CLIENT PROJECT REPORT CPR 1807

Offside Sign Removal On-Road Trials

Single offside lane closure on a dual carriageway/motorway with three lanes

Palmer M, Clark S, Reeves C

Prepared for: Balfour Beatty Mott MacDonald & HW Martin Traffic Management Ltd.

Quality approved:

Siggi Clark
(Project Manager)

Shaun Helman
(Technical Referee)
Disclaimer

This report has been produced by the Transport Research Laboratory under a contract with Balfour Beatty Mott MacDonald / HW Martin Traffic Management Ltd. Any views expressed in this report are not necessarily those of Balfour Beatty Mott MacDonald / HW Martin Traffic Management Ltd.

The information contained herein is the property of TRL Limited and does not necessarily reflect the views or policies of the customer for whom this report was prepared. Whilst every effort has been made to ensure that the matter presented in this report is relevant, accurate and up-to-date, TRL Limited cannot accept any liability for any error or omission, or reliance on part or all of the content in another context.

When purchased in hard copy, this publication is printed on paper that is FSC (Forest Stewardship Council) and TCF (Totally Chlorine Free) registered.

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>
<tr>
<td>1.0</td>
<td>12/12/13</td>
<td>First draft</td>
<td>MJP</td>
<td>IR</td>
</tr>
<tr>
<td>1.1</td>
<td>11/02/14</td>
<td>Final draft</td>
<td>MJP</td>
<td>SH</td>
</tr>
<tr>
<td>2.0</td>
<td>06/03/14</td>
<td>Client version</td>
<td>MJP</td>
<td>SH</td>
</tr>
</tbody>
</table>
## Contents

1  Introduction .......................... 5  
2  Current Signing and OSSR Alternative .......................... 7  
   2.1  Control layout .......................... 7  
   2.2  Experimental layout ................... 8  
3  Trials methodology ................... 9  
   3.1  Data capture criteria ................. 9  
   3.2  Site selection criteria ............... 9  
   3.3  Experimental condition operational methodology ............ 10  
   3.4  Locations ............................. 11  
   3.5  Provision of resources ............... 11  
      3.5.1  Balfour Beatty Mott MacDonald / HW Martin resource .... 11  
      3.5.2  TRL monitoring resource .......... 12  
4  Initial experimental closure .......... 14  
   4.1  Vehicle tracking analysis ............ 14  
   4.2  Summary of vehicle tracking analysis ...... 21  
   4.3  Obscuration: implications for trials .... 21  
      4.3.1  Comparison of control and experimental trials ......... 22  
      4.3.2  Comparison of M20 with other Area 4 motorways ....... 23  
      4.3.3  Summary ........................... 23  
5  Trials data analysis ................. 25  
   5.1  Taper running ....................... 25  
   5.2  Available Data ....................... 26  
   5.3  Checking for comparability between control data .......... 26  
   5.4  Method ............................... 26  
   5.5  Results ............................... 27  
      5.5.1  Traffic flows ..................... 31  
      5.5.2  Day of the week .................. 32  
      5.5.3  HGV count ....................... 32  
      5.5.4  Site selection .................... 32  
   5.6  Conclusions ......................... 33  
6  Conclusions and recommendations .... 34  
   6.1  Recommendations .................... 35
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 live carriageways. 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. Eliminating 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 led to the release of Interim Advice Note 150/12, Guidance for Alternative Temporary Traffic Management Techniques for Relaxation Schemes on Dual Carriageways (Highways Agency, 2012), 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 lane closure, or closure of the two nearside lanes. Further trials were completed in November 2013 which extended this technique to a closure of three nearside lanes on a four lane carriageway.

The current trial was conducted using a well-established methodology to examine the effect of this technique on a closure of a single offside lane on a three lane carriageway.

The statistical analyses of the trial results showed that the lane occupancy pattern of vehicles moving across lanes at four different sign points (800yds, 600yds, 400yds and 200yds) did not vary in the control and experimental conditions. Therefore on-road monitored trials showed that there is no statistical evidence to suggest that omission of offside signing for a Lane 3 closure on a three lane carriageway results in any difference in the lane movement of vehicles when compared with either TSM Chapter 8 relaxation closures or the optional alternative signing provided in Interim Advice Note 150/12.

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) be given consideration.

Taking all findings into account, it is considered likely that the use of the OSSR advanced signing layout poses no greater risk to either road workers or road users than the relaxation signing layout typically used for the closure of a single offside lane on three lane dual carriageways / motorways with hard shoulder. 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

Balfour Beatty Mott MacDonald / HW Martin Traffic Management Ltd. 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 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 a single offside lane closure on a dual carriageway / motorway with three lanes.
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 Balfour Beatty Mott MacDonald / HW Martin Traffic Management Ltd., including any limitations of the offside removal 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:</td>
<td>Provide support for the on-road trials of omitting offside advance warning signs for single-lane offside lane closures at relaxation scheme road works</td>
<td>Provide assistance to Balfour Beatty Mott MacDonald / HW Martin Traffic Management Ltd. to gain permissions from Highways Agency, engage with HA ‘Aiming for Zero’ programme team and comply with HA internal governance</td>
</tr>
<tr>
<td>-</td>
<td>Provide support for on-road trials</td>
<td>Methodology designed using proven techniques used in previous signs trials</td>
</tr>
<tr>
<td>2/3:</td>
<td>Design and implement a methodology to monitor driver behaviour and reaction to conventionally signed road works and to the offside sign removal method used in the on-road trials</td>
<td>Methodology implemented by Balfour Beatty Mott MacDonald / HW Martin Traffic Management Ltd. (with TRL support)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4:</td>
<td>Compare the safety performance of both sets of road works for both road users and road workers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Analyse safety performance data</td>
<td>Data from monitoring exercise analysed for erratic driver behaviour, and dangerous occurrences</td>
<td>Section 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Undertake statistical analysis of traffic lane occupancy data</td>
<td>Statistical analysis of lane occupancy data at each data measurement point</td>
<td>Section 5.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5:</td>
<td>Report the key findings to Balfour Beatty Mott MacDonald / HW Martin Traffic Management Ltd., including any limitations of the offside sign removal technique for relaxation road works signing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Analysis of the results obtained from the on-road evaluations</td>
<td>Statistical analysis of result carried out</td>
<td>Section 5.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Review of the effect of both the current Chapter 8 TTM configuration and the offside removal configuration on lane merging behaviour and lane choice</td>
<td>Statistical analysis and discussion of result completed</td>
<td>Section 5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<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>
<td>Statistical analysis of result undertaken and a summary of conclusions and associated recommendations</td>
<td>Sections 5.6 &amp; 6</td>
</tr>
</tbody>
</table>
1 Introduction

![Figure 1: Traffic Management operative carrying assembled 'wicket' sign across carriageway](image)

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 150/12, Guidance for Alternative Temporary Traffic Management Techniques for Relaxation Schemes on Dual Carriageways (Highways Agency, 2012), 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 the 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 by 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, though 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. Previous research of a monitored roll-out of a single and two lane nearside closures with offside advanced signs removed (Clark et al., 2011) led to the release of Interim Advice Note 150/12, Guidance for Alternative Temporary Traffic Management Techniques for Relaxation Schemes on Dual Carriageways (Highways Agency, 2012), 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 lane closure, or closure of two or three nearside lanes.

This report will cover the work undertaken on behalf of Balfour Beatty Mott MacDonald / HW Martin Traffic Management Ltd. to trial the Offside Sign Removal technique where Lane 3 is closed 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 used during the on-road trials.
- Section 4 details the results of the initial experimental closures, subsequent video analysis and comparison of HGV density within Area 4 and Area 10.
- Section 5 covers the by-lane data collected and statistical analysis undertaken.
- Section 6 gives recommendations based on the results from the on-road trials.
2 Current Signing and OSSR Alternative

The key requirement within the trial 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 Lane 3 relaxation lane closure. This was achieved by monitoring a control layout (Chapter 8 relaxation scheme) and experimental condition (offside signs removed) for a single offside lane closure on a three lane dual carriageway / motorway with hard shoulder. 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

Two layouts could be used for the control condition, with the decision of which to use based on an appropriate location-specific risk assessment:

- Chapter 8 relaxation scheme layout for a Lane 3 closure on a three-lane dual carriageway with hard shoulder. This comprised a Plan DZA3\(^1\) relaxation scheme approach zone, Plan DZB6 relaxation scheme lane change zone and alternative taper, as per Interim Advice Note 163/12 (see Figure 2).

- Sign Simplification layout, varied from TSM Chapter 8 Part 1 relaxation scheme guidance provided in Plan DZB6 (for a single offside lane closure). The “lane closed to traffic ahead” signs (TSRGD 2002 sign diagrams 7202 & 7208) may be omitted, from both the nearside and offside, at 600 yards and 200 yards upstream of the taper, and also the “Detail A” elements may be omitted (Table A.1.5 of the TSM Chapter 8) on the hard shoulder (where applicable) adjacent to the entry taper (see Figure 3). The alternative taper (as per IAN163/12) is permitted for this signing layout.

---

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

The experimental layout was a Chapter 8 relaxation layout for a Lane 3 closure on a three-lane dual carriageway with hard shoulder, but with offside signs to Diagram 7001 / 7001.1 and Diagram 7202 / 7208 removed from the approach and lane change zones (see Figure 4). The alternative taper is also permitted for this signing layout.

---

2 Advanced warning signs are placed at distances measured, from the datum at the start of the taper, in metres. However, these signs display distances as ‘yds’ or ‘mile’

3 Sign Diagram numbers refer to the diagrams within the Traffic Signs Regulations and General Directions 2002
3 Trials methodology

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 the taper, in particular identifying ‘taper running’; see Figure 5.

Figure 5: Experimental video imaging locations

3.1 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 ‘noise’ 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 scenarios. 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.

3.2 Site selection criteria

It was not considered appropriate to install traffic management solely for the purposes of the trial. Furthermore, Balfour Beatty Mott MacDonald and HW Martin Traffic Management considered that initially, on-road works should not to be undertaken within the closed lane being monitored for the experimental layout. Therefore to allow trials to proceed, initially they involved works where Lane 3 on each carriageway was closed (commonly known as a ‘back to back’ closure) but where only one of these closed lanes contained road workers. Commonly in these instances one carriageway is used as a safety lane and therefore the workforce is not required to work within that lane closure. This safety lane was used to operate the experimental condition and reduce the risk exposure of the workforce.

4 ‘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.
In addition to the above requirement the following criteria were applied for selecting a monitoring location:

- It should be a three lane carriageway with hard shoulder
- It should 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 occurred 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.

3.3 Experimental condition operational methodology

The monitored roll-out was carried out in the Highways Agency MAC Area 4 by Balfour Beatty Mott MacDonald and HW Martin Traffic Management. Both Balfour Beatty Mott MacDonald and HW Martin Traffic Management as the operational providers required that the experimental trial be conducted in 3 stages:

**Stage 1:** The first operational stage for assessment of the experimental condition required a Lane 3 closure on both carriageways of the road on which the trial was to be conducted (a ‘back to back’ closure). This allowed deployment of and access to offside advanced signs from within the closure on the opposing carriageway without requiring further carriageway crossings. During this first stage the entry taper was deployed under a full Chapter 8 relaxation signing layout (the control layout) and then offside signs were removed from sight by operatives within the opposite closure. Prior to removal of the closure, the offside advanced signs were reinstated from within the back to back closure, and then the lane closure and entry taper were removed. This approach allowed for the collection of driver behaviour and lane choice to be gained without requiring operatives to be directly exposed to traffic under experimental conditions.

**Stage 2:** Whilst the first operational stage would provide understanding of driver behaviour and lane choice under experimental conditions the methodology would not provide experience and understanding of these behaviours during the tasks of deployment and removal of the entry taper and lane closure. The second stage required operatives to undertake these tasks without advanced signing on the offside (the experimental condition). Trials were still to be conducted only where a Lane 3 closure was also being conducted on the opposing carriageway, therefore allowing offside signs to be placed and displayed if required from a position of relative safety.

**Stage 3:** The final stage of the planned operational methodology was to trial the experimental condition without the use of any advanced signs being placed on the offside, so removing the need for works sites with a back to back closure.

During all three stages, video data would only be analysed between the time period when the closure was fully installed and prior to it being removed.
3.4 **Locations**

The site selection criteria described in Section 3.2 were applied by Balfour Beatty Mott MacDonald when planning the trial. Balfour Beatty Mott MacDonald and HW Martin Traffic Management made the final decision on site selection based on an appraisal of the safety of their operatives and of road users. This ensured that the choice of sites was representative of where a technique such as this would be used.

3.5 **Provision of resources**

Ensuring the safe and effective monitored roll-out of offside signing relaxation required that TRL, Balfour Beatty Mott MacDonald and HW Martin Traffic Management all provided equipment, expertise, facilities and staff to support the trials.

3.5.1 **Balfour Beatty Mott MacDonald / HW Martin resource**

During the programme Balfour Beatty Mott MacDonald and HW Martin Traffic Management Ltd provided the following on-road resources:

- Provision and management of the monitored roll-out planning and programming of works at which trial data could be collected.
- 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.
- Production of Traffic Management drawings for control and experimental layouts.
- Deploying and removing camera equipment on the ‘A-frame’ signing.
- Obtaining data from each site/layout, with particular attention given to ensuring memory cards from camera systems were returned with accurate identifying information (sign distance, time, date).
- Undertaking observations of traffic behaviour if required.
- Provision of supporting data regarding weather, visibility, topography, VMS signing etc.
- Deployment and retrieval of all associated TM equipment.

Deployment and retrieval of traffic management for the experimental condition was based on the standard operating procedure (SOP) for the existing Chapter 8 ‘relaxation’ layout, with the deployment and retrieval process as detailed in the Balfour Beatty Risk Assessment, Balfour Beatty Mott MacDonald Method Statement and HW Martin Traffic Management Ltd. Method Statement.

As the roll-out involved removal of offside signing (which was a departure from Chapter 8 guidance), the Highways Agency’s Regional Control Centre was informed of the work by Balfour Beatty Mott MacDonald, in case of queries from observers unconnected with the monitored roll-out (e.g. Traffic Officers, police, members of the public).
3.5.2 **TRL monitoring resource**

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

- Experimental design.
- Support to the approvals process required to enable the trial 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 trial.
- Data analysis, interpretation and reporting.

Traffic monitoring during the trial was accomplished using camera systems provided by TRL which allowed collection of video footage on both lit and unlit carriageways. Footage allowed traffic flow, lane occupancy and driver behaviour to be assessed throughout the advanced sign zone from the 800yds sign position to beyond the 200yds sign position and at the start of the entry taper. Cameras were positioned on nearside sign frames. Typical camera images are shown in Figure 6 and Figure 7. Each camera system was uniquely identified corresponding to an A-frame sign measurement distance. TRL provided labelled storage cases to assist with the accurate return of camera data.

![Figure 6: Camera view from the ‘400yds’ advanced sign, in lit conditions](image)

Figure 7: Camera view from the ‘200yds’ advanced sign, in unlit conditions
4 Initial experimental closure

Control data were gathered in Area 4 of the Highways Agency’s network, with the initial two experimental closures also conducted in this Area. However, concerns were raised by the road workers after the second experimental closure, regarding the potential of obscuration of nearside signs due to the nearside lane(s) being occupied by HGVs. A ‘near miss’ report was raised, see Figure 8. The road workers had been replacing failed sequential road danger lamps on the taper; their vehicle was positioned on the opposite carriageway, within the back to back closure.

![INCIDENT/OBSERVATION OR OCCURRENCE REPORT (IOOR)](image)

**Figure 8: 'Near miss' report (anonymised) for second experimental closure (18/12/12)**

4.1 Vehicle tracking analysis

At the time of the reported incident, the TM crew were working on the taper, replacing a failed sequential cone lamp. As a result of this report, the experimental trials were halted and additional video analysis was undertaken to determine potential causes of concerns. Video recordings of both experimental trials were re-analysed to identify any vehicle which remained in Lane 3 during the final 200m approach to the taper. Using video from all four cameras placed on sign frames it was possible to estimate the position of vehicles in Lane 3 relative to other vehicles and their paths of travel, and the potential for obscuration of the drivers’ view of nearside signs. The diagrams from this re-analysis are presented in Figure 9 - Figure 28, with the time each vehicle passed the camera placed on the 200yds sign. This analysis was extended to additional video recorded earlier than that used for the statistical analysis of driver behaviour.

With each vehicle’s path of travel is a subjective assessment of which signs might have been obscured from the driver. If a traffic management or works vehicle was in place on the opposite carriageway, this is shown on the diagram. It must be emphasised that the camera systems were not positioned so video data could be used for this purpose and that the resulting obscuration information is estimated only.
Figure 9: Experiment 1 (17/12/12) Vehicle 1, 00:45
- 800: Not obscured
- 600: Not obscured
- 400: Not obscured
- 200: Not obscured

Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.

Figure 10: Experiment 1 (17/12/12) Vehicle 2, 00:49
- 800: Obscured
- 600: Not obscured
- 400: Not obscured
- 200: Obscured

Driver in lane 3 had a clear view of the taper from the 200yds advanced warning sign.

Figure 11: Experiment 1 (17/12/12) Vehicle 3, 00:51
- 800: Not obscured
- 600: Obscured
- 400: Not obscured
- 200: Obscured

Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.
Figure 12: Experiment 1 (17/12/12) Vehicle 4, 00:51
- 800: Not obscured
- 600: Not obscured
- 400: Possibly obscured
- 200: Possibly not obscured

Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.

Figure 13: Experiment 1 (17/12/12) Vehicle 5, 01:25
- 800: Not obscured
- 600: Obscured
- 400: Not obscured
- 200: Not obscured

Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.

Figure 14: Experiment 1 (17/12/12) Vehicle 6, 02:06
- 800: Not obscured
- 600: Possibly obscured
- 400: Not obscured
- 200: Not obscured

Driver in lane 3 had a clear view of the taper from the 600yds sign point.
It is possible that both drivers in lane 3 suffered obscuration; however, the first driver had enough time to move into lane 2 before reaching the 200yds sign point, leaving a clear view ahead for the second driver.

Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.
Figure 18: Experiment 2 (18/12/12) Vehicle 3, 22:36
- 800: Not obscured
- 600: Obscured
- 400: Obscured
- 200: Possibly not obscured

Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.

Figure 19: Experiment 2 (18/12/12) Vehicle 4, 22:37
- 800: Possibly obscured
- 600: Obscured
- 400: Obscured
- 200: Obscured

Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.

Figure 20: Experiment 2 (18/12/12) Vehicle 5, 23:11
- 800: Possibly obscured
- 600: Obscured
- 400: Possibly not obscured
- 200: Possibly not obscured

Driver in lane 3 had a clear view of the taper earlier than the 400yds sign point.
Figure 21: Experiment 2 (18/12/12) Vehicle 6, 23:15
- 800: Not obscured
- 600: Possibly not obscured
- 400: Obscured
- 200: Obscured

Driver in lane 3 had a clear view of the taper earlier than the 200yds sign point.

Figure 22: Experiment 2 (18/12/12) Vehicle 7, 23:59
- 800: Not obscured
- 600: Possibly not obscured
- 400: Obscured
- 200: Not obscured

Driver in lane 3 had a clear view of the taper earlier than the 200yds sign point.

Figure 23: Experiment 2 (18/12/12) Vehicle 8, 00:03
- 800: Not obscured
- 600: Not obscured
- 400: Not obscured
- 200: Not obscured

Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.
Figure 24: Experiment 2 (18/12/12) Vehicle 9, 00:03
- 800: Not Obscured
- 600: Not obscured
- 400: Not Obscured
- 200: Not Obscured
Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.

Figure 25: Experiment 2 (18/12/12) Vehicle 10, 00:33
- 800: Possibly obscured
- 600: Not obscured
- 400: Not obscured
- 200: Possibly obscured
Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.

Figure 26: Experiment 2 pre-count (18/12/12) Vehicle 1, 22:22
- 800: Possibly obscured
- 600: Not obscured
- 400: Not obscured
- 200: Obscured
Figure 27: Experiment 2 pre-count (18/12/12) Vehicle 2, 22:36

- 800: Not Obscured
- 600: Not obscured
- 400: Not Obscured
- 200: Not Obscured

Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.

Figure 28: Experiment 2 pre-count (18/12/12) Vehicle 3, 22:37

- 800: Not Obscured
- 600: Possibly obscured
- 400: Obscured
- 200: Obscured

Driver in lane 3 had a clear view of the taper throughout the advanced warning sign area.

4.2 Summary of vehicle tracking analysis

From the 20 instances identified in the two initial trials using the experimental sign layout, 13 involved drivers who had a clear view ahead through the advanced signing zone to the taper (cones with sequential flashing lamps). Previous Highways Agency research has identified how drivers react to sequential flashing road danger lamps installed onto tapers, at distances of up to 600m upstream from the taper. No instances were identified where the drivers involved are likely to both have had their view of all advanced warning signs obscured and their view ahead to the taper restricted. The instances identified are consistent with what might have been expected due to poor driver behaviour, and are not necessarily as a direct result of the removal of offside signs. However, several of the instances occurred when there were HGVs occupying the nearside lanes.

4.3 Obscuration: implications for trials

Due to the concerns raised by the traffic management operatives, trial deployments of the OSSR sign layout were halted, and additional analysis was undertaken to determine
whether HGV density on the M20, where the control closures and initial two experimental closures took place, is representative of other motorways within the HA’s Area 4.

4.3.1 Comparison of control and experimental trials

Table 1 displays the average hourly flow per lane at the 200 yard advance sign for each of the control and experimental trials.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Date</th>
<th>Flow L1</th>
<th>Flow L2</th>
<th>Flow L3</th>
<th>HGV Flow (200m)</th>
<th>Percentage HGV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>27/05/2012</td>
<td>243</td>
<td>97</td>
<td>2</td>
<td>342</td>
<td>31%</td>
</tr>
<tr>
<td>Control</td>
<td>30/05/2012</td>
<td>360</td>
<td>192</td>
<td>2</td>
<td>554</td>
<td>43%</td>
</tr>
<tr>
<td>Control</td>
<td>12/06/2012</td>
<td>347</td>
<td>171</td>
<td>2</td>
<td>520</td>
<td>32%</td>
</tr>
<tr>
<td>Control</td>
<td>13/06/2012</td>
<td>314</td>
<td>131</td>
<td>0</td>
<td>445</td>
<td>28%</td>
</tr>
<tr>
<td>Control</td>
<td>14/06/2012</td>
<td>249</td>
<td>85</td>
<td>0</td>
<td>334</td>
<td>33%</td>
</tr>
<tr>
<td>Control</td>
<td>15/06/2012</td>
<td>401</td>
<td>308</td>
<td>0</td>
<td>709</td>
<td>23%</td>
</tr>
<tr>
<td>Control</td>
<td>26/06/2012</td>
<td>206</td>
<td>85</td>
<td>1</td>
<td>292</td>
<td>39%</td>
</tr>
<tr>
<td>Control</td>
<td>17/12/2012</td>
<td>251</td>
<td>76</td>
<td>1</td>
<td>328</td>
<td>44%</td>
</tr>
<tr>
<td>Experiment</td>
<td>17/12/2012</td>
<td>195</td>
<td>60</td>
<td>3</td>
<td>258</td>
<td>59%</td>
</tr>
<tr>
<td>Experiment</td>
<td>18/12/2012</td>
<td>288</td>
<td>114</td>
<td>5</td>
<td>407</td>
<td>51%</td>
</tr>
</tbody>
</table>

Due to the limited data available, data are not suitable for robust statistical analysis. However, a number of similarities and differences between the control and experimental trials can be observed.

The overall hourly flow at 200m was comparable between control and experimental trials. The average hourly flows experienced throughout these trials are typical of the flows experienced on the M20 at this time of year and day.

The average hourly flow in the closed lane (lane 3) was slightly higher in the two experimental trial nights than any of the eight control nights available for analysis. Vehicles travelling in lane 3 may not see advance signs displayed only on the nearside; this may explain why more vehicles remain in lane 3 at 200m compared with the control condition.

HGV proportion was higher during the two experimental trial nights than any of the control nights. The experimental closures were installed later than the control trials and hence traffic composition is likely to have changed. The higher proportion may have contributed to the increase in vehicles seen in lane 3, due to the increased obscuration this is likely to represent. The HGV proportions experienced throughout the control and experimental trials are typical of the M20 at this time of year and day.
4.3.2 Comparison of M20 with other Area 4 motorways

Hourly flow data were obtained for a number of links on the M20 in Area 4. These data were compared with data obtained for other 3 lane stretches of motorway within this area; namely M2 junctions 3 to 4 and M23 junctions 8 to 10.

These data were obtained from a number of sources:

- MIDAS (Motorway Incident Detection And Signalling) loops which are part of the queue protection and controlled motorway system. Links that have these systems installed typically have loops every 500 metres.
- TRADS (TRAffic Data System) is an HA database which holds traffic flow data from various sources. For some links, this data source will be one of the MIDAS loops. Where these data are available there is one measurement point per link.
- Radar trailers located on various links on the M20.

Average hourly traffic flows are similar on the M20, M2 and M23. These hourly flows follow a similar pattern during the period 10pm to 5am; typically traffic flow peaks during the hour 10pm to 11pm, decreases as the night progresses and begins to increase around 3am to 4am.

For each link, flow data were obtained by vehicle class. Vehicles are classified by length into four categories: up to 17ft (5.2m), 17 to 22ft (5.2 to 6.6m), 22 to 38ft (6.6 to 11.6m) and over 38ft (over 11.6m). In order to determine the average hourly HGV flow (and HGV proportion) HGVs were classified as vehicles over 22ft (6.6m) in length.

Typically, average hourly HGV flows are higher on M20 than either M2 or M23 (see Figure 29).

![Average hourly HGV flow (carriageway B, February/March 2013)](image)

4.3.3 Summary

The M20 links the M25 to Folkestone, near Dover; as such, HGVs will use this road as a major route for transferring goods to and from the ferry port. This is likely to explain the
high HGV flows experienced on this road when compared with other similar motorways within the same area. Due to the lower hourly HGV flows on the M2 and M23, the typical HGV proportion for these motorways is much lower than links on the M20.

Two nights of experimental condition trial data were collected in December 2012. Analysis of the data from these first two nights of experimental condition in Area 4 showed the presence of a significantly high proportion of HGVs (between 50 and 60%). Visual assessment of the recorded video footage showed that HGV’s were grouped closely together in Lanes 1 and 2, potentially causing increased levels of obscuration of the nearside signs. This HGV driver behaviour was confirmed by the local Area team, where it has become known as “platooning”. On this basis, a joint decision was taken by BBMM and TRL, that an alternative trial location should be sought, with lower percentage HGVs, and where conditions are not subject to the influence of local factors such as the presence of ports.

BBMM were very keen that the trials should continue in a BBMM Area and Area 10 was suggested as a potential trial location. Initial analysis of historical flow data indicates that HGV proportions range from 6 to 44%, with an average of 20%. The conditions in Area 10 are therefore more suitable as a trial location for Stage 3, and it was recommended that support should be given to move the Stage 3 Trials from Area 4 to Area 10.
5 Trials data analysis

The data obtained from analysis of video data from the camera systems placed through the approach to the works site allowed traffic flow, lane occupancy and driver behaviour to be quantified from the 800yds sign position to the 200yds sign position.

Typically, up to two hours of video 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 occurrences.
- Taper running.

An ‘incident or occurrence’ was defined as:

- A vehicle impacts with TM equipment, or any other collision.
- Evasive action by a vehicle.
- 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.
- Excessive traffic within 200m of the taper.

‘Taper running’ data were also collected from trials undertaken in Area 10.

If any incidents or occurrences had been noted (there were none), the traffic management operatives would have been notified and trials halted.

5.1 Taper running

Taper running data were collected from five control and 16 experimental closures undertaken in Area 10.

During the five control closures, there were two closures with no taper running, two with one instance and one closure with five instances.

During the 16 experimental closures, there were six closures with no taper running identified. There were two trials with one instance recorded, two with two instances, and two with three instances. One trial had five instances, and one had six. One trial experienced 21 instances; this was the closure with the highest flow recorded of all the experimental closures, with 1418 vehicles recorded, although the next highest flow of 1209 vehicles had just two instances of taper running.

The number of taper running events at the experimental sites was more than double that at the control sites. 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.
From previous trials information, TRL has received verbal reports that taper running is not uncommon, even with offside signs in place.

5.2 Available Data

The control and experimental data are counts of vehicles in each of three lanes at each sign point, these being 800m, 600m, 400m and 200m before the start of an offside single lane closure (lane 3 closed). Data were collected at five control and 15 experimental sites in Area 10. The control data were supplemented with additional control data collected in Area 4 (five nights) and Area 10 (two nights) as part of the experimental trials for Sign Simplification 1B (see Section 5.3). Vehicles were counted for between 30 minutes and four hours at each site (dependent on the data available).

5.3 Checking for comparability between control data

Before combining the control data from different areas and time periods it is important to check that the data are comparable. All the control data were from sites where the sign simplification layout was used.

The following checks were made:

1. Checks to determine if there was a difference in the results from the two Area 10 data collection periods (i.e. is there a difference in the way in which vehicles change lanes between the recent data and the data collected in 2011 in Area 10 as part of the experimental trials for Sign Simplification 1B?)
   - The distance from the taper at which the vehicles change lanes appears similar so we can combine the data from these two trials; therefore we have seven control nights in Area 10.

2. Checks were made to determine if there was a difference between the results of the two areas (i.e. is there a difference in the way in which vehicles change lanes between the two areas?)
   - The data from Area 4 and Area 10 appear similar so we can combine the data from these two trials; therefore we have 12 control nights

Hence, the analysis was run on 12 controls sites (from Areas 10 and 4) and 15 experimental sites (all from Area 10).

5.4 Method

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

There were a number of different independent variables in the model – lane (L1-L3), sign point (800, 600, 400, 200) and trial (experimental and control). The dependent variable was the mean number of vehicles observed. The repeated measures ANOVA detects statistically significant differences on the dependent variable within each factor (e.g. whether there is a difference in the total number of vehicles observed in each lane) and within interactions (e.g. whether the number of vehicles in each lane varies by trial
type and/or sign point). In order to answer the research question, the key elements are the interactions between trial and lane, and between trial, lane, and sign point.

5.5 Results

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

*Sign point* not significant (p>0.10)

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 not statistically different. Slight differences between sign points are due to small differences in the starting times of videos.

**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>800yds</td>
<td>26,438</td>
</tr>
<tr>
<td>600yds</td>
<td>26,642</td>
</tr>
<tr>
<td>400yds</td>
<td>26,356</td>
</tr>
<tr>
<td>200yds</td>
<td>26,517</td>
</tr>
</tbody>
</table>

*Lane* significant (p<0.05)5

Table 3 shows the total number of vehicle counts made in each lane across the trial sites. Overall, 65% were observed in lane 1, 33% in lane 2 and 2% in lane 3. The ANOVA model confirms that the overall number of vehicles observed in each lane is statistically 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>68,903</td>
</tr>
<tr>
<td>Lane2</td>
<td>35,053</td>
</tr>
<tr>
<td>Lane3</td>
<td>1,997</td>
</tr>
</tbody>
</table>

*Trial* significant (p<0.05)

Table 4 shows the total number of vehicle counts at the experimental and control sites. The ANOVA model showed that these numbers are sufficiently different to be statistically significant. The numbers differ due to a difference in the amount of time vehicles in each trial were counted; data from the experimental phase of Sign Simplification 1B were

---

5 Statistical significance is classified in two categories within this report. A p-value<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<0.10 indicates 90% confidence (less confident).
counts of vehicles for up to four hours whereas the most recent data were counts for up to two hours.

Table 4: Number of vehicles in each trial

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Vehicle count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>64,080</td>
</tr>
<tr>
<td>Experiment</td>
<td>41,873</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 groups. That is, the effect of sign point on vehicle count does not differ between control and experimental trials.

*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 lane 3 from the 800yds to the 200yds sign points, and a corresponding increase in the proportion of vehicles in lane 1.
Trial * lane significant (p<0.05)

The distribution of vehicles across the lanes differs between the experiment and control sites. Figure 32 shows that a larger proportion of vehicles were in lanes 1 and 3 in the experimental condition than the control; the opposite was true in lane 2. The proportion of vehicles in lane 3 is very small in both conditions. Nonetheless in so far as it is preferable to have vehicles in lanes 1 and 2 (but not lane 3) on the approach to a lane 3 closure, this finding suggests that monitoring of vehicles in lane 3 under operational conditions should be given consideration.
Sign point * trial * lane not significant (p>0.10)

The interaction between sign point, experiment and lane is not significant. That is, the pattern of vehicles moving lanes across the 800yds to 200yds sign points does not differ between the experimental and control conditions.

Figure 33 shows the proportions of vehicles at each sign point in the control and experimental conditions in Lanes 1, 2 and 3.

Table 6 shows the proportion of vehicles in each lane at the 800yds sign point and the percentage point change at 200yds.

![Figure 33: Proportion of vehicles in each lane](image)

Taking into account the significant two-way interaction between trial and lane, 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 sign point to 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 condition (1.5%) than the control (0.8%). Again although the proportions are small, the value for the experimental condition is nearly twice that of the control condition. Again this suggests that monitoring of vehicles in lane 3 under operational conditions should be given consideration.

<table>
<thead>
<tr>
<th>Lanes</th>
<th>Control</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane 1</td>
<td>65.8%</td>
<td>66.3%</td>
</tr>
<tr>
<td>Lane 2</td>
<td>33.4%</td>
<td>32.2%</td>
</tr>
<tr>
<td>Lane 3</td>
<td>0.8%</td>
<td>1.5%</td>
</tr>
</tbody>
</table>
Table 6: Average, maximum and minimum proportion of vehicles observed across sites at 800yds and percentage point change from 800yrs to 200yds

<table>
<thead>
<tr>
<th>Lane</th>
<th>Control 800yds Mean (Min, Max)</th>
<th>Change from 800yrs to 200yds Mean (Min, Max)</th>
<th>Experiment 800yds Mean (Min, Max)</th>
<th>Change from 800yrs to 200yds Mean (Min, Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>63.1% (50.3%, 80.4%)</td>
<td>2.6% (-0.7%, 6.2%)</td>
<td>66.0% (51.2%, 85.3%)</td>
<td>0.2% (-9.0%, 10.3%)</td>
</tr>
<tr>
<td>L2</td>
<td>34.0% (19.6%, 45.3%)</td>
<td>-0.6% (-3.5%, 1.7%)</td>
<td>31.1% (13.8%, 43.2%)</td>
<td>1.1% (-8.0%, 8.8%)</td>
</tr>
<tr>
<td>L3</td>
<td>2.9% (0.0%, 5.9%)</td>
<td>-2.0% (-4.9%, 0.3%)</td>
<td>2.9% (0.0%, 5.9%)</td>
<td>1.4% (-3.2%, 0.7%)</td>
</tr>
</tbody>
</table>

5.5.1 Traffic flows

The sites had a mixture of traffic flows from 67 to 864 per hour in all lanes at the 800yds sign point. High, medium and low flows were shared across experimental and control conditions as shown in Table 7. The slight unbalance is discussed below and controlled for in Table 9.

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>0-225</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>225-475</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>475+</td>
<td>7</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>15</td>
<td>27</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) hence, there is no significant difference in the median flows for the control and experimental conditions.

---

6 Changes may not match exactly with those that could be derived from Table 5, due to rounding errors

7 Groupings calculated from hourly flow data for three lane motorways in Area 10
5.5.2 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 in both cases, 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 9.

<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>2</td>
<td>4</td>
</tr>
<tr>
<td>Tuesday</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Wednesday</td>
<td>1</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Thursday</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Friday</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Saturday</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sunday</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>15</strong></td>
<td><strong>27</strong></td>
</tr>
</tbody>
</table>

5.5.3 HGV count

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

The number of heavy goods vehicles was recorded for the recent experimental and control sites in Area 10; however, these data were not available for the control data from the experimental phase of Sign Simplification 1B. Hence, analysis to determine if there was a significant difference in the number of heavy goods vehicles between the control and experimental groups was not possible.

5.5.4 Site selection

The ANOVA results described above are based on all the sites described. In order to corroborate these results we have rerun the analysis several times removing a selection of sites (shown in Table 9) for different reasons. The result of the analyses with each selection of sites is largely stable to small unbalances to the study design.
Table 9: 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 30 minutes and 4 hours, each count was divided by the number of hours surveyed to give an hourly flow rate.</td>
</tr>
<tr>
<td>Weekdays only</td>
<td>9, 11, 29</td>
<td>The sites surveyed on Saturday and Sunday were removed.</td>
</tr>
<tr>
<td>Balanced traffic flow</td>
<td>22, 25, 28</td>
<td>A random selection of sites were removed in order to have 1 experiment and 1 control sites in the low traffic banding (0-225), 4 of each in the medium band (225-475) and 1 of each in the high band (475+).</td>
</tr>
<tr>
<td>Balanced day of the week</td>
<td>1, 8, 10, 11</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, 1 on Wednesday, 2 on Thursday, 2 on Friday and 1 on Saturday for both experiment and control.</td>
</tr>
</tbody>
</table>

5.6 Conclusions

The modelling concludes that the pattern of vehicles moving across lanes at the four different sign points does not vary between control and experimental groups.

Adjusting the data to include and remove certain sites had no effect on the pattern of vehicles moving across lanes at the four different sign points (the three-way interaction between trial, sign point, and lane) and no effect on most of the other main effects and interactions. This suggests that the effects found, overall, are robust to minor imbalances in the study design.

Differences in the proportions of vehicles in lane 3 between the experimental and control conditions (including specifically at the 200yds sign point) suggest that monitoring of the number of vehicles in lane 3 when this layout is used operationally should be given consideration.
6 Conclusions and recommendations

Balfour Beatty Mott MacDonald / HW Martin Traffic Management Ltd. 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 single offside lane closure on a dual carriageway / motorway with three lanes, 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.

Control condition closures and two experimental condition closures were undertaken on the M20 in HA Area 4. However, a near miss report submitted by the traffic management crew raised concerns over the potential for obscuration of the nearside signs, meaning that drivers is the offside lane who were approaching the taper may not have been adequately warned of the closure. From the 20 instances of this identified, 13 involved drivers who had a clear view ahead through the advanced signing zone to the taper (cones with sequential flashing lamps). Previous research (DfT, 2002) has identified that sequential flashing road danger lamps installed onto tapers, at distances upstream from the taper of up to 600m, prompt drivers to merge into the appropriate lane earlier than ‘non-sequential’ flashing lights. The instances identified in the current trial are consistent with what might have been expected due to poor driver behaviour, and are not necessarily as a direct result of the removal of offside signs. However, several of the instances occurred when there were HGVs occupying the nearside lanes.

Due to the concerns raised by the traffic management operatives, trials deployments of the OSSR sign layout were halted, and additional analysis was undertaken to determine whether HGV density on the M20, where the control closures and initial two experimental closures took place, is representative of other motorways within the HA’s Area 4. This analysis showed that although average hourly traffic flows are similar on the M20, M2 and M23, typical average hourly HGV flows are higher on M20 than either the M2 or M23; this is likely to be due to the M20 linking the M25 to Folkestone, near Dover.

BBMM were very keen that the trials should continue in a BBMM Area and Area 10 was suggested as an alternative trial location. Initial analysis of historical flow data indicated that HGV proportions range from 6% to 44%, with an average of 20%. The conditions in Area 10 were therefore deemed more suitable for a trial location for Stage 3, and it was recommended that support should be given to move the Stage 3 Trials from Area 4 to Area 10.

During these closures, with additional control data collection, an additional camera system was placed at the start of the taper to monitor taper running.

Subsequent analysis concluded that the overall pattern of vehicles moving across lanes at the four different sign points did not vary between control and experimental groups. Very small proportions of vehicles were in lane 3 throughout the approach to the taper; nonetheless at 200m there was a statistically significant increase (from 0.8% in the control condition to 1.5% in the experimental condition) of the proportion of vehicles in lane 3, which warrants further attention at implementation. The link between the
statistically significant increase in lane 3 occupancy observed and actual risk remains uncertain.

More taper running incidents were observed in the experimental conditions (although small numbers prevented formal 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. Also, despite the concerns raised by the TM crew during the two experimental closures in Area 4, no dangerous instances or incidents were noted during video analysis. 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 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 (see Section 6.1).

With Lane 3 closures accounting for about 10% of works logged on the HA’s SRW system, averaging over 5,000 such closures on motorways each year, the use of initiatives such as OSSR will provide considerable reductions in risk exposure associated with lane crossings.

6.1 Recommendations

On the balance of evidence in the current report, it is considered likely that the use of the OSSR advanced signing layout poses no substantially greater risk to either road workers or road users than the relaxation signing layout typically used for direct closure of lane 3 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 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.
Acknowledgements

The work described in this report was carried out in the Road Safety Group of the Transport Research Laboratory. The authors are grateful to Balfour Beatty Mott MacDonald and HW Martin (Traffic management) Ltd. for their full involvement and support of the on-road monitored roll-out and Shaun Helman who carried out the technical review and auditing of this report.

Also, the TRL project team would like to thank:

- At Balfour Beatty Mott MacDonald: Shane Wimble, Phil Hobson, Derek Strand and Wayne McCullock.
- At HW Martin (Traffic Management) Ltd.: David Shaw, Mark Sludds, Andy Graham and Kevin Richardson

References

Clark S, Palmer M, Lloyd L (2011). Offside Signs Relaxation for Nearside Lane Closures, Results from monitored roll-out in Area 3 (CPR1242). Crowthorne: Transport Research Laboratory (Report available on direct personal application to EnterpriseMouchel or Chevron Traffic Management Ltd. only).


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


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

Palmer M, Reeves C, Helman S (2012). Offside Signs Relaxation for Lane 1-2 Closures, Results from monitored roll-out in Area 2 (CPR1308). Crowthorne: Transport Research Laboratory (Report available on direct personal application to Balfour Beatty Mott MacDonald or HW Martin Traffic Management Ltd. only).