 Part 1: Design (2009)
2.2 Experimental layout

The alternative layout used during on-road trials omitted offside advance signing for two-lane offside closures on three lane carriageways. This resulted in the lane closure being signed using a single “road works 1 mile” sign (Diagram 7001 / 7001.1 in the Traffic Signs Regulations and General Directions 2002) and four “wicket” signs (Diagram 7202 / 7208 in TSRGD) placed on the nearside verge only. A total of 4 “wicket” signs were placed at 200m intervals, starting 800m prior to the location of the first cone placed at the nearside of the entry taper (see Figure 3).

![Experimental signing layout with offside signs omitted](image)

**Figure 3: Experimental signing layout with offside signs omitted**

The entry taper followed the alternative taper layout (as per IAN163/12) and directly closed two lanes. This resulted in the first cone in each lane being located at the following points relative to the datum shown above:

**Table 1: Taper location relative to datum**

<table>
<thead>
<tr>
<th>Lane</th>
<th>Taper location relative to datum (m)</th>
<th>First cone in lane</th>
<th>Last cone in lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>135</td>
</tr>
<tr>
<td>2</td>
<td>135</td>
<td></td>
<td>270</td>
</tr>
<tr>
<td>1</td>
<td>No taper – lane open</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3 Trials Methodology, Planning and Implementation

3.1 Measurement method
The use of video recording allowed measurement of the effect of the proposed offside signs relaxation layout on driver lane choice and behaviour. Covert video monitoring equipment was fitted to nearside sign frames and directed downstream to determine lane occupancy and capture information regarding driver behaviour as shown. During later trials undertaken in Area 10, an additional system was placed at the start of the cone taper to monitor driver behaviour adjacent to it, in particular identifying ‘taper running’² (see Figure 4).

Video equipment was placed on the TTM signs by a member of Connect Plus staff after the closure had been installed by the TM crew assigned to the works.

² ‘Taper running’ was defined as any vehicle remaining within a closed lane beyond (downstream) of the first cone placed as part of the closure of that lane.

Figure 4: Camera locations
3.2 Data capture criteria

Previous monitoring activity had indicated that the difference between control and experimental scenarios was likely to be small, thus requiring a large sample of observations to ensure that such differences could be detected against the background variability in the data.

The sampling design created for this monitored trial was based around experience gained from several previous signing trials and involved collection of data for both experimental and control layouts. A balanced design was proposed to ensure that variations in traffic flow, composition and driver behaviour throughout the week were controlled for as far as possible.

3.3 Site selection criteria

It was not considered appropriate to install traffic management solely for the purposes of the trial. Connect Plus had the final decision on using sites selected according to guidance applying to relaxation schemes, including sight stopping distance and flow, to ensure the safety of both their operatives and of road users.

The following criteria were applied when selecting a monitoring location:

- It was a three lane carriageway with hard shoulder
- It did not incorporate a dedicated off-slip or on-slip as part of the running lanes
- It did not have a slip road in or near the approach zone
- It was not within major road improvement scheme traffic management (TM)
- The closure should occur during overnight works on a weeknight

In addition, works were subject to all limitations and restrictions imposed by contractors, Chapter 8 or the Highways Agency, including for example the maximum traffic flow and Heavy Goods Vehicle (HGV) proportion criteria defined in Chapter 8 under which relaxation works can be undertaken. This approach reduced risk to road workers, minimised the effect on Journey Time Reliability (JTR) and ensured that road user reaction was representative of real-world conditions.

Connect Plus considered that on-road works could be undertaken within the closed lane, subject to appropriate risk assessment. This had the benefit of ensuring that the choice of sites was representative of those where a technique such as this would be used.

3.4 Provision of resources

Ensuring the safe and effective trials of offside signing relaxation required that TRL and Connect Plus provide equipment, expertise, facilities and staff.

3.4.1 Connect Plus resource

During the programme Connect Plus provided the following resources:

- Carrying out of a generic risk assessment, followed by site-specific risk assessments and method statement preparation associated with on-road implementation of the experimental condition.
• Identification of suitable sites for deployment of the control and experimental layouts.
• Provision and management of trials planning and programming of works at which trial data were collected.
• Deployment and retrieval of all associated TM equipment.
• Deploying and removing camera equipment on the ‘A-frame’ signing.
• Obtaining data from each site/layout, with particular attention given to ensuring that memory cards from camera systems were returned with accurate identifying information (sign distance, time, date).
• Provision of supporting data regarding weather, visibility, topography, VMS signing.

As the trial involved omission of offside signing (which was a departure from Chapter 8 guidance) the work was flagged up to the Highways Agency’s Regional Control Centre by Connect Plus, in case of queries from observers unconnected with the on-road trials (e.g. Traffic Officers, police, members of the public).

3.4.2 TRL monitoring resource

During the project the TRL was responsible for provision of the following resources:

• Experimental design.
• Support to the approvals process required to enable the on-road trials to commence.
• Provision of video recording and recording systems.
• Support to operational trials.
• Analysis of video to obtain traffic counts (including HGVs) for both control and experimental conditions.
• Data handling, management and storage for the duration of the trials.
• Data analysis, interpretation and reporting.

Traffic monitoring during experimental and control conditions was undertaken using proprietary camera systems. These enabled collection of video footage on lit and unlit carriageways and allowed traffic flow, lane occupancy and driver behaviour to be quantified from the 800yds sign position to the 200yds sign position. The presence of a camera 200m before the taper also made it possible to track a vehicle’s position to the start point of the taper. The camera installed on the taper allowed driver behaviour within the initial taper zone to be monitored.

TRL uniquely identified each camera system corresponding to an A-frame sign measurement distance and provided labelled storage and despatch envelopes for each memory card to assist with the accurate return of camera data. Example camera views are shown in Figure 5.
Figure 5: Typical camera views; from ‘400yds’ wicket sign (top), ‘200 yds’ wicket sign (centre), start of taper (lower). These views are of the closure and signs shown in Figure 10.
4 Data Analysis

4.1 Video analysis criteria

Typically, up to two hours of video footage from each closure (control or experimental) was reviewed. Video analysis was undertaken by trained analysts. While viewing the video the following variables were recorded:

- Vehicle count, by lane.
- HGV percentage (of total flow).
- Any incidents or dangerous occurrences.
- Taper running.

An ‘incident or dangerous occurrence’ was defined as:

- A vehicle impacts with TM equipment, or any other collision.
- Evasive action by a vehicle because of action by others.
- Swerving, an extreme direction change.
- Dangerous driving, e.g. racing, blocking, lane hogging, obvious excess speed.
- Braking, in particular sustained brake lights, possibly with obvious change of speed.
- Late/poor merge, i.e. forcing into traffic in adjacent lane.

4.2 Incidents, dangerous occurrences and taper running

No incidents or dangerous occurrences were noted during video analysis of either control or experimental closures. There were several instances of taper running, but no taper strikes. No incidents were reported by TTM crews or supervisors.

Previous trials and observer reports provide a large body of evidence that taper running is not uncommon even with offside signs in place. Several instances of taper running were identified during video analysis, with around twice as many being under experimental conditions:

- During the 13 control trials there were 21 instances of taper running; six closures had no instances and two had six instances each
- During the 14 experimental closures there were 44 instances of taper running; two closures had no instances and two closures had nine and 10 instances respectively. The remainder ranged from one to five instances each.

Although the absolute numbers in the current dataset are too small to support a formal test of whether this difference is statistically significant, this is worthy of further investigation during any future monitoring.

4.3 Statistical analysis

The control and experimental data are counts of vehicles in each of three lanes at each sign point which were 800m, 600m, 400m and 200m before the start of the offside lane closure for the 800yds, 600yds, 400yds and 200yds signs respectively (lanes 3 and 2 closed). The data were collected at 13 control and 14 experimental sites on the M25.
Vehicles were counted for between 42 minutes and 2 hours at each site (dependent on the video data available).

4.3.1 Key question

The key question addressed by the trial is whether there is a difference in the behaviour of vehicles moving out of lanes 3 and 2 between control and experimental conditions.

4.3.2 Method

The statistical technique used to test this question is a repeated measures ANOVA. An ANOVA tests whether there is a statistically significant difference between a number of mean (average) values. A repeated measures analysis is required as the same vehicles are counted at four different points.

There are a number of different independent variables in the model – lane (L1-L3), sign point (800yds, 600yds, 400yds, 200yds) and trial (experimental and control). The dependent variable was the mean number of vehicles observed. The repeated measures ANOVA detects statistically significant differences in the dependent variable within each factor (e.g. whether there is a difference in the total number of vehicles in each lane) and within interactions between the factors (e.g. whether the number of vehicles in each lane varies by trial type and/or sign point). The two key elements are the interaction between trial and lane, and between trial, lane, and sign point. The first of these tells us whether lane occupancy through the approach to the taper varies for the control and experimental set-ups, and the latter tells us about lane changing behaviour broken down by sign point as well.

4.3.3 Results

The results of the repeated measures analysis are shown below for each factor and interaction.

Sign point significant (p<0.05)³

Table 2 shows the total number of vehicle counts made at each sign point at the 27 trial sites. The ANOVA model shows that these four numbers are statistically significantly different; this will be due to small differences in the starting times of videos.

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³ Statistical significance is classified into two categories within this report. A p-value of<0.05 indicates that there is a 95% chance that the comparison being made has arisen due to the variable under investigation, and not simply random fluctuations (‘noise’) in the data. A p-value of <0.10 indicates a 90% chance.
Table 2: Number of vehicles at each sign point

<table>
<thead>
<tr>
<th>Sign point</th>
<th>Vehicle count</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 yds</td>
<td>22,905</td>
</tr>
<tr>
<td>600 yds</td>
<td>22,078</td>
</tr>
<tr>
<td>400 yds</td>
<td>22,874</td>
</tr>
<tr>
<td>200 yds</td>
<td>22,567</td>
</tr>
</tbody>
</table>

Lane significant (p<0.05)

Table 3 shows the total number of vehicle counts made in each lane across the trial sites. Overall, 63% were observed in lane 1, 33% in lane 2 and 3% in lane 3 (percentages do not add up to 100 due to rounding). The ANOVA model confirms that the overall number of vehicles observed in each lane is significantly different.

Table 3: Number of vehicles in each lane

<table>
<thead>
<tr>
<th>Lane</th>
<th>Vehicle count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane1</td>
<td>57,268</td>
</tr>
<tr>
<td>Lane2</td>
<td>30,070</td>
</tr>
<tr>
<td>Lane3</td>
<td>3,086</td>
</tr>
</tbody>
</table>

Trial not significant (p>0.10)

Table 4 shows the total number of vehicle counts for the experimental and control layouts. The ANOVA model showed that these numbers were not significantly different from each other.

Table 4: Number of vehicles in each trial

<table>
<thead>
<tr>
<th>Trial</th>
<th>Vehicle count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>43,714</td>
</tr>
<tr>
<td>Experimental</td>
<td>46,710</td>
</tr>
</tbody>
</table>

Sign point * trial not significant (p>0.10)

Differences in the number of vehicles at each sign point are the same across the control and experimental layouts. That is, the variation in vehicle count at sign points does not differ between control and experimental trials.
Figure 6: Number of vehicles at each sign point in each trial

Sign point * lane significant (p<0.05)

Differences in the number of vehicles at each sign point vary by lane. In this case, there is a reduction in the proportion of vehicles in lanes 3 and 2 by the 200m point and a corresponding increase in the occupancy of lane 1.

Figure 7: Proportion of vehicles in each lane at each sign point
Trial * lane not significant (p>0.10)

The distribution of vehicles across the lanes does not differ between the experimental and control layouts. Figure 8 shows that the proportions of vehicles in each lane were broadly comparable across the experimental and control trials.

Figure 8: Proportion of vehicles in each lane in each trial

Sign point * trial * lane significant (p<0.05)

The interaction between sign point, trial and lane is significant. That is, the pattern of vehicles moving lanes across the 800yd to 200yd sign points differs between the experimental and control layouts.

Figure 9 shows the proportions of vehicles at each sign point in the control and experimental conditions in lanes 1, 2 and 3. At the 600yds, 400yds and 200yds sign points there would appear to be a higher proportion of vehicles in lanes 3 and 2 in the experimental group than the control group and vice versa in lane 1.

It is worth examining the proportions of vehicles in lane 3 at the 200yds sign point for the two conditions, since this arguably represents the point of greatest relevance in terms of risk (being the closest point to the beginning of the taper). The proportions of vehicles in each lane at the 200yds sign point are shown in Table 5. A proportion test shows that a significantly higher proportion of vehicles remained in lane 3 in the experimental layout (1.5%) than the control (0.9%). Although the proportions are small, the value for the experimental layout is over 50% greater than that of the control layout. This suggests that monitoring of vehicles in lane 3 under operational conditions should be given consideration.

Table 6 shows the proportion of vehicles in each lane at the 800yds sign point and the percentage point change from this at the 200yds sign point.
Figure 9: Proportion of vehicles in each lane

Table 5: Proportion of vehicles in each lane at 200m

<table>
<thead>
<tr>
<th>Lane</th>
<th>Control</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>73.7%</td>
<td>71.6%</td>
</tr>
<tr>
<td>L2</td>
<td>25.3%</td>
<td>26.9%</td>
</tr>
<tr>
<td>L3</td>
<td>0.9%</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

Table 6: Average, maximum and minimum proportion of vehicles observed across sites at 800m and percentage point change at 200m

<table>
<thead>
<tr>
<th>Lane</th>
<th>Control 800m</th>
<th>Change from 800m to 200m</th>
<th>Experiment 800m</th>
<th>Change from 800m to 200m</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Mean (Min, Max)</td>
<td>Mean (Min, Max)</td>
<td>Mean (Min, Max)</td>
<td>Mean (Min, Max)</td>
</tr>
<tr>
<td></td>
<td>54.2% (37.3%, 71.3%)</td>
<td>19.5% (13.7%, 24.9%)</td>
<td>55.0% (47.8%, 72.1%)</td>
<td>16.6% (8.1%, 23.3%)</td>
</tr>
<tr>
<td>L2</td>
<td>40.2% (25.3%, 51.3%)</td>
<td>-14.9% (-22.8%, -9.5%)</td>
<td>39.2% (25.2%, 47.1%)</td>
<td>-12.3% (-18.8%, -6.2%)</td>
</tr>
<tr>
<td>L3</td>
<td>5.6% (1.9%, 11.4%)</td>
<td>-4.7% (-10.0%, -1.9%)</td>
<td>5.8% (2.7%, 8.0%)</td>
<td>-4.3% (-7.1%, -1.9%)</td>
</tr>
</tbody>
</table>
4.3.4 **Traffic flows**

The sites had a range of traffic flows from 240 to 881 per hour in all lanes at 800m. High, medium and low flows were shared across experiment and control sites as shown in Table 7. The slight unbalance (a greater proportion of experimental sites were 400-600 vehicles per hour) is discussed below and controlled for in Table 10.

**Table 7: Number of control and experiment sites by hourly traffic flow**

<table>
<thead>
<tr>
<th>Average number of vehicles per hour</th>
<th>Control</th>
<th>Experimental</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-400</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>400-600</td>
<td>3</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>600+</td>
<td>4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13</strong></td>
<td><strong>14</strong></td>
<td><strong>27</strong></td>
</tr>
</tbody>
</table>

In order to determine if there is a significant difference in the distribution of flows across control and experimental conditions, a Mann-Whitney test was carried out. The Mann-Whitney test was not significant (p>0.10), showing that there is no significant difference in the median flows for the control and experimental groups.

4.3.5 **Day of the week**

Although every effort was taken to ensure the day of the week on which experimental and control trials were conducted was the same, there were slight differences. The distribution of trials by day of the week is given in Table 8. The slight unbalance is controlled for in Table 10.

**Table 8: Number of control and experiment sites by day of the week**

<table>
<thead>
<tr>
<th>Day of week</th>
<th>Control</th>
<th>Experimental</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Tuesday</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Wednesday</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Thursday</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Friday</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13</strong></td>
<td><strong>14</strong></td>
<td><strong>27</strong></td>
</tr>
</tbody>
</table>

4.3.6 **Count of HGVs**

Heavy goods vehicles may have an effect on lane changing behaviour under experimental conditions, since they may obscure nearside signs from other road users.

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4 Groupings calculated from hourly flow data for three lane links on the M25
The number of heavy goods vehicles was also recorded for both experimental and control sites to determine if there was a significant difference between the two.

The sites have a range of HGV flows from 13 to 141 per hour in all lanes at the taper. High, medium and low rates were shared across experiment and control sites as shown in Table 9. The slight unbalance is discussed below and controlled for in Table 10.

**Table 9: Number of control and experiment sites by hourly HGV flow**

<table>
<thead>
<tr>
<th>Average number of HGVs per hour</th>
<th>Control</th>
<th>Experimental</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-24</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>24-62</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>62+</td>
<td>5</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>14</td>
<td>27</td>
</tr>
</tbody>
</table>

In order to determine if there is a significant difference in the distribution of HGV flows across control and experimental conditions, a Mann-Whitney test was carried out. The Mann-Whitney test was not significant (p>0.10), showing that there was no significant difference in the median HGV flows for the control and experimental sites.

**4.3.7 Site selection**

The ANOVA results described above are based on 13 control sites and 14 experimental sites. In order to corroborate these results we have rerun the analysis several times removing a selection of sites (shown in Table 10) for different reasons. The result for the three-way interaction (*Sign point * trial * lane*) moves from significant (p<0.05) to only approaching significance when the analysis is balanced by flow and day of the week. It remains statistically significant when balanced by HGV flow. Therefore we conclude that the key result (the movement of vehicles across lanes by trial) is largely, but not completely stable to small unbalances to the study design.
Table 10: Selection of sites for additional analyses

<table>
<thead>
<tr>
<th>Extra analysis type</th>
<th>Remove sites</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hourly flow rates</td>
<td>N/A</td>
<td>As the counts were based on vehicle counts of between 42 minutes and 2 hours, each count was divided by the number of hours surveyed to give an hourly flow rate.</td>
</tr>
<tr>
<td>Balanced traffic flow</td>
<td>1, 3, 9, 11, 15, 16, 18, 25, 27</td>
<td>A random selection of sites were removed in order to have 4 experiment and 4 control sites in the low traffic banding (0-400), 3 of each in the medium band (400-600) and 2 of each in the high band (600+).</td>
</tr>
<tr>
<td>Balanced day of the week</td>
<td>7, 12, 17, 24, 25</td>
<td>A random selection of sites was removed in order to balance the day of the week on which experimental and control trials were conducted. This analysis was conducted with 2 trials on Monday, 2 on Tuesday, 3 on Wednesday, 2 on Thursday, and 2 on Friday for both experiment and control.</td>
</tr>
<tr>
<td>Balanced HGV flow</td>
<td>1, 18, 22</td>
<td>A random selection of sites were removed in order to have 4 experiment and 4 control sites in the low (0-24) med (24-62) and high (62+) hourly HGV rate bands.</td>
</tr>
</tbody>
</table>

4.3.8 Conclusions

The modelling concludes that the pattern of vehicles moving across lanes at the four different sign points varies significantly between control and experimental groups.

However when the analysis was re-run balancing for vehicle flow and day of the week the differences in movement across lanes at four different sign points became statistically non-significant. Nonetheless, small increases in the proportion of vehicles in lane 3, and possible increases in taper running, both associated with the experimental layout, suggest that monitoring of vehicles in lane 3 under operational conditions (particularly at 200m and nearer to the taper) should be given consideration.
5 Conclusions and recommendations

The Highways Agency requested that TRL undertake appropriate monitoring activity in order to determine whether removal of offside ‘wicket’ signs from the current Chapter 8 (Department for Transport/Highways Agency, 2009) ‘relaxation scheme’ traffic management layout on the approach to a lane 3 and 2 closure of a three-lane dual carriageway would cause a significant change in driver behaviour and lane choice.

The on-road trials used a proven methodology which monitored driver behaviour through the advanced signing zone approaching the taper and allowed statistical analysis of driver lane choice. Additional analysis was undertaken to determine whether any incidents or occurrences took place, such as poor merging behaviour.

Data were collected from 13 nights for the control layout (Plan DZA3 relaxation scheme approach zone and Plan DZB7 relaxation scheme lane change zone) and 14 nights for the experimental layout (omitting offside advance signing for two-lane offside closures on three lane carriageways).

Analysis showed that the overall pattern of vehicles moving across lanes at the four different sign points varied slightly between control and experimental groups. Greater proportions of vehicles were in lanes 3 and 2 throughout the approach to the taper (especially from 600m and closer), although this result became non-significant (although approaching significance) when the analysis was rerun balancing for day of the week and traffic flow.

At the last measurement point (200m before the taper) there was a statistically significant difference (0.9% in the control condition, 1.5% in the experimental condition) of the proportion of vehicles in lane 3. Although the absolute proportion is small, the significant increase may be worthy of consideration at implementation. The link between the statistically significant increase in lane 3 occupancy observed, and actual risk, has never been quantified.

More taper running incidents were observed in the experimental layout (although small numbers prevented formal statistical comparison). Previous trials and observer reports provide a large body of evidence that taper running is not uncommon, even with offside signs in place. This is confirmed by the current data. However, no dangerous occurrences or incidents were noted during any of the control or experimental closures.
As with lane occupancy data, further monitoring of such occurrences at implementation should be given consideration.

Taking all findings into account, it appears that the OSSR technique can be applied to lane 3 and 2 closures at relaxation scheme road works, with the caveats on monitoring for any (rare) adverse consequences, and taking into account the below recommendation on sequential road danger lamps.

### 5.1 Recommendations

On the balance of evidence in the current report, the use of the OSSR advanced signing does not substantially change driver behaviour and lane choice from the relaxation signing layout typically used for the closure of lanes 3 and 2 on three lane dual carriageways / motorways with hard shoulder. Therefore it is recommended that this layout be permitted for implementation.

However, since it has been identified in previous work that a major advanced warning for drivers in the offside lane (lane 3 approaching the taper) is likely to be the taper itself (assuming it is equipped with sequential flashing road danger lamps) it is considered essential that any traffic management deployed using the OSSR technique involving a lane 3 closure should meet the following requirements:

- Sequential flashing road danger lamps, specified in Chapter 8 Section D3.12.2, should always be used
- Any works should meet all of the visibility requirements specified in Chapter 8 Section D1.6.3.
Acknowledgements

The project team is grateful to Shaun Helman for technical review of the report.

On-road trials could not have been taken place, and data have been acquired so rapidly, without the full co-operation and support given by Stuart Baker, Colin Rudd and Simon Taylor of Connect Plus.

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Clark S, Palmer M, Lloyd L. (2011). Offside Signs Relaxation for Nearside Lane Closures, Results from monitored roll-out in Area 3. CPR1242


Department for Transport. (2002). Trial Report: Sequential Flashing Cone Lamps


Highways Agency (2012). Interim Advice Note 163/12 Guidance for Alternative arrangements for Entry Tapers at relaxation scheme temporary traffic management on high speed roads.


HSE. Construction Information Sheet 53 (CIS53), ‘Crossing high-speed roads on foot during temporary traffic-management works’.