HIGHWAYS AGENCY

TRL

RINGWAY carillion

Safe Temporary Traffic Management Operations Initiative

Trial Report: Sequential Flashing Cone Lamps

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1 INTRODUCTION

The Highways Agency's aim is *"Safe Roads, Reliable Journeys and Informed Travellers"*. Maintaining high quality roads and ensuring the safety of those on the motorway and trunk road network is paramount to the Agency as reflected in the Prime Objective – "*To deliver a high quality service to our customers by: - reducing congestion and improving reliability through a programme of improvements to the strategic road network, Improved management of incidents and roadworks [and] .... improving road safety*".

Road maintenance and improvement schemes are an essential part of delivering a high quality road network, but the work required often requires lane closures. The cones at the beginning at a lane closure (referred to as the 'cone taper') are frequently struck by vehicles that have failed to see them or exit the closed lane in sufficient time. Near miss data collected by Carillion in Area 4 showed that cone taper strikes accounted for around 50% of "near miss" incidents recorded in 2001 and 2002 (Trials Team Annual Report 2002). Cone taper strikes can lead to accidents which not only affect the operatives working within the confines of the TTM scheme, but can injure members of the public and cause road congestion and secondary incidents.

In 2002 the Trials Team began evaluating the use of sequential flashing cone lamps to enhance the visibility of cone tapers and so reduce the frequency of cone taper strikes in temporary traffic management schemes. Following a number of off-road evaluations of sequential flashing cone lamps, the Trials Team developed a generic specification for the type of sequential lamp system that would prove simple to deploy and provide the level of enhanced visibility required. A copy of this generic specification is contained in Appendix A of this report.

The generic specification was sent to all UK lamp manufacturers and interested parties, and one manufacturer (Dorman Traffic Products Limited) indicated that an existing product in their range could be developed to meet

the requirement of the specification. With assistance from the Trials Team, the product was developed and tested. Following an off-road demonstration of the system to representatives from the Department for Transport, trial approval was granted for a live trial of the lamps on the road network.

This report provides an overview of the live trial and presents the results from the analysis of the trial data.

2 TRIAL DESCRIPTION AND METHOD

The trial was conducted over a two-week period in April 2005. This section details the equipment, trial location and data collection methodology used.

2.1 Site Location

The site location for the trial had to meet the following requirements:

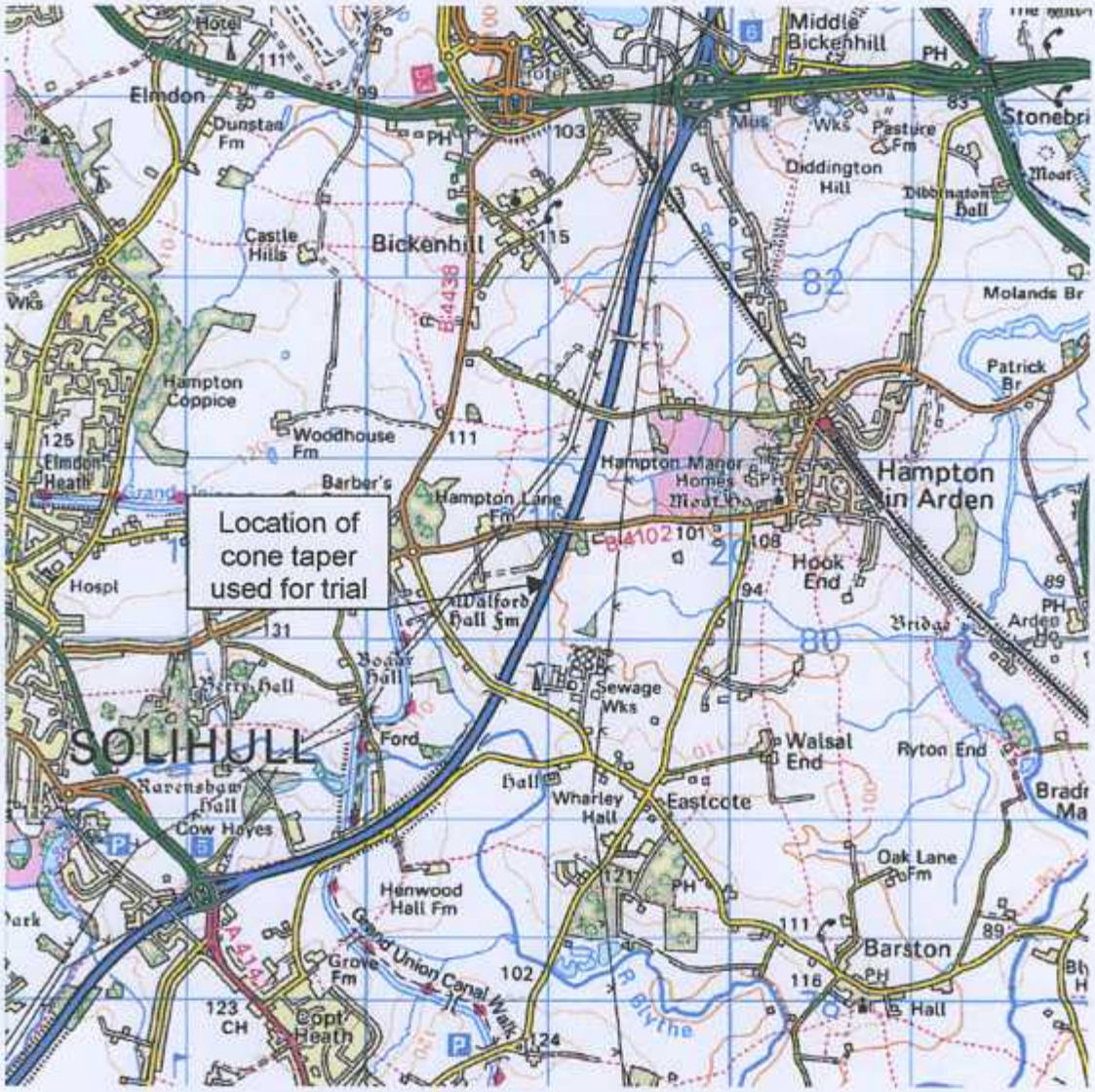
- An existing programme of temporary traffic management should be in place
- Identical temporary closures should be required at the same location for the same period over a period of two weeks
- No additional signing (e.g. gantries) to be active other than the 'standard' Chapter 8 signing
- Inductive loop pairs should be installed every 100m in the carriageway surface to sense vehicles approaching the trial site

Identifying a site location capable of meeting all four requirements was extremely difficult. A large number of locations were identified which met the first three requirements and the installation of inductive loops at one of these sites was investigated but found to be prohibitively expensive.

A trial site was finally identified that met all the site criteria. This was on the M42 northbound carriageway between Junction 5 (Solihull) and Junction 6 (Bickenhill). This was within M42 Active Traffic Management (ATM) pilot area, and hence was equipped with vehicle sensing loops every 100m.

The trial was conducted before Phase 2 of the ATM works was commenced and thus there was no additional gantry signing displayed during the trial. High-intensity lighting was present on this section of the motorway to support the use of CCTV for the ATM pilot. The closure commenced at marker post 29/5 (location arrowed in Figure 1 below):

Figure 1: Location of Trial Site



2.2 Traffic Management

The M42 Active Traffic Management pilot scheme works were managed on behalf of the Highways Agency by MouchelParkman Services Limited. Traffic management was contracted to Highway Traffic Management Limited (HTM) under standing arrangement with MouchelParkman in relation to existing works on the M42 and this was used for the purposes of the trial. The method statement relating to the use of the lamps for trial is contained in Appendix B.

All closures carried out took place in Lane 1 of the three lane northbound carriageway. The first cone of the cone taper for the trial was placed at marker

post 29/5. Closures were carried out overnight, starting on the evening of the day indicated and typically being removed by 03:00 on the following day. Closures were not scheduled for Friday nights due to the higher traffic flows present on the motorway at these times. The closures used for the trial were carried out as shown in Table 1:

Table 1: Closures used to trial sequential flashing cone lamps

Day of week	Week 1		Week 2	
	Date	Lamp Type	Date	Lamp Type
Monday	18th	Static lamps	25th	-
Tuesday	19th	Sequential lamps	26th	-
Wednesday	20th	Static lamps	27th	Sequential lamps
Thursday	21st	Sequential lamps	28th	Static lamps

Closures were not installed on the 25th and 26th due to other roadspace bookings on these evenings.

2.3 Equipment

Previous trials of sequential flashing cone lamps identified that the optimum technology for enhancing the visibility of the cone taper was the use of LED cone lamps with integral backlight. The Sequential Flashing Cone Lamps were also intended to replace standard road danger lamps (as defined in Regulation 55 of the Traffic Signs Regulations and General Directions 2002) and therefore would be expected to be set at a maximum of nine metre centres. These requirements were both reflected in the specifications for lamps for trial.

Lamps were produced for the trial by Dorman Traffic Products Limited based on their TrafiLITE® microprocessor controlled self-sequencing LED cone lights. The type of lamp is shown below in Figure 2:

Figure 2: Dorman TrafiLITE® cone lamps

Note: this image (© Dorman Traffic Products Limited) was not taken at the trial location and is only intended to show the style of lamp body used and their method of mounting on the cones

The sequenced TrafiLITE® lamps were modified to provide each lamp in the set with a backlight function (2 Cd) in addition to the higher intensity sequenced flash.

2.4 Data collection

Previous trials of sequential flashing cone lamps in the US used lane occupancy upstream of the closure to determine the effectiveness of the lamps. This was measured using video surveillance and post-trial processing or manual traffic counts at three points (1000ft, 500ft and 0ft before the taper).

This methodology was adopted for the M42 trial, but using inductive loop pairs to sense lane occupancy and vehicle speed. These had been installed in each lane in preparation for motorway incident detection and automated signalling (MIDAS) and had been tested for continuity.

The installation of loops had been undertaken on a lane-by-lane basis and so the lane in which each loop was located was known absolutely. However, at the time of the trial the sequence of the loops had not been verified. The loop terminations within the Combined Equipment Cabinets (CECs) were labelled with the probable loop number, but this had not been validated at the time the trial was carried out. The only loops for which locations had been validated were those already connected to MIDAS outstations, as detailed in Table 2:

Table 2: Loop location status for trial

Distance from start of taper (m)	Loop Number	Termination Cabinet	Used for Trial Data Collection
-1,100	N98	P27A	Yes
-1,000	N99	P27A	Unavailable (MIDAS use)
-900	N102	P27A	Yes
-800	N104	P27A	Yes
-700	N107	P27A	Yes
-600	N110	P28A	Yes
-500	N112	P28A	Yes
-400	N115	P28A	Unavailable (MIDAS use)
-300	N118	P28A	Yes
-200	N120	P29A	Yes
-100	N123	P29A	Yes

Data were collected using Peek Traffic ADR counters in "per vehicle" mode, which generated a record for each vehicle indicating date and time detected together with vehicle speed. This data was collected for Lanes 1 and 2. The

counters were connected to the loops and the label number assigned to each loop was programmed into the associated counter to ensure all data files were 'stamped' with the loop designation. Data were retrieved from the counter daily, post-processed and supplied to TRL for subsequent analysis and reporting.

At the time of writing, post-processed data for Loop N118 was still outstanding for Day 1 from Week 1 of the trial. The analysis conducted was based on the data from the remainder of the trial period.

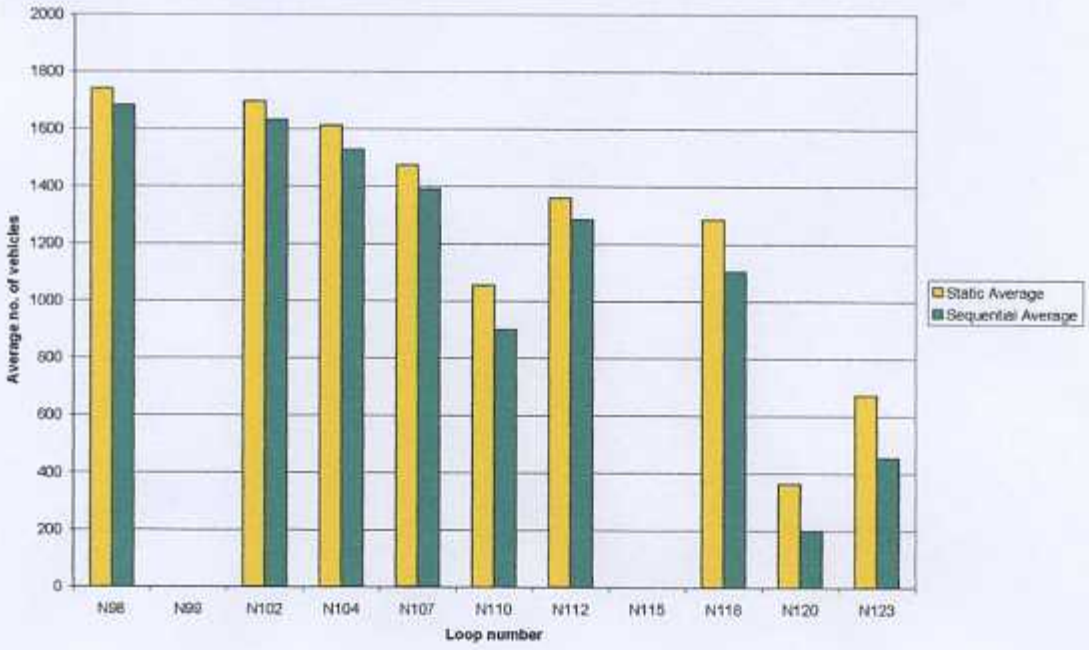
3 Analysis and Results

The results from the monitoring of traffic on the M42 generated a large amount of data. This section of the report sets out the method applied to develop an indicator for the lamp effectiveness and the statistical tests used to determine the statistical validity of the observed differences in the data.

3.1 Data Processing

Traffic data from the trial was received in 'per vehicle' format. This format was designed to provide data on speed for further analysis of the effects of the lamps on driver speed choice. However for the initial analysis, the 'per vehicle' data was summed to provide total vehicles in the lane during the closure period (22:00 – 03:00). This process was performed for each of the loop measurement locations identified in Table 2. The data was averaged for each type of lamp across the six days of the trial and these results were then plotted to examine the traffic profile as vehicles approached the cone taper, separated by lamp type. The results of this plot are shown in Figure 3:

Figure 3: Average traffic profile approaching the cone taper (uncorrected)



The data as plotted appeared anomalous, in that the number of vehicles in the closed lane (Lane 1) appeared to increase nearer to the taper. This issue was flagged to MouchelParkman, who investigated and on testing the loops confirmed that a number of the loop designations were incorrect within termination cabinets 28 and 29. The data were corrected for this by application of the following mapping:

Table 2: Corrected loop locations for trial

Distance from start of taper (m)	Loop Designation	Termination Cabinet	Correct?	Actual Loop Label
-1,100	N98	P27A	Y	-
-1,000	N99	P27A	N/A	-
-900	N102	P27A	Y	-
-800	N104	P27A	Y	-
-700	N107	P27A	Y	-
-600	**N110**	P28A	**N**	**N112**
-500	**N112**	P28A	**N**	**N118**
-400	N115	P28A	N/A	-
-300	**N118**	P28A	**N**	**N110**
-200	**N120**	P29A	**N**	**N123**
-100	**N123**	P29A	**N**	**N120**

Application of this mapping to the data produced corrected data, which was used for the remainder of the analysis.

For each day of the trial, the corrected total flow data for the loop 1,100m upstream of the taper was used as a baseline. The percentage of traffic remaining in Lane 1 was then calculated at the other eight active loop positions.

Statistical comparison was undertaken using a two-tailed distribution *t*-test. The use of a two-tailed distribution provided a conservative estimate of the significance of the differences between the two samples.

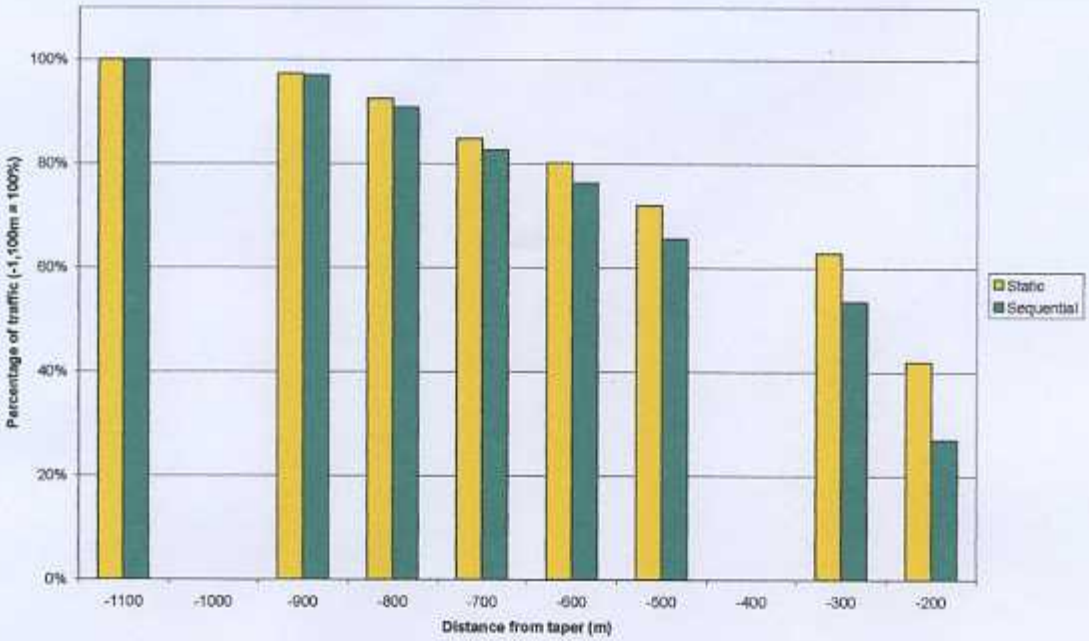
3.2 Results

The full results from the baseline analysis are presented in Appendix B. A summary data set was prepared from summed data for all complete days. This is shown in Table 3, and plotted in Figure 4:

Table 3: Trraffic profile data for summed data set

Distance from taper (m)	Traffic profile approaching cone taper (corrected data, -1,100m count = 100%)	
	Static cone lamps	Sequential cone lamps
-1100	100%	100%
-1000	-	-
-900	97%	97%
-800	93%	91%
-700	85%	83%
-600	80%	76%
-500	72%	66%
-400	-	-
-300	63%	54%
-200	42%	27%
-100	24%	12%

Figure 4: Traffic profile (normalised) approaching the cone taper (corrected data)



4 DISCUSSION

4.1 Use of equipment

The traffic management for the M42 ATM works was installed by Highway Traffic Management Limited (HTM). The HTM team reported the lamps were easy to use and there were no problems with the method statement or deployment of equipment. On the final night of the trial (Thursday 28th), the taper lit with static lamps was destroyed by an unknown vehicle. However, all the TrafiLITE® sequential lamp units used for the trial survived the trial, and the spares kindly supplied by Dorman Traffic Products Limited were not required.

4.2 Trial data collection

The M42 ATM works gave the Trials Team unprecedented access to an array of pre-installed vehicle detection loops spaced at 100m centres. Installation of this level of infrastructure for the trial would have proved prohibitively expensive and thus the benefits obtained from using the ATM section for the trial were significant. However, careful design and timing of the trial proved critical, due to the gantry works in the trial area.

The development of the ATM site included implementation of an enhanced gantry signals and VMS panels to support lane closures and hard shoulder running. The setting of these was automatically triggered by requests to display other legends such as 'WORKFORCE IN ROAD – SLOW'. It was vital for purity of measure that the effect of these gantries did not affect the drivers approaching the trial location and thus the trial took place at the interface between Phases 1 and 2 of the ATM scheme.

At the time the trial was carried out, the vehicle detection equipment had been installed in the carriageway but the gantries were not yet operational. The trial was thus not affected by the automated signalling, which was brought into service the week following the trial.

4.3 Data analysis

Examination of the data indicated the raw data had an unusual profile that did not fit the expected pattern for traffic approaching a lane closure. A consistent increase was seen between the traffic flows (number of vehicles) at the 100m loop position when compared with the 200m loop position. This was considered anomalous, as it would indicate drivers vacating Lane 2 in favour of Lane 1 at the 200 metre point, only to return to Lane 2 between the 100m loop and the taper. A similar effect was observed for the 600m loop position compared to the 500m loop position, although this effect was not as strong as that observed at the 100m / 200m loop positions.

The occurrence of this effect was not related to the type of lamp used, as identical patterns were seen in the static lamp data as well as in the sequential lamp data. Local site conditions were investigated but could not explain the anomalies, as there was no junction or structure within the closure location. This suggested an issue with the loop assignments in the carriageway, which were tested and found to be not as labelled. Once corrected, the data followed the expected trend of decreasing traffic volumes as the taper was approached.

The sequential flashing cone lamps exhibited a much stronger effect on driver lane choice behaviour than had been expected. Taking into consideration the site location and high levels of street lighting necessary for the ATM CCTV system, the level of effect was clearly visible even in the raw data. The time period after which the closed lane was re-opened was also visible in the data, with the numbers of vehicles increasing after the removal of the lane closure at approximately 03:00.

The values of the corrected data in Table 3 suggested that the sequential lamps cause a greater decrease in Lane 1 occupancy than the static lamps as the distance to the taper decreases. Based on the sample of vehicles shown in Table 3, this hypothesis was tested for significance. The Student's *t*-test was used to determine the significance at the 5% level for the pairs, thus

indicating where the differences in data cannot be assigned to random variation. The results of this statistical test are shown in Table 4:

Table 4: Significance testing for static vs. sequential cone lamp data (significant values are shown in **bold**)

Distance from taper (m)	Calculated *t* value	Probability percentage
-1100	N/A	-
-1000	-	-
-900	0.214	83.0%
-800	1.130	25.8%
-700	1.491	13.6%
-600	2.679	0.7%
-500	**4.688**	**0.0%**
-400	-	-
-300	**7.139**	**0.0%**
-200	**13.584**	**0.0%**
-100	**14.445**	**0.0%**

The two-tailed *t*-test was chosen as a conservative measure of significance as two hypotheses were possible for the test (i.e. the lamps could cause either an increase or decrease in lane occupancy at any particular point). The tests on the average data suggest a strong effect from 600m before the taper, with consistent decreases seen in closed lane occupancy from 500m before the taper.

Examination of the detailed statistical data in Appendix B confirmed the findings of the averaged data analysis, in that the sequential flashing cone lamps caused a consistent decrease in closed lane occupancy from a point 500m before the taper. However, at the 600m point the effect was significant for 50% of the day pairs for which comparisons were made. This was slightly

different to the results from the averaged data, as the averaged data did not include data from Monday 18th, since full data was not available for this time period due to issues with the traffic counters.

5 CONCLUSIONS AND SUMMARY

The trial of sequential flashing cone lamps detailed in this report was intended to evaluate the effectiveness of the lamps in reducing closed lane occupancy upstream of the cone taper. This report details the initial data analysis and findings.

In summary:

- The trial was designed to measure the effect of sequential flashing cone lamps on driver lane choice when approaching a lane closure.

- Traffic volume data was collected at distances between 100m and 1,100m before the cone taper to measure traffic behaviour when approaching a closed lane

- Anomalies in the traffic profile observed in the data were explained by incorrect labelling of loop tails, which was verified by testing.

- From the statistical analysis of the trial data, it can be concluded that the use of sequential flashing cone lamps causes drivers to vacate a closed lane earlier than the use of static road danger lamps.

- The effect of the sequential lamps is seen consistently from a point 500m before the taper, but also has an effect at a point 600m before the taper in half the cases.

- The effect of sequential flashing cone lamps is thus to encourage drivers to vacate the closed lane earlier (and thus farther from the protective cone taper)

- This information is presented to allow the Highways Agency to provide scientifically rigorous evidence of the safety benefits gained through the use of sequential flashing cone lamps on cone tapers.

APPENDICES

APPENDIX A: Sequential Flashing Cone Lamp Generic Specification

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Equipment and Trial Specification

Sequential Flashing Cone Lamps