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Monitoring and evaluation of the 55/60mph pilots

Interim report for the on-road trials of 60mph on the M5
Junction 4a to 6 scheme

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Executive Summary

Improving customer satisfaction, particularly through roadworks, is a priority for Highways England. One potential measure to achieve this is raising the speed limit through roadworks from the current 50mph limit to 55mph or 60mph. This approach aligns with recommendation 6 from the ‘Incidents and roadworks – A road user perspective’ report which suggests that “Highways England should set speed limits in roadworks no lower than is required to maintain safety” (Transport Focus, November 2016).

This project supports the monitoring and evaluation of trials which involve raising the speed limit through roadworks, where the scheme is designed in a way that makes it safe to do so, and when road workers will not be exposed to increased risk from the increased speed limit.

This report presents the findings from the on-road pilot of an increased speed limit at the M5 Junction 4a to 6 scheme, during the operational testing phase of Smart Motorway development. The trial involved implementation of a 60mph speed limit on part of the scheme on the southbound carriageway; drivers travelling on this part of the scheme experienced a ‘step down’ in speed limit from 60mph to 50mph. Variable Message Signs (VMS) were used to improve driver awareness of this step down. Driver behaviour was measured throughout the trial to understand whether the change in speed limit to 60mph impacted on the safety of road users. In addition, surveys were carried out with local drivers in order to understand their perceptions of the 60mph speed limits.

The results showed that in general drivers noticed and responded to the change in speed limit, with average speeds increasing to around 56-58mph. Comparison of the journey times associated with these average speeds and those measured prior to the trial suggested average savings of 30-40 seconds per driver during the trial period. Compliance with the 60mph speed limit was good, but average speeds after the step down to 50mph were around 51-53mph. This suggests that some drivers either missed the VMS and terminal signs informing them of the speed limit reduction, or deliberately continued to drive at speeds faster than the 50mph limit. Compared with the signing configuration used in a similar trial on the A1 Leeming to Barton scheme (Wallbank, Hammond, Myers, & Chowdhury, 2017b), there was a reduced number of signs around the step down in this trial. Possibly, this contributed to the lower compliance observed after the step down in this trial.

When the speed limit was 50mph, close following was more common in HGV drivers than car drivers; although over 50% of the vehicles in both categories were recorded at gaps of less than two seconds during peak daytime hours. The introduction of the 60mph speed limit had little impact on close following by car drivers, but substantially reduced the amount recorded for HGV drivers. HGV driver compliance with the 60mph speed limit was also better than that observed for car drivers. Further, there was some evidence that overtaking manoeuvres performed by HGVs was reduced in the 60mph speed limit. These findings may be linked to the use of speed limiter devices in HGVs which restrict speeds to 56mph (i.e. below the speed limit).

There were no safety issues identified from the incidents and incursions data provided by the scheme; safety concerns will be investigated further following a focus group with stakeholders in early May 2017.

Despite the increase in average speeds observed on-road, the survey results indicated that some drivers still missed the change in speed limit. Results also suggested that other aspects of the roadworks (aside from the speed limit) could be changed to improve customer satisfaction, including reducing the length of the works.

1 Introduction

1.1 Background

Customer satisfaction and safety are critical components of Highways England's vision for the future; as part of this vision, Highways England is committed to improving the customer experience through roadworks by maximising safety (for both road users and road workers) and minimising disruption caused by roadworks schemes.

One potential way of improving customer satisfaction at roadworks is to challenge the approach to speed management that is usually taken at Major Schemes. Typically, a 'blanket' speed reduction of 20mph is imposed throughout the scheme, resulting in a 50mph enforced speed limit in place for the entire length and duration of the roadworks.

Following consultation with stakeholders across Highways England and the Supply Chain, this project was set-up to support the monitoring and evaluation of the potential benefits of raising the speed limit through roadworks from 50mph to 55mph or 60mph where the scheme is designed in a way that makes it safe to do so, and when road workers will not be exposed to unacceptable risk from the increased speed limit.

Three specific scenarios were defined for on-road trials:

Scenario 1: Implementation of a 60mph speed limit on lead-in and exits to/from the works, with a 50mph speed limit through the works area

Scenario 2: Changing the speed limit (to either 55mph or 60mph) during the operational testing (or 'pre-commissioning') phase of Smart Motorway schemes

Scenario 3: Changing the speed limit (either to 55mph or 60mph) throughout the works during a 'holiday period' when there are no road workers present

1.2 Study objectives

This report summarises the findings from an on-road pilot of 60mph on the M5 Junction 4a to 6 scheme during Spring 2017. This is the third pilot aiming to understand the impact of increasing the speed limit to 55mph or 60mph at roadworks.

This trial implemented a 60mph speed limit under the conditions of Scenario 2, that is, where the speed limit was only increased during the operational testing phase of Smart Motorway development. During this stage, the former hard shoulder (Lane 1) remains closed until all the Motorway Incident Detection and Signalling (MIDAS) system detectors are commissioned. Once all is well, Lane 1 is opened to traffic, and queue protection (HIOCC) is tested.

From the customers' (road users') perspective, during the first part of this stage the former hard shoulder (Lane 1) is coned off and no work is taking place; during the second part, the whole carriageway is open and the Smart Motorway will appear "complete". During both of these periods a 50mph speed restriction is in place, for no apparent reason from the customers' point of view. For the purposes of the trial, this 50mph speed limit was increased to 60mph when Lane 1 was coned off (during which monitoring took place) and

then reverted back to 50mph during the testing of HIOCC; this decision was made by the scheme.

TRL were commissioned by Highways England to monitor driver behaviour (and customer satisfaction), to ensure that safety of road users and workers was not compromised by the increase in speed limit during the trial period, and to understand how customer satisfaction was impacted by the increased speed limit.

The key objectives of the research were to gather evidence of the impact of increasing the speed limit on the M5 Junction 4a to 6 scheme from 50mph to 60mph on:

- a) Lane distribution
- b) Average vehicle speed
- c) The number of non-compliant vehicles
- d) Average vehicle headway
- e) The proportion of vehicles close following
- f) The number of incidents
- g) Journey times
- h) Customer satisfaction

This report provides an overview of the scheme and the data collection methodology (Section 2), presents the results from the monitoring of driver behaviour (Section 3), summarises the conclusions from the trial (Section 4) and makes recommendations for the next steps (Section 5).

2 Method

2.1 Overview of the scheme

The M5 Junction 4a-6 Smart Motorway scheme commenced in January 2016 and is due to finish in spring 2017. This scheme will replace the existing three lane motorway with a four lane (all lane running) Smart Motorway.

The roadworks between Junction 4a and 5 were identified as a suitable for trialling an increased speed limit during the commissioning phase of the Smart Motorway All Lane Running scheme (i.e. 'Scenario 2' – see Section 1.1). On this link, the northbound carriageway was used as the 'control location' and retained the current 50mph speed limit throughout the monitoring, whilst the southbound carriageway was used as the 'experimental location' and had a 60mph speed limit implemented on part of the link. During the trial, drivers travelling southbound through the scheme experienced a step down in the speed limit from 60mph to 50mph, prior to further roadworks and narrowed lanes beyond Junction 5.

An overview of the scheme and the monitoring locations is provided in Figure 1.

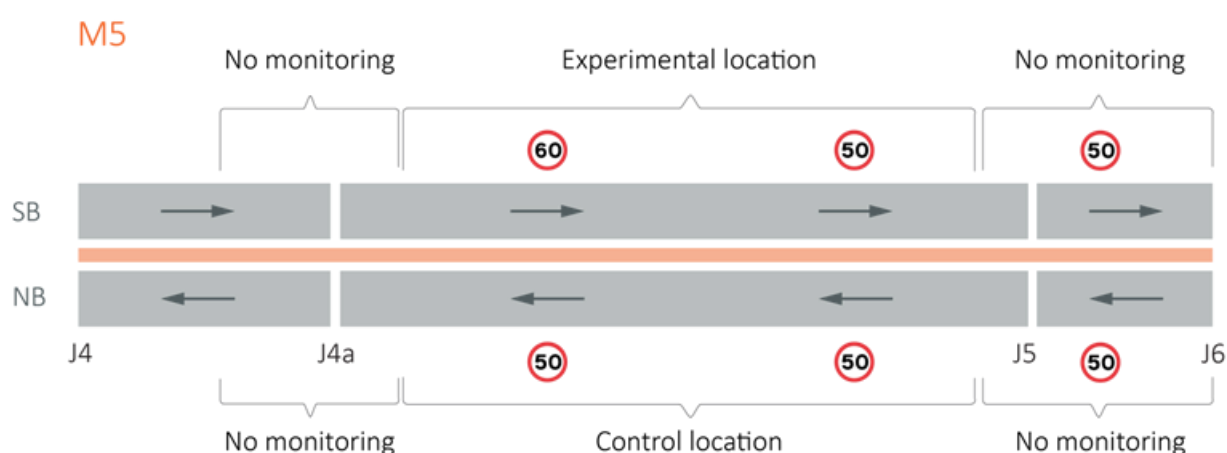


Figure 1: M5 Junction 4a to 6 scheme monitoring locations

2.2 Monitoring locations and signage

The monitoring covered two periods: the 'baseline' monitoring period during which both carriageways retained the current 50mph speed limit and the 'trial' monitoring period during which the 60mph speed limit was implemented southbound while the northbound carriageway speed limit remained at 50mph.

An overview of the scheme and monitoring locations is provided in Figure 2.

During the trial period, drivers travelling southbound entered the scheme north of Junction 4a, transitioning from a motorway section with National Speed Limit (NSL) and no roadworks, into the 60mph speed limit within the works. They travelled for approximately 6.6km in the 60mph speed limit (the 'upstream section') and then the speed limit stepped down to 50mph at a point 2km before the narrow lanes commenced (the 'downstream section'). Driver behaviour was monitored throughout these two sections, with the trial site ending at the 800 yard warning sign for narrow lanes, which began just before Junction 5.

Figure 2 shows how the step down in speed limit was communicated to drivers. A Variable Message Sign (VMS) preceded the pair of 50mph 1500mm diameter terminal signs marking the change in speed limit. Repeater signs were displayed after the terminal signs at 350m intervals on alternate sides of the carriageway as specified in TSM Chapter 8.

At the request of the police, an additional pair of terminal signs were located 1.1km downstream, followed by two further 1500mm repeaters and two VMS displaying '50' speed limit symbols. This signing arrangement was located beyond the end of the trial site and as a result its influence on driver behaviour was not evaluated by the trial monitoring – as shown in Figure 2.

Four mobile radar units were used to monitor vehicle speeds, headways and flow, both upstream and downstream of the step down, to establish whether the combination of VMS and terminal signs was effective at notifying drivers of the change in speed limit. The radar units were configured to collect data on individual vehicles for part of the trial. In addition, TRL's 'R-Cam' system was mounted on two overbridges in the scheme during two days of the monitoring to measure headway and lane distribution by vehicle type.

The radar were also used to monitor driver behaviour on the northbound (control) carriageway which served as a control location where no changes in speed limit were implemented. This enabled the analysis to account for any extraneous influences on behaviour between the baseline and trial periods (such as weather or local traffic conditions).

Throughout the southbound trial site, Lane 1 was coned off and the remaining three lanes were full width. The traffic management (TM) on the northbound carriageway was identical. Speed cameras and warning signs were in place throughout the scheme to provide drivers with the perception of enforcement.










2.3 Timelines

The trial took place between 13th March and 27th March 2017. On 28th March, the scheme removed the traffic management (TM) from Lane 1 and commenced All Lane Running as part of the final stage of commissioning required for the Smart Motorway.

During the trial, on-going monitoring of average speeds via the radar identified an issue with the signing of the scheme: the 50mph terminal signs for the step down were initially positioned in the wrong location. Figure 2 shows the signing as it should have appeared, but the 50mph terminal signs (at marker post 31/6, just after radar 3) were initially omitted from the scheme, resulting in the step down from 60mph to 50mph occurring after radar 4 (at marker post 32/7). This issue was rectified overnight on 22nd March (with the 50mph terminal signs installed in the correct position). As a result, the trial period was divided into

two phases: phase 1 from 20th to 22nd March where the speed limit was 60mph on the southbound carriageway at all four radar and phase 2 from 23rd to 27th March where the speed limit the experimental location (southbound carriageway) was 60mph at radars 1, 2 and 3 and 50mph at radar 4 (see Table 1).

Table 1: Timeline for monitoring

Dates	Description of activity	Experimental location (southbound carriageway)		Control location (northbound carriageway)
		Upstream section (Radars 1, 2 & 3)	Downstream section (Radar 4)	
13 th March – 19 th March	Baseline monitoring period			
20 th March – 22 nd March	Trial phase 1 monitoring period			
23 rd March – 27 th March	Trial phase 2 monitoring period			

All radar units were removed prior to the TM being removed. This ensured that all Emergency Refuge Areas were available for use by road users during the final commissioning period and that the risk to road workers was minimised. As a result, monitoring ceased on the night before the TM was removed, in order to allow decommissioning of the radar units.

2.4 Risk assessment

Prior to commencing the pilot, the M5 Junction 4a to 6 Scheme team carried out a scheme-specific GD04 risk assessment. This assessment examined the risks to road workers and road users from the increase in speed limit, detailing the mitigation measures required to address these risks and an assessment of the tolerability of any risk change. On the basis of this risk assessment the project board agreed the pilot could commence, provided on-going monitoring and safety reviews were carried out and that a suitable abort process was in place (this is detailed in Section 2.5).

2.5 Safety reviews and abort process

Throughout the trials, the scheme had overall responsibility for risk and retained the right to initiate the abort process at any stage. Other parties to the trial (TRL and Highways England) could also request that the scheme initiate the abort process should evidence be obtained that immediate termination of the trial was necessary.

The abort process was formally documented by the scheme team as part of the GD04 risk assessment. The abort process was never used and the trial was completed successfully without any concern for safety.

2.6 Data collection and statistical comparisons

In order to achieve the objectives of this research (see Section 1.2), a number of different data sources were used:

- Radar and video data (both portable mounted radar and TRL's R-Cam system);
- Incident data;
- Survey data (administered online with road users who had driven through the scheme).

These data sources, and the statistical comparisons made in the analysis, are outlined in more detail in the sections below.

2.6.1 Radar and video data

During the monitoring period the MIDAS loops/radar were not yet operational between Junctions 4a and 5. Therefore, in order to monitor vehicle flows, speeds and headway, four portable radars were deployed. A single radar system is capable of collecting data for vehicles on both carriageways; each radar was therefore used to monitor both the control and experimental locations simultaneously.

The locations of the mobile radar are shown in Figure 2 and further described in Table 2.

Table 2: Locations of the portable radar systems





Radar ID	Location	Trial section
Radar #1	MP 29/1 A - 4km after start of scheme, 1.6km from closest junction markings	Upstream
Radar #2	MP 30/8 A - 850m before step down in speed limit	Upstream
Radar #3	MP 31/5 A – co-located with the VMS sign and approximately 100m prior to the step down	Upstream
Radar #4	MP 32/0 B – approximately 1km after the step down	Downstream

The locations of the radar were chosen to enable monitoring of driver behaviour at key points in the roadworks, at sufficient distances off the carriageway in areas which did not result in increased risk to either road users or road workers. Each radar was located at least 1km from either entry (or exit) slip roads or from other critical points within the TM (such as the narrowing of lanes). This ensured that drivers' speed choice was not greatly influenced by these features, allowing study of the behaviour of drivers in response to the changes in speed limit rather than in response to changes in other features in the road environment.

Average vehicle data from the radar were downloaded by MVIS (the radar supplier) via a 3G link, then passed to TRL on a daily basis to be analysed as part of the on-going monitoring (see Section 2.5). Individual vehicle data (IVD) were also recorded by the radar and stored locally on a hard-drive. The IVD were retrieved for analysis once the trial was complete and the signs had been removed from site.

In addition, the radar data were complimented by data on lane distribution and close following from TRL's R-Cam system (see Appendix A) positioned at two overbridges (see Table 3).

Table 3: Locations of TRL's R-Cam system

R-Cam locations	Baseline (8 th March)	Trial phase 1 (22 nd March)
Grafton Lane Overbridge Marker Post 30/6		
Swan Lane Overbridge Marker Post 32/4		

2.6.1.1 Data collected

The radar provided average speed and average headway (defined as the average time separation between vehicles, measured from the front bumper to the front bumper of the following vehicle) which was recorded at one minute intervals. Vehicle flow was recorded by lane and separately by vehicle class (class 1 - up to 17ft, class 2 - 17-22ft, class 3 - 22-38ft and class 4 - 38-120ft)¹. For this analysis, HGVs were defined as all vehicles in the '38-120ft' category plus half those in the '22-38ft' category.

In addition to average speed, a count of vehicles in speed bins was provided. Speed data were split into the following bins: 0-40mph, 40-50mph, 50-57mph, 57-60mph, 60-68mph and 68+mph. These bins were selected to allow analysis of the number of drivers who were non-compliant with enforcement guidelines (i.e. 10% + 2mph above the speed limit²). For example, this enabled analysis of the number of vehicles travelling more than 57mph in the 50mph speed limit and 68mph in the 60mph limit.

Due to equipment issues, the IVD loggers were only installed part-way through the trial period (from 22nd March) and so analysis of these data was restricted to the five day period between 23rd March and 27th March.

The IVD loggers provided information on the length of each vehicle, which was used to classify three vehicle classes: 0-17ft as cars, 17-24ft as vans/LGVs, 24-61ft as HGVs³. Around

¹ These classes align with those used by the permanent MIDAS radars installed on the scheme, which when commissioned are used to monitor traffic flow and sense incidents or congestion. The MIDAS radars were not operational during the trial of this scheme so temporary radar had to be installed to monitor driver behaviour.

²² This is based on the National Police Chiefs Council/Association of Chief Police Officers (ACPO) Speed Enforcement Policy Guidelines 2011-2015 (ACPO, 2013) which suggest that a Fixed Penalty or speed awareness education may be appropriate when the speed is 10% +2mph above the speed limit (see paragraph 9.6). These are only guidelines and a police officer/ force can decide to enforce at a speed lower than this limit assuming they have considered the tolerance of the measurement equipment (paragraph 9.7).

³ These lengths were informed by vehicle safety experts and broadly align with the lengths used for the one minute radar data. The main difference between the two classifications was that of HGVs: for the IVD, HGVs

9% of vehicles recorded a length over 61ft. These were considered as anomalies and were not reported in the analysis.

The primary purpose of collecting IVD was to investigate the effect of increasing the speed limit on close following, particularly by HGVs. Due to the technical issues with the IVD loggers, comparison of IVD data between the 50mph and 60mph speed limits was not possible. However, the analysis was enabled by headway data obtained from TRL's R-Cam system, which was split by vehicle-type and lane. The R-Cam system was in place on two days: Wednesday 8th March (baseline) and Wednesday 22nd March (trial phase 1), at two sites, covering both carriageways (see Table 3).

IVD were also used to understand how average speed data differed between vehicle classes within the 60mph speed limit.

2.6.1.2 Data processing

In order to understand the potential impact of the speed limit change on vehicle speeds, driver behaviour must be investigated when drivers are free to choose their speed. This requires conditions with free-flowing traffic; congested traffic was defined as periods when the average speed of vehicles was lower than 40mph. This resulted in removal of around 2.4% of the data.

Many statistical tests assume that data are independent, that is that individual data points are not related to or influenced by each other. However, consecutive data points from radar data may not necessarily be truly independent since the average speed or flow during one minute is likely to be closely related to the average speed or flow of the previous minute. This problem of dependence was managed by random sampling: one minute was selected from each 10 minute interval, resulting in a dataset containing six randomly sampled minutes from each hour for each radar location.

It was assumed that data from the different locations were independent as there was a sufficient time delay between a car passing the first radar location and the same car passing the second radar location within a link.

2.6.1.3 Occlusion of the radar

Whilst the temporary radars were calibrated to monitor both sides of the carriageway, there were some issues with occlusion at the site (particularly at radars 3 and 4) which meant that not all vehicles were recorded. Radar 1, 2 and 3 were located on the southbound carriageway and radar 4 was located on the northbound carriageway. The problems arose for vehicle flows on the opposite side of the carriageway to the radar; the high central reservation and topography of the site limited the ability of some of the radar to accurately

were defined as between 24-61ft in length, whereas for the one minute average data HGVs included all vehicles in the '38-120ft' category plus half those in the '22-38ft' category. This resulted in a very minor difference in the total number of HGVs in each dataset (16% vs. 17%).

record every vehicle⁴. As a result, the vehicle flows and composition from radars 3 and 4 are unlikely to be accurate, but the radar supplier has indicated that the speed accuracy for the vehicles that are captured should still be good. Since speed is the key measure for this analysis, there is limited impact on the validity of the results, especially since radar 1 and 2 (positioned within the 60mph speed limit) did not experience the same issues.

2.6.1.4 Flow comparisons

During the baseline and trial periods, vehicle flow data were collected every minute by the radar. The data were split by lane and by vehicle classification (based on the vehicle's length).

Changes in vehicle flow could have an impact on average speed or headway. As a result, it is important to understand whether or not there were significant changes in vehicle flow between the baseline and trial periods. Specifically, the following comparisons were made:

- 1) Comparison of average vehicle flow between the baseline and trial periods
- 2) Comparison of average vehicle composition between the baseline and trial periods

The results of these comparisons are presented in Section 3.1.

2.6.1.5 Lane distribution comparisons

Vehicle counts by vehicle type and lane allowed the following comparisons to be made:

- 1) Comparison of the proportion of vehicles using each lane between the baseline and trial periods at the experimental location (i.e. when the speed limit changed from 50mph to 60mph)
- 2) Comparison of the distribution of vehicle types by lane between the baseline and trial periods at the experimental location (i.e. when the speed limit changed from 50mph to 60mph)

The results of these comparisons are presented in Section 3.2.

2.6.1.6 Average speed and speed non-compliance comparisons

Average speed data, split by-lane were collected every minute at each of the radar. In addition, speed bin data were provided to enable analysis of speed limit non-compliance.

The following comparisons were made:

- 1) Comparison of average speed (and speed limit non-compliance) between the baseline and trial periods at the control location (i.e. when the speed limit remained at 50mph)

⁴ Alternative radar locations were sought and two of the temporary radars were moved (to the positions outlined in this report) but it was not possible to improve the accuracy of the radar any further.

- 2) Comparison of average speed (and speed limit non-compliance) between the baseline and trial periods at the experimental location (i.e. when the speed limit changed from 50mph to 60mph)
- 3) Comparison of average speed (and speed limit non-compliance) between the radar at the experimental location (i.e. to determine whether drivers adjusted their speed following the step down in speed limit)
- 4) Comparison of average speed (and speed limit non-compliance) between cars and HGVs at the experimental location (i.e. when the speed limit was 60mph)

The results of these comparisons are presented in Sections 3.3 and 3.4.

2.6.1.7 Average headway comparison

Average vehicle headway (i.e. the average time between vehicles in the same lane) was also collected for each lane using the radar.

The following comparisons were made:

- 1) Comparison of average headway between the baseline and trial periods at the control location (i.e. when the speed limit remained at 50mph)
- 2) Comparison of average headway between the baseline and trial periods at the experimental location (i.e. when the speed limit changed from 50mph to 60mph)

The R-Cam data were also used:

- 3) Comparison of average headway by vehicle class between the baseline and trial periods at the experimental location (i.e. when the speed limit changed from 50mph to 60mph)

The results of these comparisons are presented in Section 3.5.

2.6.1.8 Close following

Data from the R-Cam system were processed to calculate the proportion of vehicles with a gap between vehicles of less than two seconds (the minimum following distance recommended by the Highway Code). These data were split by vehicle class to investigate differences between the close following behaviours of HGV and car drivers.

The data from the R-Cam system allowed the following comparisons to be made:

1. Comparison of close following by vehicle class between the baseline and trial periods at the experimental location (i.e. when the speed limit changed from 50mph to 60mph)

The results of these comparisons are presented in Section 3.6.

2.6.2 Incidents and incursions data

Recovery log records containing information on all incidents recorded by the CCTV team were provided by the scheme. The scheme provided data for road traffic collisions (RTCs)

and breakdowns occurring in the works⁵. These data were analysed to understand the number and type of incidents that occurred at the control and experimental locations during the baseline and trial monitoring periods.

The following comparisons were made:

- 1) Comparison of the number of RTCs between the baseline and trial periods
- 2) Comparison of the number of other incidents (e.g. breakdowns) between the baseline and trial periods

In addition, information on incursions into the roadworks were recorded in AIRSweb and provided to TRL after the trial was complete.

A summary of these data is presented in Section 3.7.

The Traffic Safety and Control Officer (TSCO) reports for the scheme, which detail TSCO daily activities and comments relating to the TM, were also reviewed to identify any incidents or unusual events which were not picked up by the CCTV records. Nothing of note was identified from this source.

2.6.3 *Journey time*

Data on Journey Time Reliability (JTR) were not available for this scheme. Instead, estimates of the average journey time were calculated based on the length of the experimental link and the average speed of vehicles observed in the baseline and experimental monitoring periods. These estimates were compared between baseline and trial periods to ascertain whether the change in speed limit resulted in a change in average journey time. Whilst not as informative as JTR, these estimates will provide an indication for customer journey times (and therefore a potential indicator for customer satisfaction) through the roadworks scheme. The findings from these calculations are presented in Sections 3.8.

2.6.4 *Customer satisfaction survey data*

The previous on-road trials for this project (e.g. M1 J32-35a and A1 Leeming to Barton schemes) involved surveys with road users, carried out at local Motorway Service Areas (MSAs) close to the scheme. However, discussions as part of the lessons learned meeting, following the successful trial of a 60mph speed limit at the M1 J32-35a scheme, suggested that it would be beneficial to target drivers who are “regular users” of the scheme to understand their views on the increased speed limit. Since the majority of drivers who break at Motorway Service Areas are not local to the area, local business parks were used as a potential source for regular commuters.

⁵ Due to data protection requirements, no CCTV footage of any of the incidents was provided to TRL. The scheme have clarified that the incidents which did occur were all minor incidents, and subsequently footage was not recorded and retained. The only information provided to TRL about each incident was the details from the recovery logs (detailing who attended etc.). Full incident reports are only generated if an injury or fatality occurs, neither of which apply in this case.

Consideration was given to also running a survey at the local MSA; however, this methodology was considered impractical for this scheme due to the location of the nearest services relative to the works. The nearest MSA was Strensham Services, located between Junctions 7 and 8, approximately 28km south of junction 5.

TRL contacted many of the businesses at the Apex Business Park, which is located just off Junction 6 on the M5, to invite them to participate in an online survey. Flyers were also used to advertise the survey at locations local to the scheme. This provided input from road users who use the M5 as part of their daily commute. The survey was hosted online and was incentivised by entry into a prize draw.

The survey asked questions about respondents' experience of the journey, what they thought the posted speed limit on each link was, the suitability of this speed limit and whether the behaviour of other drivers made them feel less safe. Participants were also asked which route they would choose when given a choice of two routes with roadworks, each with different attributes. The aim of this short 'stated preference' survey is to inform the relative importance of a number of different features of roadworks, or 'attributes' (speed limit, length, enforcement and lane width). The questionnaire is included in Appendix B.

Responses from the MSA surveys were used to answer the following questions:

- 1) Did drivers notice the change in speed limit between Junction 4a and Junction 5?
- 2) What features of the roadworks are likely to have the biggest impact on driver satisfaction?

The results from this survey are presented in Section 3.9.

2.6.5 Statistical comparisons

Appropriate statistical tests⁶ were used to test for significant differences between data recorded during the baseline and trial periods (i.e. to determine whether driver behaviour changed following implementation of the increased speed limit). Two types of statistical test were used, the choice of which was dependent on the type of data:

- **Chi-squared tests** were used to test for a difference in the distribution of categorical data, for example to test for a difference in the distribution of incidents between the baseline and trial periods.
- **Analysis of variance (ANOVA)** were used to test for a difference in the mean response between groups, for example to test for a difference in the average speed between the baseline and trial periods.

Results were classified as 'statistically significant' if the p -value was less than 0.05 (a common standard in the behavioural sciences). The p -value is a measure of probability and, in the context of the tests carried out in this report, a value of less than 0.05 can be

⁶ Where required, data were transformed to meet the assumptions required by the statistical test.

interpreted as meaning that there is a statistically significant difference between the groups being tested with a less than 5% chance that the difference occurred at random.

3 Results

3.1 Vehicle flow

Figure 3 shows the change in average daily vehicle flow between the three monitoring periods (baseline, phase 1 and phase 2), at each of the four radar locations, for the experimental location.

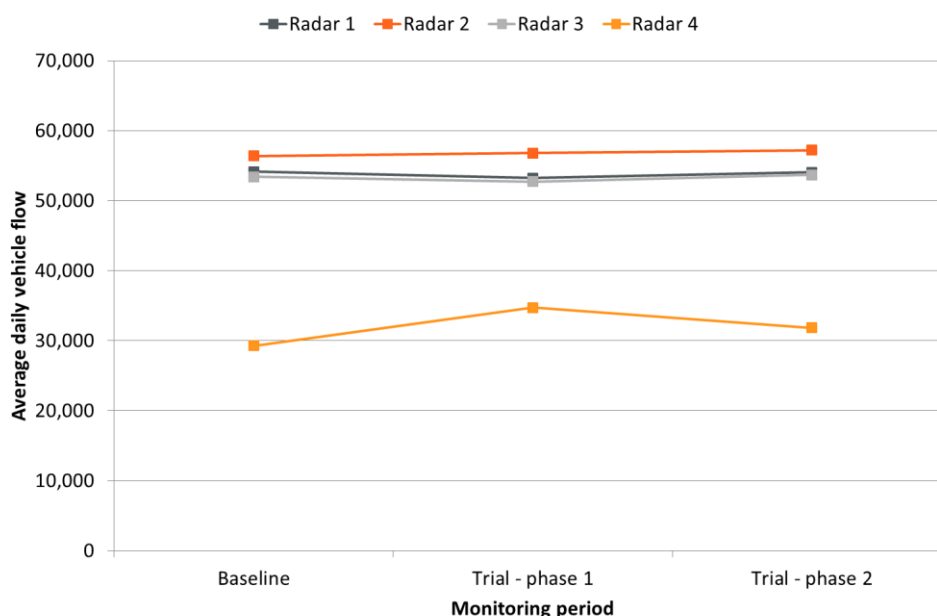


Figure 3: Average daily vehicle flow by radar location and monitoring period at the experimental location (southbound carriageway)

Since there were no junctions between the four radar locations, vehicle flow is expected to be comparable across the locations within each monitoring period. However, the vehicle flow was found to vary by location (as can be seen in Figure 3), possibly due to issues with occlusion (see Section 2.6.1.3). In particular, radar 4 recorded a substantially lower flow than the other three radars; this radar was the only radar located on the northbound carriageway and so measurements on the southbound carriageway may have been affected by the concrete central reservation. This issue is likely to have been particularly prevalent in the lanes closest to the central reservation. A similar pattern can be seen when examining flow data for the control location (northbound carriageway) from radar 1, 2 and 3 which were located on the southbound carriageway.

Examination of the flow between monitoring periods suggests that there were only minor differences. Excluding radar 4, statistical tests showed that there was no significant difference ($p = 0.168$) in the distribution of vehicle flow across the monitoring periods between the remaining three radar locations. This suggests that any changes in average vehicle speed or headway between the monitoring periods are likely to be the result of the change in speed limit, rather than due to differences in vehicle flow.

The proportion of vehicles that were classified as HGVs, split by radar location and monitoring period, are shown for the experimental location in Figure 4.

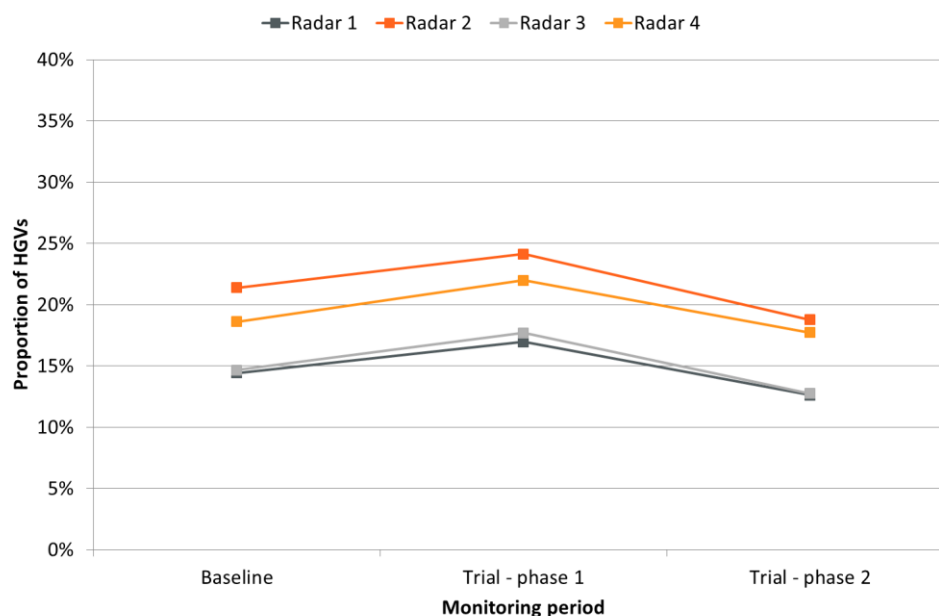


Figure 4: Proportion of HGVs by radar location and monitoring period at the experimental location (southbound carriageway)

Across all the radars, the proportion of HGVs was slightly higher in phase 1 (Mon-Wed) than in the baseline (Mon-Sun) and phase 2 (Thurs-Mon) periods; this may be at least partially explained by the greater numbers of HGVs known to be on the roads on weekdays.

As with the total flow, there was some variation in the proportion of HGVs between the four radars within each monitoring period. These differences are likely to be due to the misreporting of total flow.

Key findings

- Excluding the inaccurate data, there was little difference in the vehicle flow between monitoring periods, so any changes in average vehicle speed or headway are likely to be the result of the change in speed limit.
- Approximately 15-25% of vehicles were HGVs, with some variation in this figure by day of the week.

3.2 Lane distribution

Figure 5 shows the proportion of vehicles in each lane in the three monitoring periods at radar 1 at the experimental location (southbound carriageway).

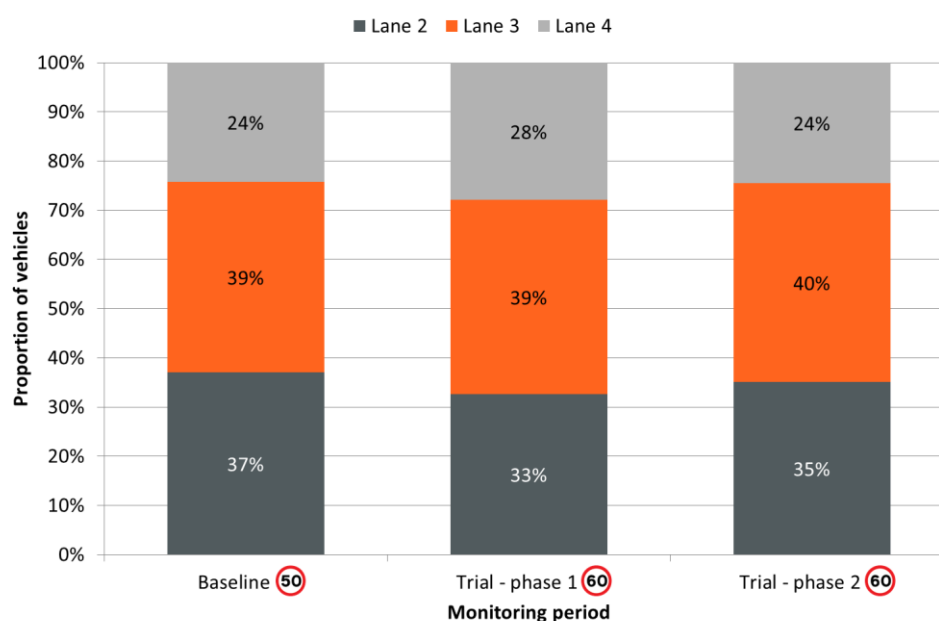


Figure 5: Proportion of vehicles by monitoring period and lane at the experimental location (southbound carriageway, radar 1)

The distribution of vehicles by lane was fairly similar across the three monitoring periods, suggesting that the change in speed limit did not change the overall lane choice of vehicles.

Specific changes in the lane distribution by vehicle class were investigated (see Figure 6)⁷. These charts show the distribution of cars, vans/LGVs and HGVs by lane in the 50mph and 60mph speed limits.

⁷ Similar results were observed using data from the R-Cam system.

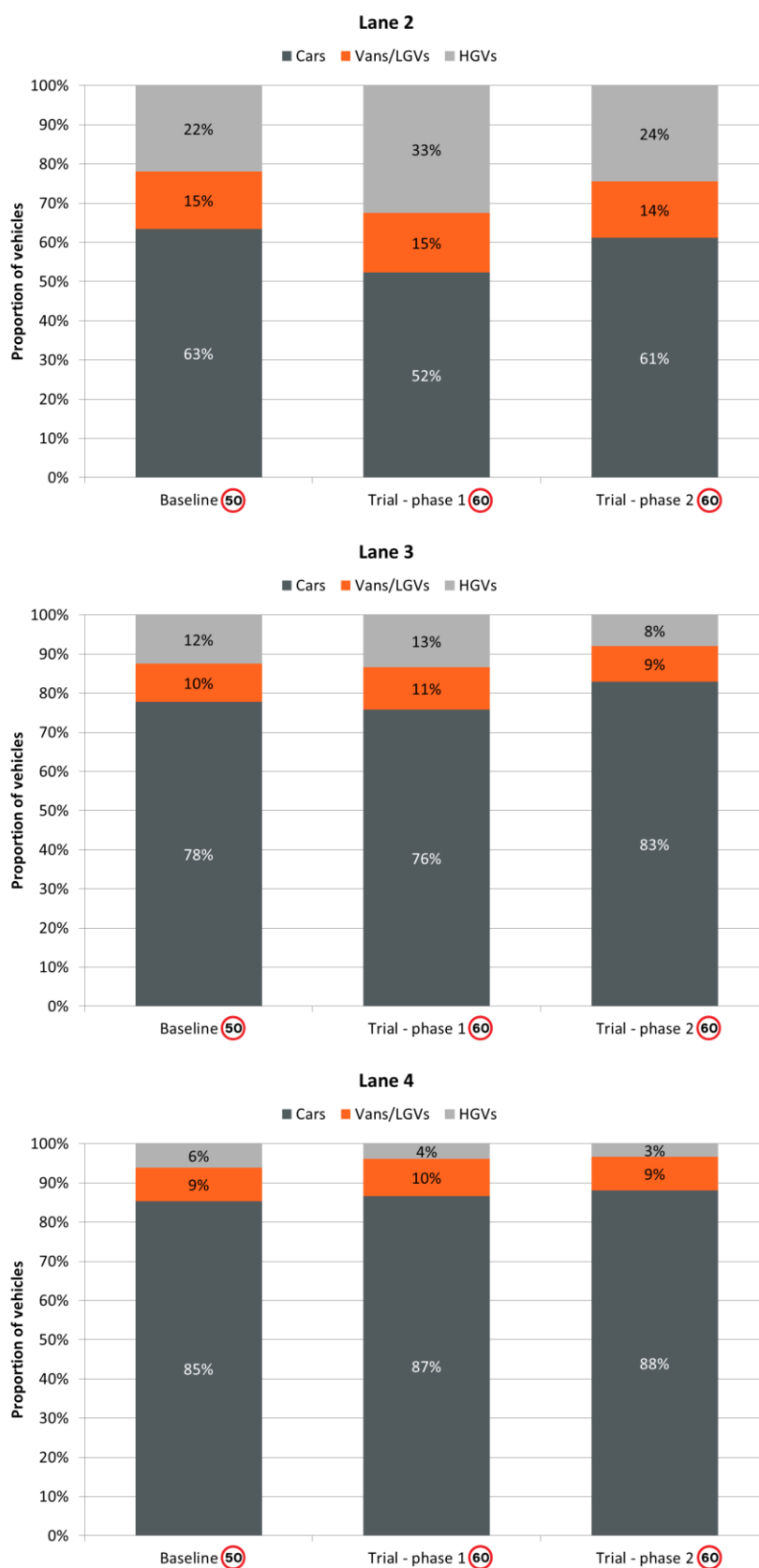


Figure 6: Distribution of vehicle types by lane and monitoring period at the experimental location (southbound carriageway)

Within each lane, the distribution of vehicles in phase 1 was substantially different from the baseline and phase 2 results; this is likely to be linked to the higher levels of HGV travel on weekdays compared to the weekends (as seen in Figure 4).

Comparison of the results from the baseline and phase 2 monitoring periods suggests that the change in speed limit had a different effect on the lane choice of HGVs to that of cars. The proportion vehicles in Lane 2 which were HGVs increased and the proportion in Lanes 3 and 4 decreased (resulting in the opposite finding for cars); these changes were significant ($p < 0.01$). Possibly, this may be related to differences in speeds by vehicle type (see Figure 10) which suggested that fewer HGVs were overtaking in the outer lanes.

Key findings

- The overall number of vehicles in each lane remained relatively stable.
- The proportion of vehicles which were HGVs in Lane 2 increased following implementation of the 60mph speed limit, while the proportion in Lane 3 decreased. Coupled with the average speed data these findings suggest that there were fewer overtaking manoeuvres carried out by HGVs following the change in speed limit.

3.3 Average vehicle speed

Figure 7 shows the free-flow average speeds on the control and experimental links (northbound and southbound carriageway, respectively) at radar 1 across the three monitoring periods.

Throughout this section, please note the compressed vertical axis on the charts, displaying data from 45mph to 60mph.

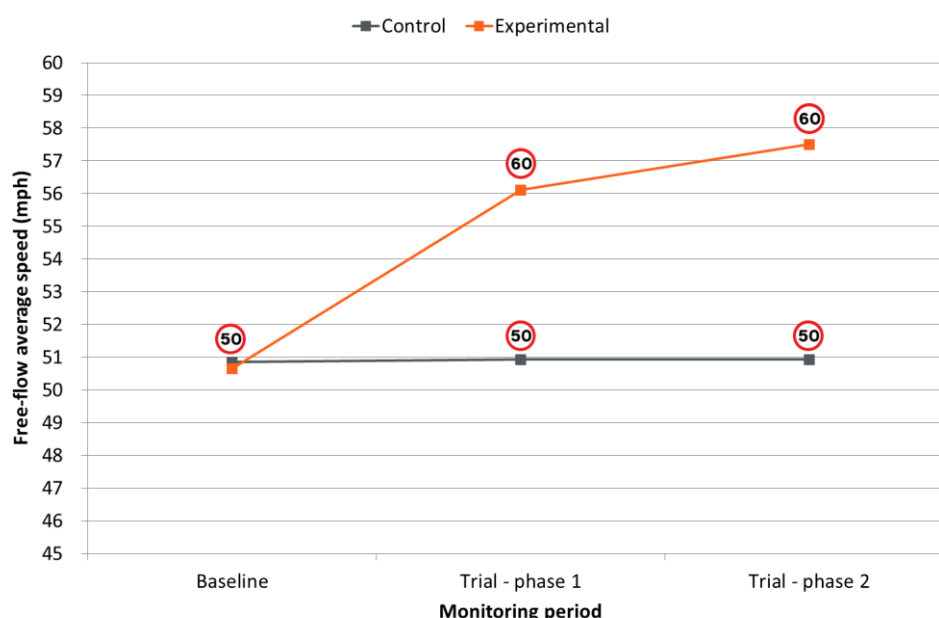


Figure 7: Free-flow average speed during the monitoring period by location (radar 1)

The free-flow average speed remained fairly similar at the control location (with a speed limit of 50mph throughout), but increased at the experimental location as the speed limit changed in the monitoring period (50mph in baseline, 60mph in phase 1 and 2). This suggests that, on average, drivers did notice the change in speed limit.

Throughout both phase 1 and phase 2 of the trial, the average speed remained around 56-58mph, below the speed limit of 60mph.

A statistical test (ANOVA) showed that the interaction between location (control vs. experimental) and monitoring periods (baseline vs. phase 1 vs. phase 2) was significant ($p < 0.01$). This indicates that the change in free-flow average speed (across the three monitoring periods) was significantly different between the control and experimental locations. The slight differences in the vehicle flow and composition between carriageways could explain some of the differences in speed, however the results provide strong evidence that most of the differences observed can be attributed to the change in speed limit.

As shown in Figure 7, average speeds were fairly consistent at radar 1 on the northbound carriageway (the control location). Although not shown in the figure, a similar trend was observed at the other three radar on this carriageway, suggesting that the change in speed limit on the southbound carriageway (experimental location) had little to no effect on driver behaviour on the northbound carriageway (control location).

Figure 8 shows how average speed changed at the four radar positions at the experimental location (southbound carriageway). The 60mph speed limit was implemented at all four radar locations on 20th March and changed at radar 4 (back to 50mph) on 23rd March.

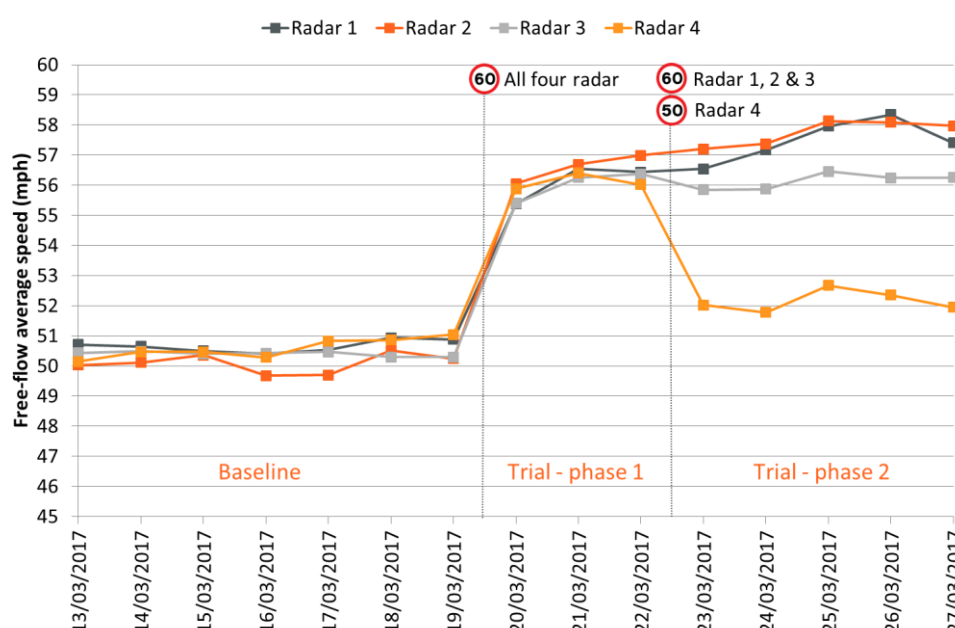


Figure 8: Free-flow average speed by radar location and date at the experimental location (southbound carriageway)

The changes in speed limit had an immediate impact on the free-flow average vehicle speeds. The average speeds across all four radars remained roughly the same during the baseline period (until 19th March 2017), during which the speed limit was 50mph throughout the scheme. An increase in average speeds was observed between 20th to 22nd

March (phase 1) when the speed limit was increased to 60mph at all four radars; with an average speed of 55-57mph, lower than 60mph speed limit.

On 23rd March, the signing arrangement changed again with the 60mph speed limit remaining in place at radars 1, 2 and 3 followed by a 'step down' in speed limit to 50mph at radar 4. A VMS was co-located with radar 3, notifying drivers of the change in speed limit ahead. The results suggest that average speeds increased slightly at radars 1 and 2 during phase 2; however, the overall average speed still remained below the 60mph limit. At radar 3, which was located alongside the VMS, speeds were slightly lower but remained around 55-57mph. This might suggest that some drivers reacted to the VMS, slowing even before they reached the first terminal sign showing 50mph. However, the proportion of drivers who reacted in this way is likely to be small (since there is only a 1-2mph difference between radar 3 and radar 1/2).

At radar 4 in phase 2, the speed limit was 50mph. Average speeds remained higher than the speed limit (around 51-53mph) and higher than the average speeds seen in the baseline period, suggesting that not all drivers adjusted their speed following the VMS and terminal signs. It is not clear what is driving this finding; it is possible that some drivers missed the step down and continued driving at 50mph. Alternatively, since the next pair of average speed cameras doesn't occur until after Junction 5 (downstream of the step), some drivers may have realised that the drop in speed limit was not being enforced at that point and continued to drive at speeds faster than the limit deliberately.

In order to investigate speeds on the southbound carriageway at a higher level of granularity, free-flow average speeds by lane are shown in Figure 13. This analysis is restricted to radar 1 at the experimental location.

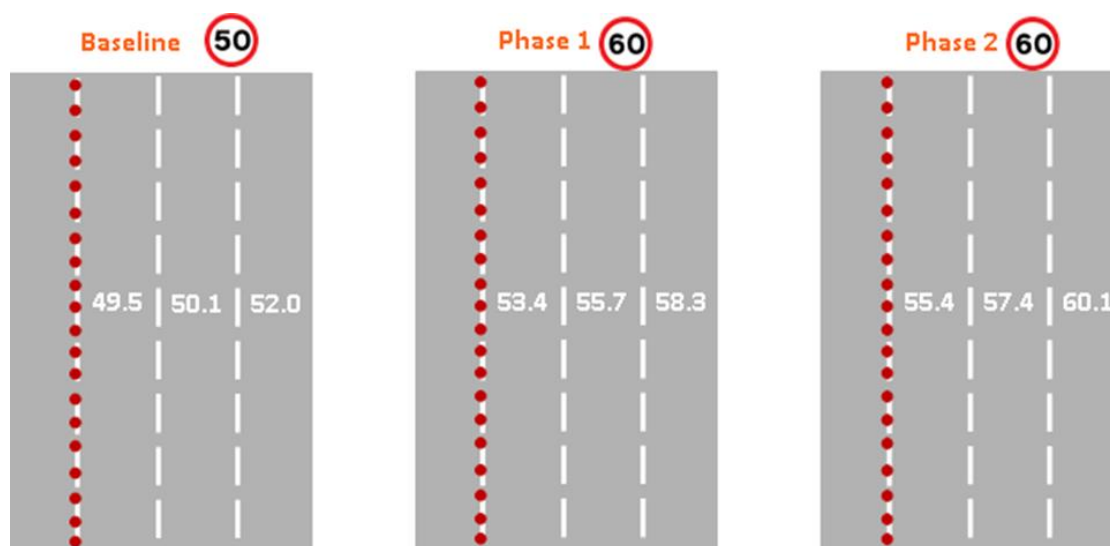


Figure 9: Free-flow average speed (in mph) by monitoring period and lane at the experimental location (southbound carriageway, radar 1)

In all three periods, speeds were typically higher in Lane 4 and Lane 3 than in Lane 2. Comparison between the monitoring periods indicates that average speeds increased in all three lanes between the baseline and phase 2 periods: Lane 2 increased by 5.9mph, Lane 3

by 7.3mph and Lane 4 by 8.1mph. Although not shown here, there was little change in the average speeds by lane at the control location.

Finally, the IVD provide information on the speeds of each vehicle type. Figure 10 shows the average speed of cars, vans/LGVs and HGVs in phase 2 at radar 1. Unfortunately due to the availability of the IVD, no comparisons can be made before and after the change in speed limit (data were restricted to phase 2). However, comparison between locations (i.e. carriageways) provided some indication as to the change in average speed for each vehicle type between a 50mph speed limit and a 60mph limit.

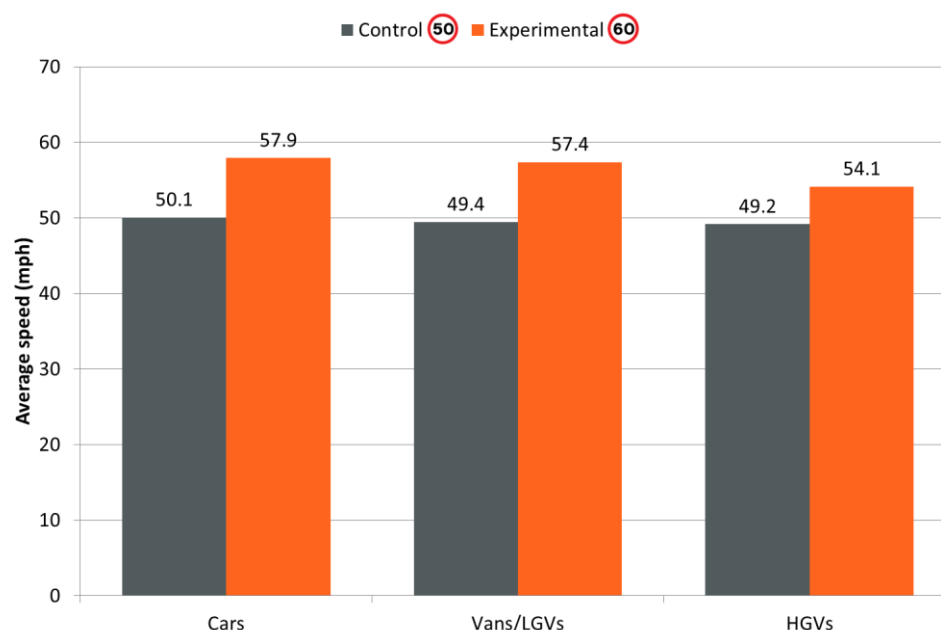


Figure 10: Free-flow average speed (in mph) by vehicle type and location (radar 1, phase 2)

The results suggest that HGVs were typically travelling slightly slower, on average, than cars in both speed limits. There was also a bigger speed differential between cars in the two speed limits (50mph to 58mph) than HGVs (49mph to 54mph), suggesting that cars increased their speed more than HGVs when the speed limit increased to 60mph. Since these results are based on different carriageways, differences in topography⁸ might influence speed choice, in particular by HGVs. It is not possible to quantify the extent to which this has influenced the results presented here.

⁸ The northbound carriageway (control location) between Junctions 4a and 5 is on a slight incline whilst the southbound carriageway (experimental location) declines.

Key findings

- Free-flow average speeds increased significantly (by around 6-8mph) following implementation of the 60mph speed limit, suggesting that drivers noticed and responded to the change in speed limit.
- Throughout the trial, the average speed remained around 56-58mph, below the speed limit of 60mph.
- There was some indication that a small proportion of drivers may have reacted to the VMS located just before the step down, slowing even before they reached the first terminal sign showing 50mph.
- Not all drivers reduced their speed following the step down: average speeds remained higher than the speed limit (around 51-53mph) and higher than the average speeds seen in the baseline period.
- Following implementation of the 60mph speed limit, speeds increased more in Lane 4 than Lanes 2 and 3.
- On average, HGVs typically travelled slower than cars in both the 50mph and 60mph speed limits.

3.4 Speed limit compliance

Figure 11 shows the proportion of vehicles recorded in each speed bin across the three different monitoring periods at radar 1 (located within the 60mph speed limit in both phase 1 and 2 of the trial). The grey bars show the proportion of vehicles travelling below the speed limit in each period; the dark orange bars show vehicles travelling above the speed limit but below the enforcement threshold and the lighter orange bars indicate the proportion of vehicles travelling above the enforcement threshold.

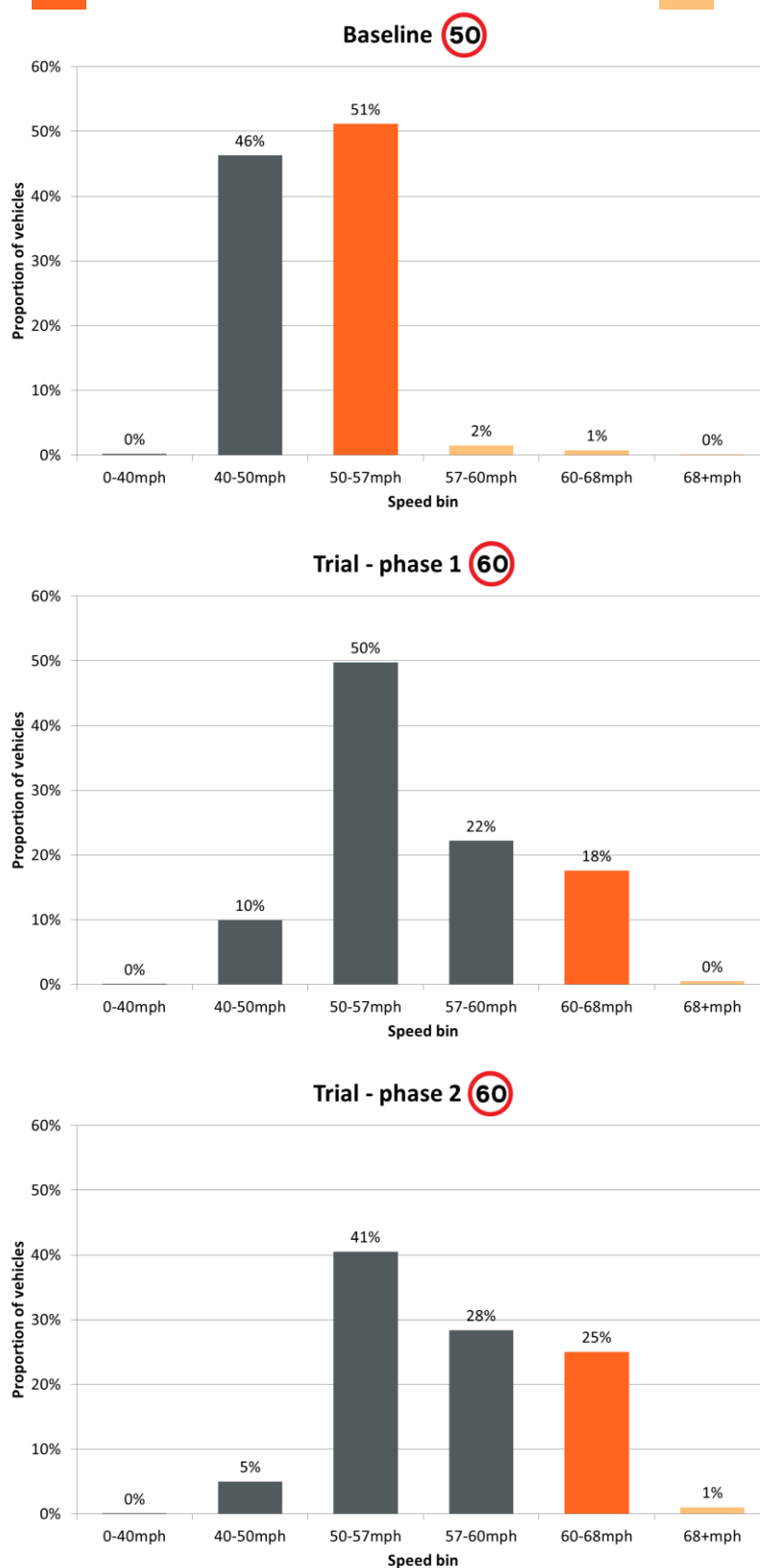
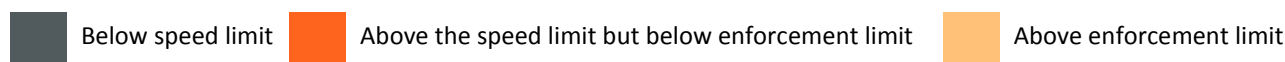


Figure 11: Proportion of vehicles in each speed bin by monitoring period at the experimental location (southbound carriageway, radar 1)

The proportion of drivers who complied with the speed limit at the experimental location (southbound carriageway) was 46% in the baseline period when the speed limit was 50mph, and over 75% in the trial period (phase 1 and 2 combined) when the speed limit was 60mph. Although not shown in the figure, the proportion of vehicles within the speed limit (50mph) at the control location (northbound carriageway) was around 42-43% throughout the monitoring, suggesting that overall compliance with the 60mph speed limit was better than compliance with the 50mph speed limit.

The distribution of vehicles across the different speed categories was very similar between phase 1 and 2 at the experimental location. There was a higher proportion of vehicles recorded in the 57-60mph and 60-68mph categories during the trial period compared to the baseline, due to increase in speed limit to 60mph.

The lightest orange bars represent the drivers who travelled above the enforcement threshold in each speed limit (57mph in the 50mph limit and 68mph in the 60mph limit). The proportion of vehicles above the enforcement threshold was 2.4% in the baseline period, 0.5% in phase 1 and 1.5% in phase 2 of the trial, suggesting that the number of vehicles who would have been prosecuted for speeding would have decreased during the trial (from an average of 129 per day during the baseline period to 36 per day during the trial).

Figure 12 shows the corresponding data for radar 4 (located within the 60mph speed limit in phase 1 and 50mph speed limit in phase 2).

Below speed limit
 Above the speed limit but below enforcement limit
 Above enforcement limit

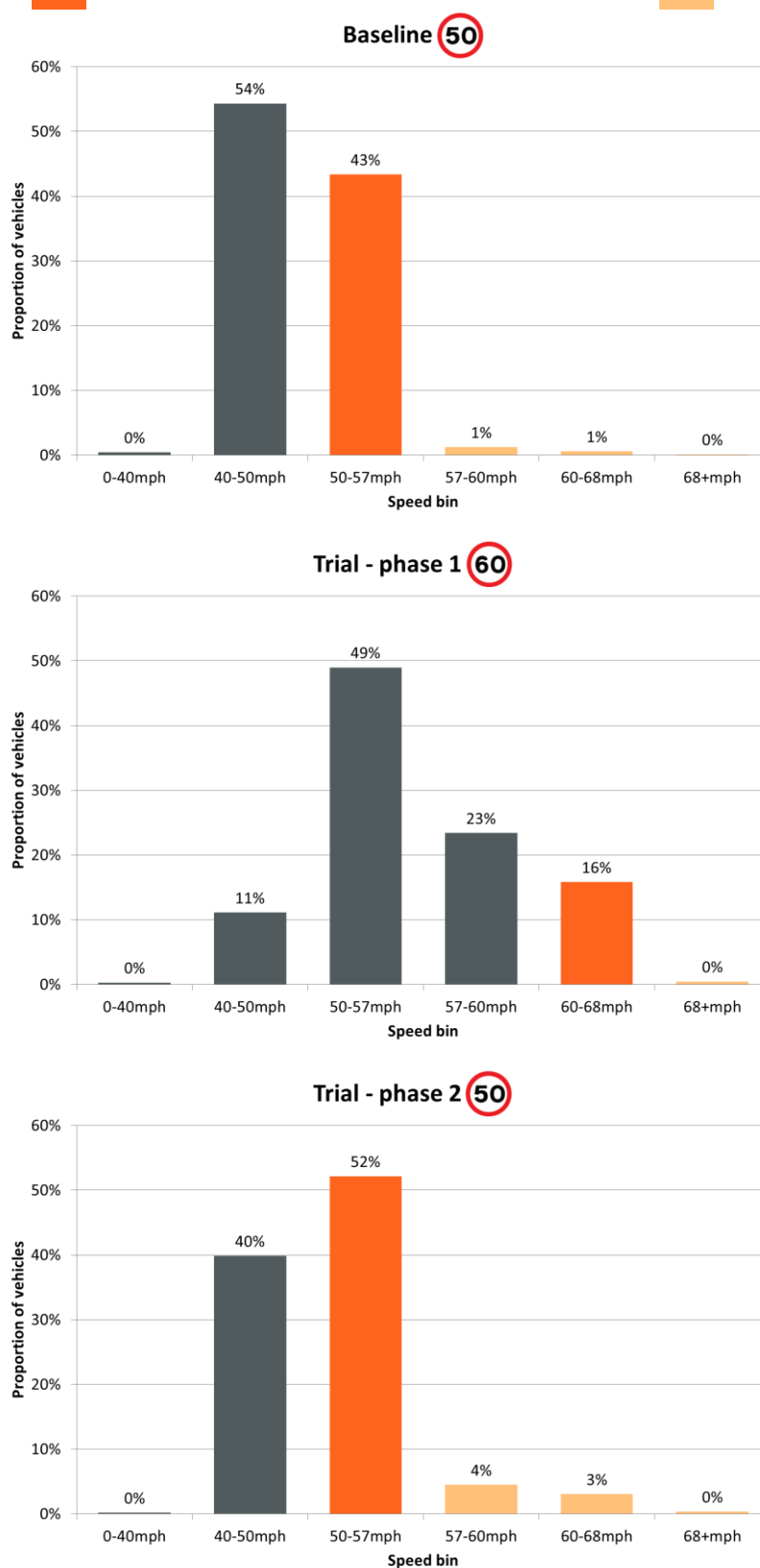


Figure 12: Proportion of vehicles in each speed category by monitoring period at the experimental location (southbound carriageway, radar 4)

Between phase 1 and phase 2, the speed limit at radar 4 changed from 60mph to 50mph. Comparing these two periods, it can be seen that drivers were more compliant with the speed limit in phase 1 (84%) than phase 2 (40%), and there were fewer drivers exceeding the enforcement threshold (0.5% compared to 8%). This matches with the finding from radar 1 that drivers were more compliant in the 60mph limit than the 50mph.

Comparing data from the baseline period and phase 2 shows that compliance with the speed limit was worse during trial phase 2 (55% compared to 40%) and the proportion of people over the enforcement threshold was higher (2% compared to 8%). If the step down was effective we would expect little difference in these results. As with the average speed data, this might suggest that there were some drivers who missed the step down or who chose to drive faster than the limit.

The darkest orange bar represents the proportion of drivers who travelled above the speed limit but below the enforcement threshold. This proportion was highest during phase 2 (52%), slightly lower in the baseline period (43%) and substantially lower during phase 1 (16%). This suggests that a proportion of drivers were prepared to travel slightly faster than 50mph during phase 2 (at speeds up to 57mph), risking enforcement action, but when the 60mph limit was in force they were content to travel at a speed that was below the posted speed limit and so were compliant.

The IVD can also be used to investigate how speeding differs by vehicle type (Figure 13), although analysis is restricted to a comparison between cars, vans/LGVs and HGVs during the 60mph limit only.

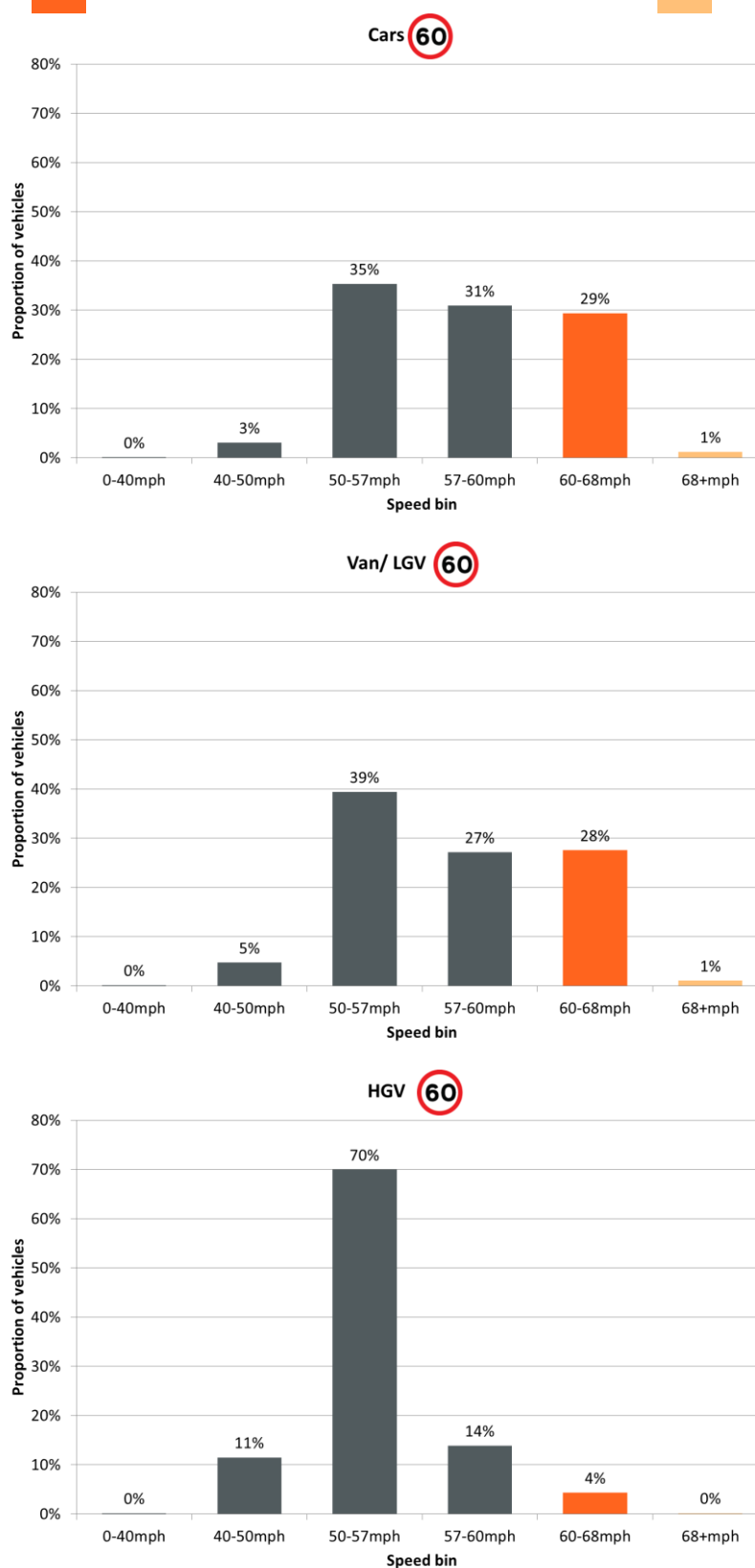
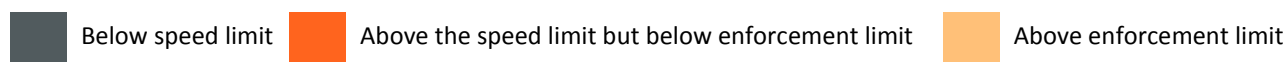


Figure 13: Proportion of vehicles in each speed category by vehicle type at the experimental location (southbound carriageway, radar 1, phase 2)

The distribution across speed categories was similar for car and vans, but differed for HGV drivers. The proportion of HGV drivers complying with the 60mph speed limit was 95%, but was much lower for car and van drivers (69% and 71% respectively). This high level of compliance for HGV drivers may be linked to use of the speed limiter devices which are restricted to 56mph (90km/h) .

The lighter orange bar shows that the proportion of drivers driving over the enforcement threshold was low for all three vehicle types: 1% for cars and vans and less than 1% for HGVs.

Key findings

- The proportion of drivers who complied with the speed limit was higher during the trial period, suggesting that overall compliance with the 60mph speed limit was better than compliance with the 50mph speed limit.
- The number of vehicles over the enforcement threshold (speed limit + 10% + 2mph) was lower during the trial, suggesting that the number of speeding prosecutions would have decreased during the trial compared with the baseline period.
- Comparison of the baseline and phase 2 data indicates that there were some drivers who missed the step down or who chose to drive faster than the limit.
- The proportion of HGV drivers complying with the 60mph speed limit was higher than the figure for car and van drivers. This may be linked to use of speed limiters which restrict these vehicles to 56mph.

3.5 Average vehicle headway

Average vehicle headway can be expected to be linked with flow since headway will naturally increase when flow is lower.

Figure 14 compares the average vehicle headway at radar 1⁹ between the control and experimental locations by monitoring periods.

⁹ Analysis is restricted to radar 1, since issues with occlusion (see Section 2.6.1.3), particularly at radar 3 and 4, is likely to have influence the headways recorded at the other radar sites.

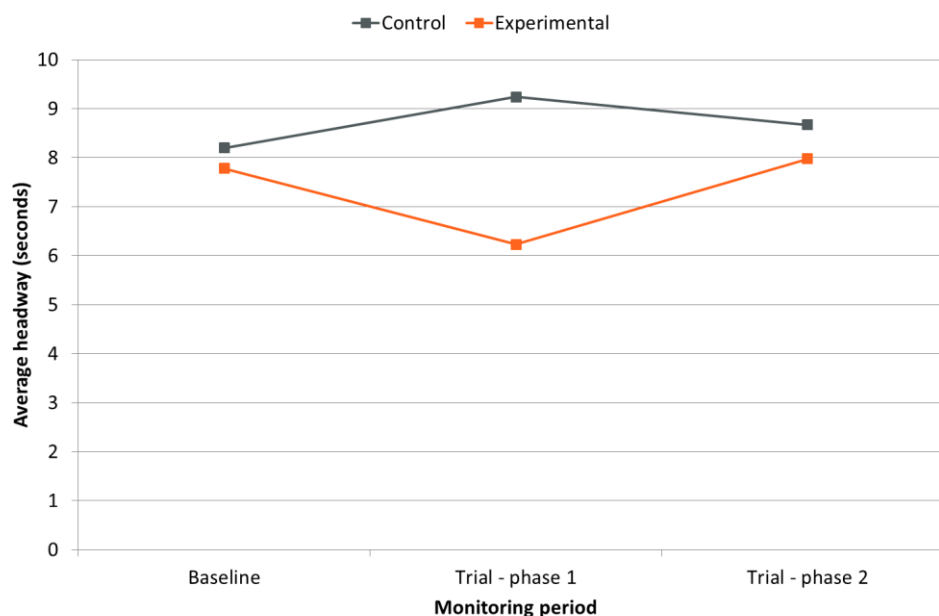


Figure 14: Free-flow average headway by monitoring period and location (radar 1)

The free-flow average headway was higher at the control location than the experimental location, possibly due to slightly lower traffic flows on average (46,000 compared to 54,000 vehicles per day).

Whilst there were only small differences in average headway at the control location across the three periods (some of which will be attributable to differing flows and traffic composition across the different periods), there was a larger change in headway at the experimental location. During both phase 1 and 2 the speed limit was 60mph at this location, but there was a difference of nearly 2 seconds in average headway, with the phase 2 result being more comparable to the baseline period. Some of this might relate to the lower flows (and thus longer headways) included in the baseline and phase 2 periods as a result of the weekend drop-off in flow. However, it is not clear whether any of the difference can be attributed to a change in behaviour as a result of the implementation of the 60mph speed limit, resulting in more close following (at least in the first few days following this change). A statistical test (ANOVA) comparing average headway across monitoring periods and locations shows that the change in headway across monitoring periods was significant for the two locations ($p < 0.01$).

The Highway Code (DfT, 2015) suggests that drivers should allow at least 2 seconds gap between themselves and the vehicle in front on roads carrying faster moving traffic, with this distance at least doubled on wet roads and increased still further on icy roads. The average free-flow headway was typically much larger than 2 seconds (although there was some variation with lower headways observed at times of day during with more traffic and during phase 1 - as seen in Figure 14). These data do not suggest that the occurrence of unsafe headways between vehicles was greatly impacted by the 60mph speed limit.

IVD data can usually be used to provide information on the headway of each vehicle type (in order to understand close following). However, this field was not provided within the output of the IVD loggers used in this trial. As such, data from the R-Cam system were used to estimate the average headway between vehicle types (although the data are limited to

daytime peak hours only). Figure 15 shows the average headway of cars/vans and HGVs in the baseline and phase 1 periods; this gives an indication as to the change in average headway for each vehicle type between a 50mph speed limit and a 60mph limit.

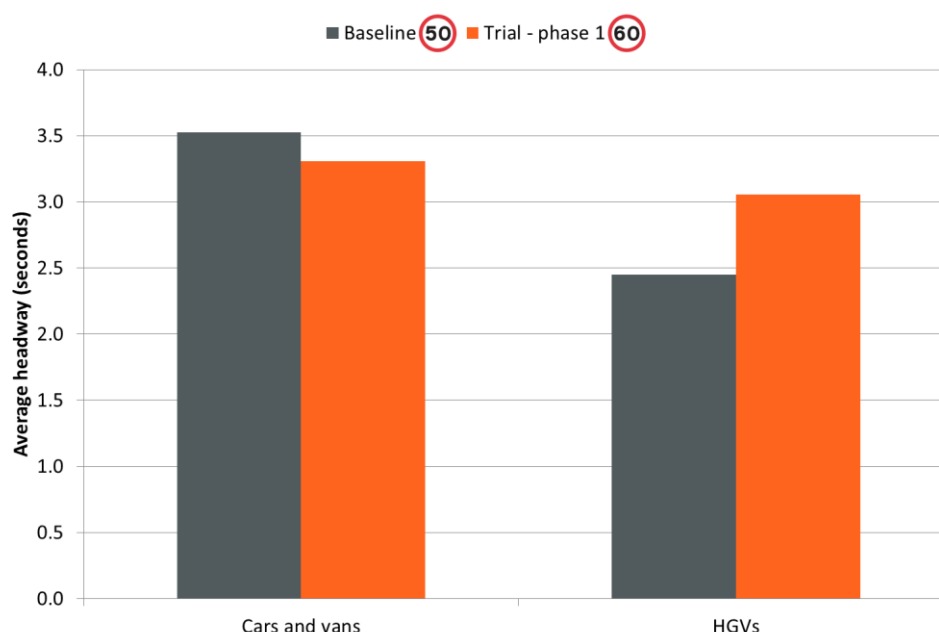


Figure 15: Average headway by monitoring period and vehicle type at the experimental location (southbound carriageway, R-Cam data)

The results suggest that the headway was, on average, larger for cars and vans in the 50mph speed limit than in the 60mph speed limit, whilst the opposite was true for HGVs. This change in headway was significant ($p < 0.01$), suggesting that the increase in speed limit had a different effect on the behaviour of the two vehicle types.

A comparison of headways between vehicle types suggests that in both speed limits headways were, on average, shorter for HGVs than cars. However, headway takes no account of the length of the vehicle (since it is measured from the front bumper of one vehicle to the front bumper of the next vehicle). As such, the average gap is a better measure of close following which measures from the front bumper of the vehicle behind to the rear bumper of the vehicle ahead. Figure 16 presents the average gap by vehicle type.

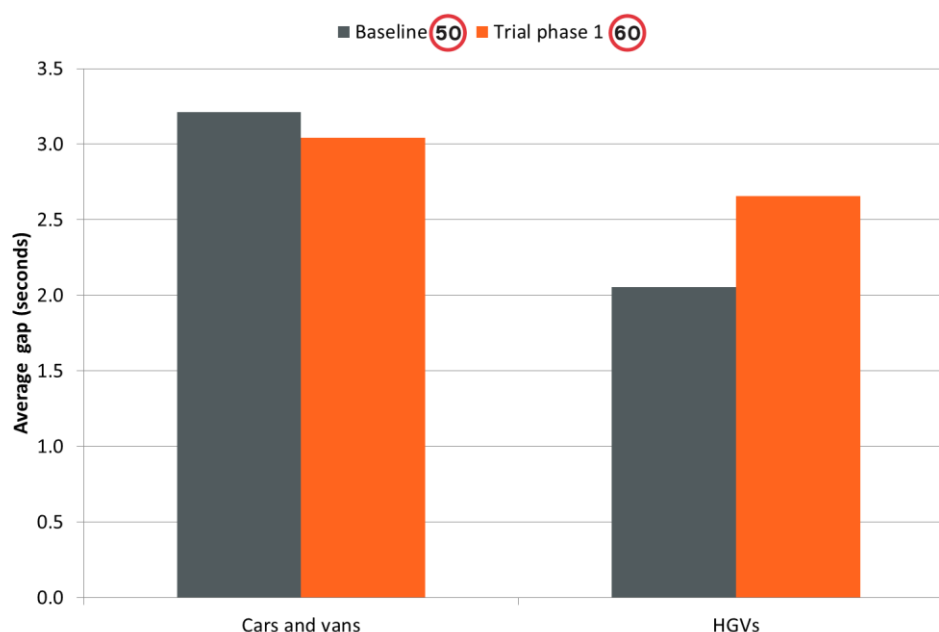


Figure 16: Average gap by monitoring period and vehicle type at the experimental location (southbound carriageway, R-Cam data)

The results are similar to those presented for headway: car/van gap was slightly reduced in the 60mph speed limit, but HGV gap increased. Average gap is shorter for HGVs than cars and vans in all conditions, suggesting that close following is more prevalent in HGV drivers, but that it reduced in the 60mph condition.

Key findings

- Across the entire monitoring period, average headway was higher than the minimum two second headway recommended by the Highway Code and as a result, there is limited evidence to suggest that the prevalence of unsafe headways was increased by the 60mph speed limit.
- However, a smaller subset of data from the R-Cam system showed that average headway was substantially lower during the daytime peak, and lower for HGVs than cars.
- Average headway (and gap, which is used to measure close following) decreased slightly between the 50mph and 60mph limits for cars but increased for HGVs.

3.6 Close following

TRL's R-Cam system was used to investigate the amount of close following by different vehicle types during the baseline and phase 1 trial periods. 'Close following' was defined as any incidence in which vehicles had a gap of less than 2 seconds.

The R-Cam System collected individual vehicle data for 25,459 instances of close following at the experimental location (southbound carriageway); 20,632 of these were cars/vans and 4,827 were HGVs. Whilst cars and vans accounted for a larger number of close following

instances than HGVs, these vehicles also accounted for more traffic. Figure 17 shows the proportion of incidences classified as close following by vehicle type and speed limit.

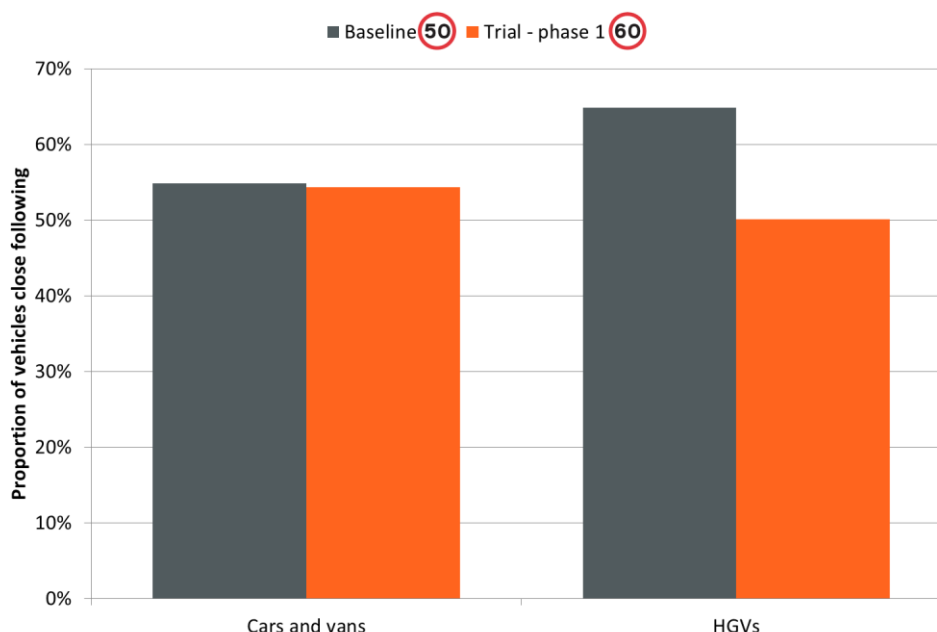


Figure 17: Proportion of vehicles travelling less than two seconds from the rear of the vehicle in front by monitoring period and vehicle type at the experimental location (southbound carriageway, R-Cam data)

Following the change in speed limit from 50mph to 60mph, the proportion of cars and vans close following remained stable at around 55%. However, the proportion of HGVs close following dropped from 65% to 50%. Chi-squared tests showed that this finding was significant ($p < 0.01$). These results suggest that the increase in speed limit led to a considerable (15%) reduction in close following by HGVs, but had little impact on the rates of close following by cars and vans. Similarly to the results for speed (Figure 10 and Figure 13), this finding might be linked to the requirement for HGVs to be fitted with a 56 mph speed limiter.

Key findings

- Over 50% of all vehicles were classified as close following (i.e. gap less than 2 seconds) in both speed limits.
- HGVs were significantly less likely to close follow when the speed limit was 60mph than 50mph.
- There was no substantial change in the amount of close following by cars and vans.

3.7 Incidents and incursions

3.7.1 Recovery log

In total, 32 breakdowns were reported, 22 of which were in the baseline period, four in phase 1 of the trial, and six in phase 2. Due to the limited number of reported instances, no statistical analysis could be undertaken. A summary of the reported breakdowns¹⁰, by monitoring period and carriageway, is presented in Table 4.

Table 4: Number of breakdowns by monitoring period and location

Monitoring period	Carriageway		Total
	Control (N/B)	Experimental (S/B)	
Baseline (7 days)	20	2	22
Phase 1 (3 days)	1	3	4
Phase 2 (3 days)	4	2	6

Individual video footage of RTCs were not provided to TRL; reports for the RTCs were only completed if an injury or fatality occurred (neither of which was applicable to the six collisions which did occur during the monitoring). Therefore, it was not possible to determine whether the change in speed limit may have been a contributory factor in any of these collisions.

The number of RTCs by monitoring period and carriageway is presented in Table 5.

Table 5: Number of RTCs by monitoring period and location

Monitoring period	Carriageway		Total
	Control (N/B)	Experimental (S/B)	
Baseline (7 days)	2	1	3
Phase 1 (3 days)	0	0	0
Phase 2 (3 days)	3	0	3

Due to the small number of incidents reported it is not possible to draw robust conclusions; interpretation of the figures should be completed with caution.

¹⁰ Breakdowns include those which the recovery operatives have documented as “gear box”, “puncture”, “out of fuel”, “clutch”, “electrical”, “overheated” and “engine”.

3.7.2 Incursions log

Unfortunately, the total number of incursions which occurred during the monitoring could not be accurately determined. During the period 13th March 2017 to 27th March 2017, a total of two incursions were recorded. It is not clear from the descriptions (provided to TRL from AIRSweb) what time these events occurred or their precise location; however, none were identified by the scheme as having resulted due to the change in speed limit.

Key findings

- Six minor RTCs were reported during the monitoring (three in the baseline and three in the trial periods); however, it was not possible to determine whether the change in speed limit was a contributory factor in any of these collisions.
- Two incursions into the roadworks were logged by the scheme; neither were identified as having resulted due to the change in speed limit.

3.8 Journey time

Estimates of the average journey time were calculated based on the length of the link¹¹ and the average speed of vehicles from the radar data. Table 6 shows the average journey time in the baseline and trial phase 1 periods. Both the control (northbound carriageway) and experimental locations (southbound carriageway) are included for the purposes of comparison.

Table 6: Journey time estimates by location (baseline compared to trial phase 1)

	Length of link (miles)	Journey time (minutes)		Difference (seconds)
		Baseline	Trial – phase 1	
Control (N/B)	4.8	5.61	5.60	-0.6
Experimental (S/B)	4.8	5.63	5.08	-32.9

The results suggest that changing the speed limit from 50mph to 60mph decreased the average journey time southbound by just over 30 seconds. No noticeable change in journey time was observed northbound as the speed limit remained at 50mph throughout both periods.

The analysis was repeated, comparing the estimated journey time in the baseline period to trial phase 2. Whilst the TM was slightly shorter (since the 50mph terminal signs at the step down were installed approximately 1km upstream of their location in phase 1), the average speeds were slightly higher in phase 2, so the overall difference in journey time was slightly greater (see Table 7).

¹¹ The length of each link was calculated using the start of the traffic management southbound (marker post 25/1) and the end of the 60mph speed limit, which varied between phase 1 and phase 2).

Table 7: Journey time estimates by location (baseline compared to trial phase 2)

	Length of link (miles)	Journey time (minutes)		Difference (seconds)
		Baseline	Trial – phase 2	
Control (N/B)	4.1	5.61	5.60	-0.5
Experimental (S/B)	4.1	5.63	4.96	-40.3

It is estimated that introduction of the 60mph speed limit saved customers, on average, 30-40 seconds in journey time. Journey time savings could be much greater if the speed limit was implemented over the entire scheme length. Whilst not a substantial saving for an individual driver, when considering the many thousands of drivers who travel through the scheme each day, the time savings are notable.

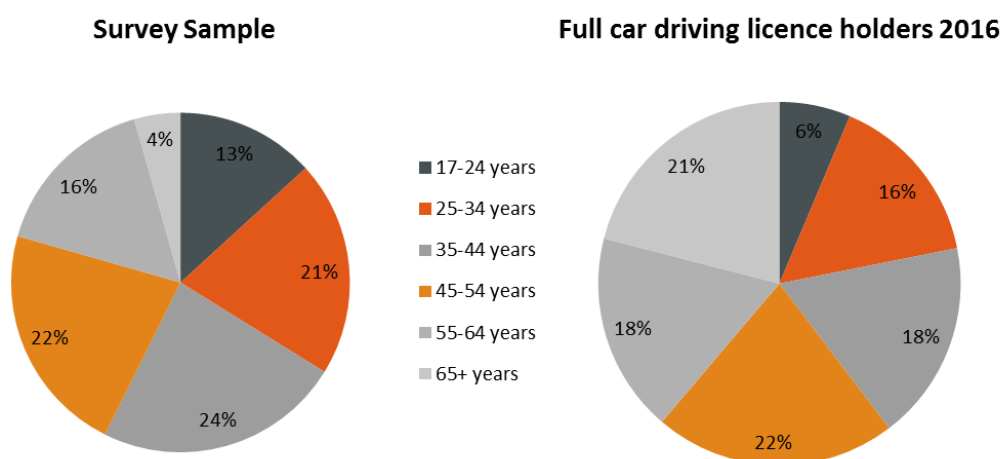
Key findings

- It is estimated that introduction of the 60mph speed limit saved each driver, on average, 30-40 seconds in journey time.

3.9 Customer satisfaction

3.9.1 Participant sample

In total, 80 people completed the online survey. Twenty two participants were female, 46 were male and 12 did not provide age or gender information. Figure 18 compares the distribution of the survey sample to the distribution of full car (Category B) driving license holders in Great Britain in 2016 (data.gov.uk, 2016).

**Figure 18: Distribution of age of the sample compared to car driving license holders in GB**

Licence holders aged from 17 to 24 years are overrepresented in the sample and those aged 65+ years are underrepresented. However, while GB licence holder data is a good indication

of the distribution of age of all drivers, it may not be exactly representative of drivers using the Strategic Road Network (SRN). In particular, older drivers (65 years or over) tend not to drive as often as younger drivers, hence the under-representation of older drivers is not a cause for concern.

Almost all of those who participated in the survey were car drivers (75) although a small number reported driving a coach (4) and a light commercial vehicle (1).

Due to the nature of the survey being advertised at businesses local to the scheme, the vast majority of drivers were commuting to work (52%) or travelling on business (21%) (see Figure 19).

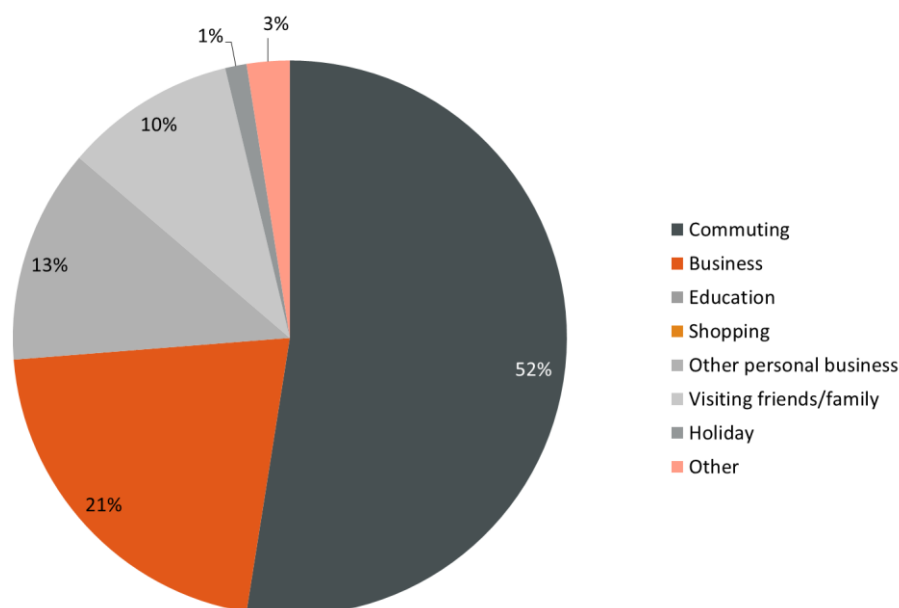


Figure 19: Reported journey purpose

Drivers were asked the extent to which they agreed or disagreed with the three statements regarding long term benefits of the roadworks (Figure 20).

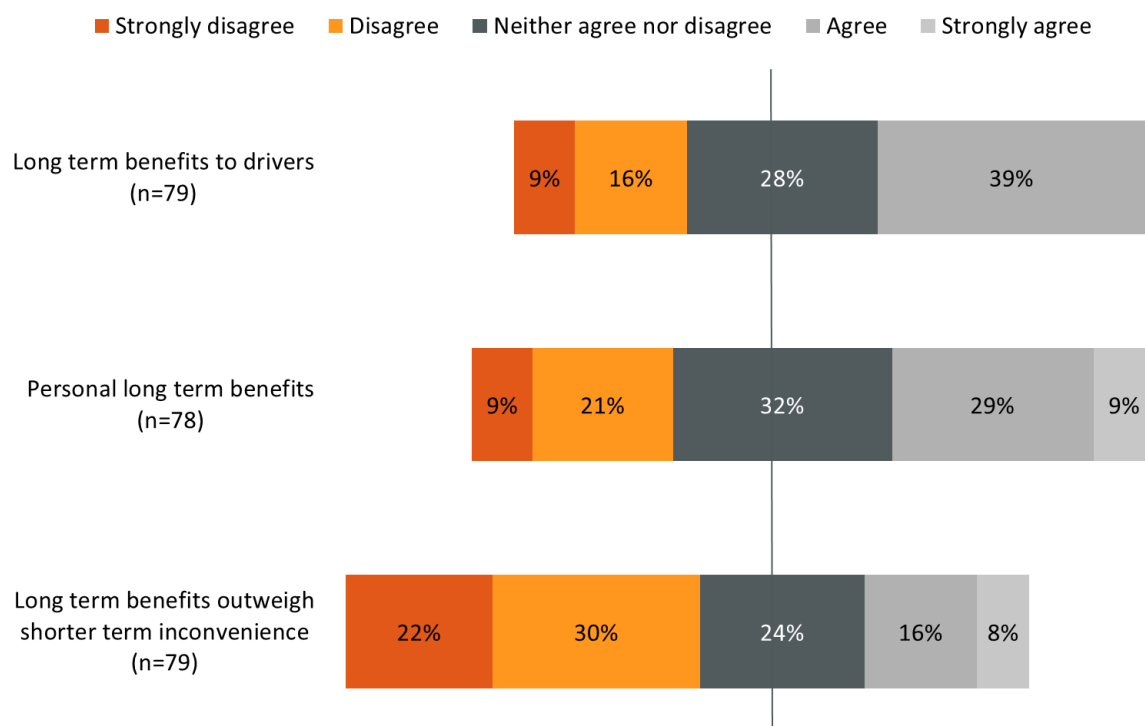


Figure 20: Responses to questions about long-term benefits of roadworks

The responses were more negative than those seen for the previous two trials, where the survey was carried out at the nearest MSA. In both of the previous pilots (Wallbank *et. al.* 2017a & 2017b), over three-quarters of respondents were neutral or agreed with all three statements but in this survey, more people disagreed with the statements, in particular the one about long term benefits outweighing the shorter term inconvenience. This may be a reflection of the differences in the sample: individuals who live local to the scheme may be more impacted by any delays and diversions and so could be more likely to reduce overall levels of satisfaction.

This is supported by the findings shown in Figure 21.

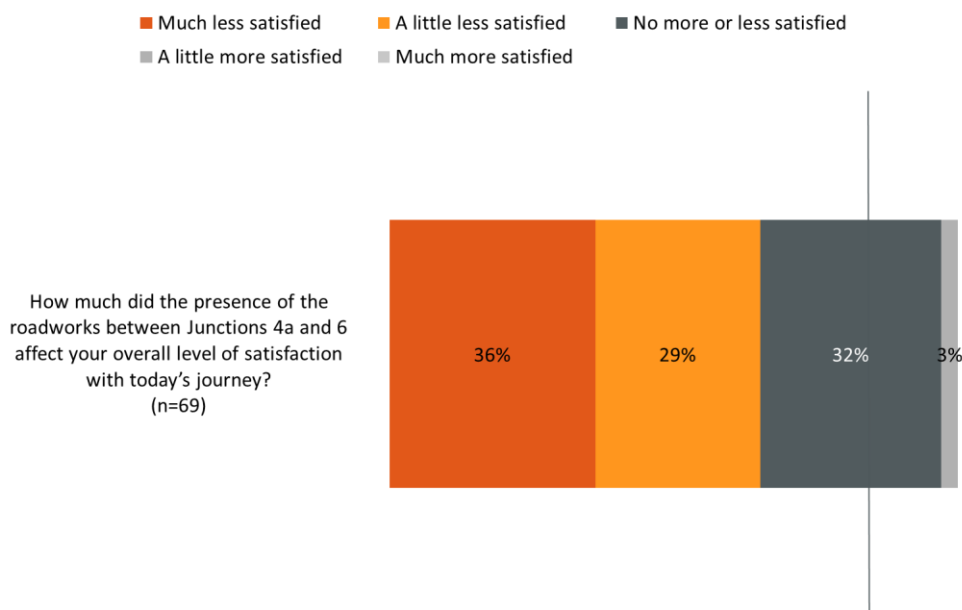


Figure 21: Participants' overall level of satisfaction with their journey

The vast majority of drivers were 'much' or 'a little' less satisfied as a result of the roadworks. Participants were asked to include a reason for their response. Many of these related to the length of the works, the absence of road workers, journey times, road closures, narrow lanes and safety aspects associated with incidents. Some example responses are included below:



- *"It would be nice if you actually saw any roadworks being done!!! This job has taken twice as long as it should have done."*
- *"Journey time was slowed down considerably"*
- *"Large sections of road seem closed for a long time with cones without evidence of any work being done. "*
- *"No progress is observable in the "work" being done. Speed restrictions are in place even when no workers are on site. No clear end date for the road works is visible. No clear benefit from these works is defined- and this is after a similar period of works to create the solid concrete barrier down the middle of the motorway- talk about stretching out a job to get more money!"*
- *"Some sections are clearly finished and the length of the road works - which is and has always been excessive - should be reduced to reflect this."*
- *"Due to no run offs or refuge areas, if a car breaks down it causes absolute chaos. The narrowing of the lanes causes accidents; I have seen many instances with lorry drivers hitting other road users as they travel too close. I struggle to see how the net benefit of these upgrades will be felt during my working life. I must have lost over fifty hours of travel time due to these works."*

This might suggest that more could be done locally to improve the perception of the works: perhaps providing more information to drivers about the timescales, long term benefits and progress.

3.9.2 Understanding of the speed limit

In order to determine whether participants noticed the change of the speed limit through the roadworks, participants were asked to recall the speed limit on each of the two links (Table 8).

Table 8: Speed limits reported by participants (and actual speed limits in place)

		Junction 5 to 6		
				
		50mph	60mph	Don't know/ no answer
Junction 4a to 5 	40 mph	2	0	1
	50 mph	48	3	5
	60 mph	14	3	0
	70 mph	1	0	0
	Don't know/ no answer	0	0	3

Only 18% (14) people correctly recalled that the speed limit was 60mph between Junction 4a to 5 and 50mph between Junction 5 and 6. The vast majority of drivers (60%, or 48 people) incorrectly believed that the speed limit was 50mph throughout, and a few (3) thought it was 60mph throughout. These figures suggest that despite the additional signage (VMS warning of a reduction in speed limit ahead and the VAS at Junction 5), a large proportion of drivers still missed that the speed limit had changed between Junction 4a and 5. This might explain why the average speed was 3-5mph lower than the speed limit throughout the trial (see Figure 8).

Once participants had answered the question they were informed of the correct answer (60mph for Junction 4a to 5 and 50mph for Junction 5 to 6). They were then asked how appropriate they felt each of these speed limits was (see Figure 22).

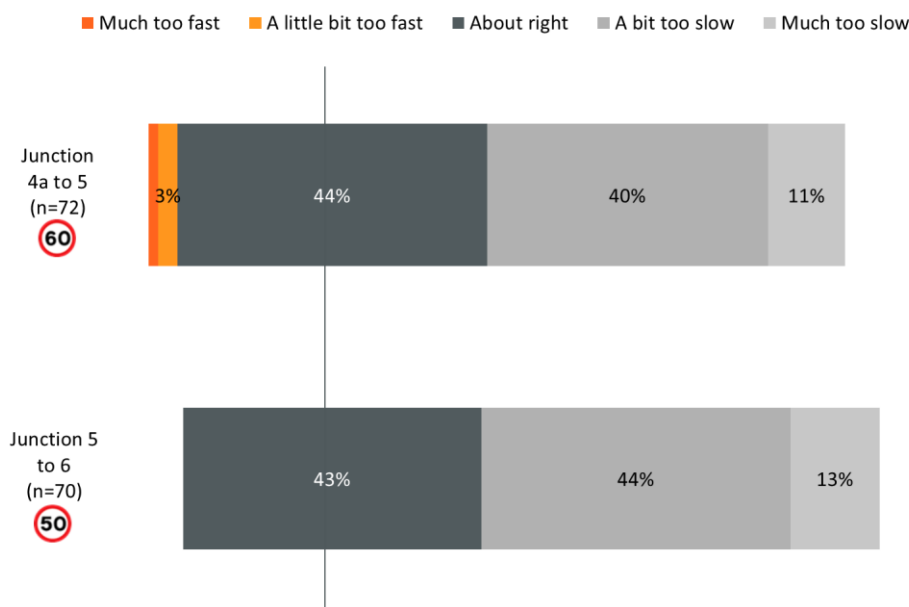


Figure 22: Reported 'appropriateness' of the speed limits

A large proportion of drivers believed the two speed limits were 'about right' (44% and 43% respectively) but more people thought both were too slow (51% and 57% respectively). A small minority (4%) thought 60mph was too fast.

3.9.3 Driver behaviour

Participants were asked whether there were any times where the behaviour of other drivers made them feel less safe. Driver behaviours included overtaking, close following, speeding and mobile phone use. Participants were also given the opportunity to comment on other behaviours which made them feel less safe.

Figure 23 shows the number of times each driver type was recorded as making the participant feel less safe. If multiple reasons were given for a particular driver type by a participant then this was only counted once in this chart. For example, if participant 1 recorded that car drivers made them feel less safe because of close following and overtaking then this is only recorded once.

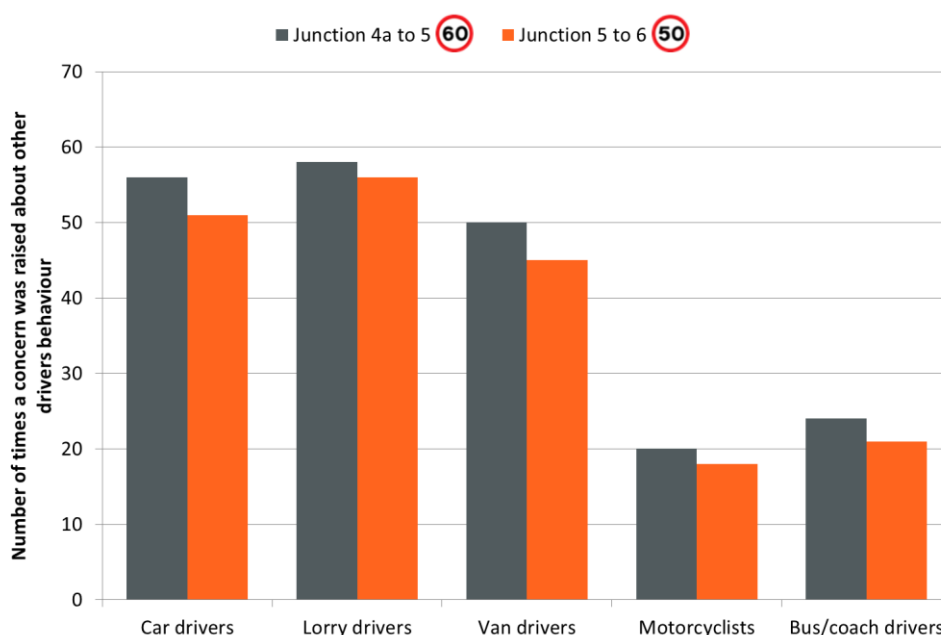


Figure 23: Count of times each driver type was recorded as having made the participant feel less safe

A slightly larger number of concerns were raised about behaviours between Junctions 4a and 5 (the 60mph speed limit) than between Junctions 5 and 6 (the 50mph limit); however, these differences were not significant ($p > 0.05$ in all cases), which suggests that the increase in speed limit had no noticeable change on driver behaviour.

More concerns were raised about lorry drivers than any other vehicle type, despite them making up a less than a quarter of all traffic. Car and van drivers were also identified as making drivers feel less safe, although to a slightly lesser extent. The specific behaviours identified for three driver types are examined in Figure 24.

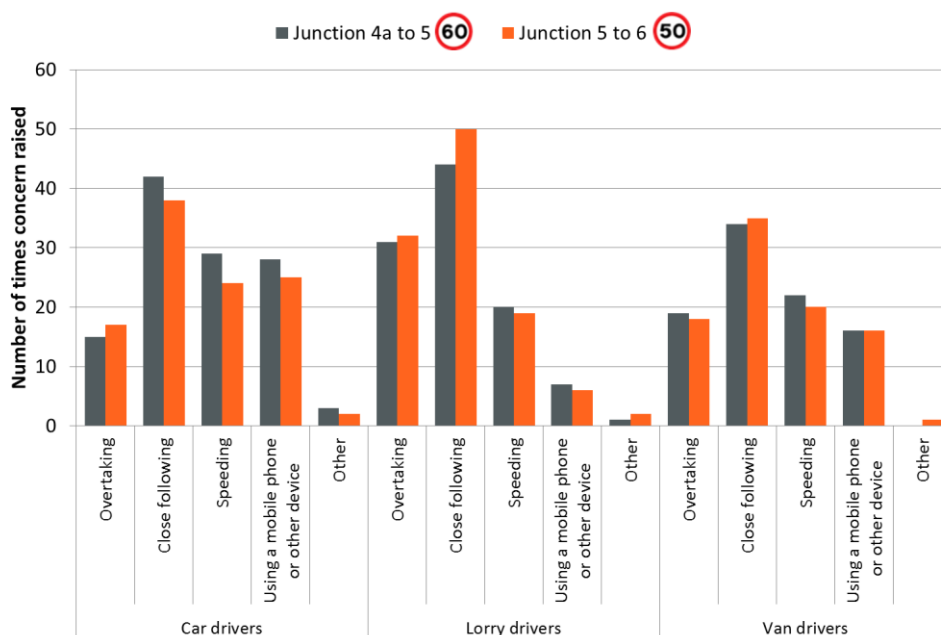


Figure 24: Unsafe behaviour of car, lorry and van drivers

Similar counts of unsafe behaviours were identified for each link, with the biggest difference in reported close following by lorry drivers. This might suggest that the increased speed limit helped to reduce this behaviour, a finding which was supported by the data from the R-Cam system (see Section 3.6).

Other behaviours which reportedly made people feel less safe included:

- Lane hogging: “Cars staying in the middle or inside lane when driving too slowly and when there are no other vehicles to prevent them from changing lanes.”
- Undertaking: *“A lot of undertaking happening - changing lanes and undertaking worst offences.”*
“People in outside lane driving 50mph, unaware of the new 60 limit.”
“Heavy goods vehicles over/under taking on the inside lane whilst my lane slowed to 20 mph due to traffic.”
- Lane drifting, particularly by HGVs: *“HGVs drifting across the lane markings”*
- Motorbikes weaving in and out of the traffic.

3.9.4 Route preferences

In addition to specific questions about the M5 scheme, the survey also included a short choice experiment¹² to investigate the relative importance of different attributes of the roadworks on a driver’s route choice. Survey participants were asked to imagine they were driving from A to B with two possible motorway routes to choose from. Both routes had roadworks but the roadworks had different characteristics.

Each driver was presented with six different questions, each with two choices (route 1 or route 2) where the two routes had different attributes (speed limit through the works, length of the roadworks, lane widths and speed enforcement) and were asked “which route would you choose?” Each attribute had a number of levels, representing typical scenarios a driver might experience in the real world:

- Speed limit: 50mph, 60mph or 70mph
- Roadworks length: 5 miles, 10 miles or 15 miles
- Lane width: standard width lanes or narrow lanes
- Speed enforcement: none or average speed cameras

Figure 25 gives an example question from the choice experiment; the full list is included in Appendix B.

¹² The purpose of a choice experiment is to simulate the decision-making process made by drivers in the real world. When choosing between various alternatives, drivers are assumed to trade-off between the attributes of each in order to come to a decision. The analysis is used to quantify the different weighting consumers apply to each attribute.

	Route 1	Route 2
Speed limit	70mph	50mph
Roadworks length	10 miles	5 miles
Lane width	Narrow lanes	Standard width lanes
Speed enforcement	Average speed cameras	None
Choice	<input type="checkbox"/>	<input type="checkbox"/>

Figure 25: Example question included in the choice experiment

The analysis of these data utilised a statistical technique known as multinomial logit (MNL) modelling¹³ to estimate the relative weightings (importance) of each of the four attributes. Table 9 presents the results from this model. The table presents the coefficient (estimate) for each attribute, along with a significance value showing whether the coefficient is significantly different from zero (i.e. whether it is an important factor when customers choose between routes).

Table 9: MNL model results

Attribute	Coefficient	t value	Significance
Length	- 0.13	- 6.14	Significant ($p < 0.05$)
Lane width	- 0.98	- 6.72	Significant ($p < 0.05$)
Enforcement	- 0.33	- 2.18	Significant ($p < 0.05$)
Speed limit	0.05	4.80	Significant ($p < 0.05$)

The results showed that all four variables were significant and thus important in the choice task, but the magnitude of the coefficient varied suggesting some attributes were more important than others. Three of the attributes had a negative coefficient, and one had a positive coefficient. The sign of each factor signifies the direction of the relationship with drivers' choices. For example, length has a negative coefficient which indicates that as increasing length of the roadworks reduced the likelihood of drivers choosing the route. The presence of narrow lanes and enforcement also had a negative impact on likelihood to

¹³ This is a relatively simple technique which involves estimating one coefficient for each attribute; these coefficients can then be interpreted to determine which factors are more important in the decision making process than others. Whilst more complex modelling techniques exist, which involve fewer assumptions and allow the weighting of the different attributes to vary between respondents, due to the small sample size ($N = 67$) and for ease of interpretation, the MNL model has been applied in this case. Further work involving a larger, stratified sample of SRN users could investigate these relationships further, including consideration of further attributes, understanding whether the decision making process differs between different users (e.g. between different driver segments, ages or genders) and investigating non-linearity in the attributes.

choose the route. Alternatively, the coefficient for speed limit was positive, suggesting that drivers preferred roadworks where the speed limit was faster.

Comparing the absolute magnitude of the coefficients for lane width and enforcement (where the choice for both is a binary option) suggests that lane width is nearly three times more important for route choice than whether or not average speed cameras are installed (-0.98 is around 3 times bigger than -0.33).

The interpretation of the length and speed limit variables is slightly different since these are included in the model as linear predictors; here the coefficients represent the effect of a one mile increase in length, or a 1mph increase in speed limit, respectively. The magnitude of the coefficients demonstrates that a one mile increase in length is 2.7 times more important than a 1mph increase in speed limit.

The results from this choice experiment suggest that when asked to choose between routes with roadworks, drivers felt that the speed limit of the roadworks was the least important aspect. The length of the roadworks, the presence of narrow lanes and average speed cameras contributed more to their decision. This might suggest that, in order to improve customer satisfaction, Highways England should also take steps to improve other aspects of the roadworks, including making the length of roadworks shorter. However, further work needed to verify these decisions on a wider sample of SRN users. Further, whilst some factors (standard width lanes and no speed enforcement) are seemingly preferred by most drivers, it is recognised that these elements are often installed for practical and safety reasons and it may not be possible to remove these at some schemes.

3.9.5 General comments

At the end of the survey, participants were asked if they had any further comments. Some key themes could be drawn from the comments provided. These included:

Comments on the speed restrictions, presence of road workers and length of the works:

"The speed limit isn't necessarily the issue, it's when it goes on for miles with long stretches where very little seems to be happening. If the job were done in shorter segments rather than bringing a long stretch I feel it would be less disruptive, although I do understand that traffic control would be more difficult with people carrying higher speeds into the roadworks."

"I would like to see workers working at all times the roads are closed or have restrictions, it's becoming a joke that everyone can always say the never saw a worker during their journey. I can't believe that it's not possible to structure the work load to make quicker progress and finish the job sooner."

Comments on the appropriateness of a SMART motorway on this section:

"I don't see the advantage of "smart motorway" on this stretch, there was never a problem. There was only a problem on the northbound due to holdups on adjoining roads backing up onto the motorway."

"This work is to install smart motorway systems. Having completed the journey daily between both through J4a on the M5 and also onto the M42 from the M5 at 4a and onwards to the M40 or M42 north, the real problem in my opinion is the stretch of

M42 between M5 J4a and the M40. The variable speed limit would have been much better deployed along this section.”

Recommendations for increased communication and better planning:

“Don't mind there being roadworks, but please tell drivers when the motorway is going to be closed in advance so we can plan detours!!!!!! So many times have we not been told and then taken up the m42 with no warning!! Infuriating!!”

“Disappointed that this road was dug up and under roadworks for months to replace central barriers. Operated normally again for a short time before being put under roadworks again for months on end for this work. Planning should have had these jobs done at the same time.”

“Why did the road works over run so badly? And not once has anyone apologised or made any effort to explain.”

Comments about the number of accidents and near-misses within the works:

“The tailback of traffic that comes of the southbound 5 junction on to the carriageway is extremely dangerous as cars are suddenly stopping and breaking harsh. The entry from 5 northbound has a short lane merge. This nearly caused me an accident with a lorry. The overall roadworks have caused many accidents and it feels a dangerous section to use.”

“You have reduced the speed and included more cameras, and the accidents seem to have only gotten higher in frequency.”

Key findings

- 80 local people completed the online survey; many of those included in the sample were commuting to work when they used the M5.
- Responses to statements regarding long term benefits of the roadworks were more negative than those seen for the previous two trials. This may be a reflection of the differences in the sample, which included more individuals from local area who could be impacted by any delays and diversions.
- This might suggest that more should be done locally to improve the perception of the works: the vast majority of drivers were 'much' or 'a little' less satisfied as a result of the roadworks and cited reasons for this dissatisfaction as the length of the works, the absence of road workers, journey times, road closures, narrow lanes and safety aspects associated with incidents.
- Some drivers missed the speed limit change between Junction 4a and 5: only 18% (14 people) correctly recalled that the speed limit was 60mph between Junction 4a to 5 and 50mph between Junction 5 and 6. The vast majority of drivers (60%, or 48 people) incorrectly believed that the speed limit was 50mph throughout.
- Over 40% of drivers believed the 50 and 60mph speed limits on the two links were 'about right', but more people (over 50%) thought both were too slow.
- More concerns were raised about lorry drivers' behaviour than any other vehicle type, despite them making up a less than a quarter of all traffic.
- Close following by lorry drivers was reported more on the link with the 50mph speed limit in place, suggesting that the increased speed limit might have helped to reduce this behaviour. This was supported by the close following data collected by the R-Cam system.
- The choice experiment suggested that drivers felt that speed limit within the roadworks was the least important aspect of route choice. Drivers responses indicated that the length of the roadworks, the presence of narrow lanes and average speed cameras contributed more to their decision. This might suggest that, in order to improve customer satisfaction, Highways England should also take steps to improve other aspects of the roadworks, including making the length of roadworks shorter.

4 Summary

The on-road trial of 60mph at the M5 Junction 4a to 6 Smart motorway scheme was the third trial of increased speed limits at roadworks as part of this project. The scheme trialled a 60mph speed limit during the operational testing phase of the Smart motorway development (i.e. 'Scenario 2').

The 60mph speed limit was implemented for part of the scheme (between Junction 4a and 5) on the southbound carriageway, with drivers experiencing a 'step down' in speed limit from 60mph to 50mph. The northbound carriageway was used as the control location and remained at 50mph throughout.

Monitoring took place between 13th and 27th March with one week of baseline data collection (where both locations remained at 50mph), followed by a nine day trial period with a 60mph speed limit implemented at the experimental location (southbound carriageway). Due to issues with the location of the terminal signs displaying the step down from 50mph to 60mph, the trial period was split into two phases, analysis of both of these has been included in this report.

Four mobile radar units were used to monitor vehicle speeds, headways and flow. For part of the trials the radar systems were equipped with Individual Vehicle Data (IVD) loggers. In addition, TRL's R-Cam system was mounted on two overbridges in the scheme during the baseline and trial phase 1 periods to measure close following and lane distribution by vehicle type.

The results showed that free-flow average speeds increased significantly (by around 6-8mph) following implementation of the 60mph speed limit, suggesting that, on average, drivers noticed and responded to the change in speed limit. Average speeds remained below the 60mph speed limit throughout the trial. Based on these average speeds, the 60mph speed limit is estimated to have saved drivers, on average, 30-40 seconds in journey time.

The proportion of drivers who complied with the speed limit was 46% in the baseline period when the speed limit was 50mph, and over 75% in the trial period (phase 1 and 2 combined) when the speed limit was 60mph, suggesting that overall compliance with the 60mph speed limit was better than compliance with the 50mph speed limit. The number of the vehicles over the enforcement threshold followed a similar pattern suggesting the number of vehicles who would have been prosecuted for speeding decreased during the trial.

Behaviour at the step down showed some issues with non-compliance. Average speed slightly reduced at the VMS which warned drivers of the reduced speed limit ahead; this suggests that a small proportion of drivers slowed even before they reached the first terminal sign showing 50mph. However, after the step down to 50mph, average speeds remained higher than the speed limit (around 51-53mph) and higher than the average speeds seen in the baseline period, suggesting that not all drivers adjusted their speed following the VMS and terminal signs. It is possible that some drivers missed the step down and continued driving at 50mph. Alternatively, some drivers may have realised that the drop in speed limit was not being enforced at that point and deliberately continued to drive at speeds faster than the limit.

Average headway varied across the monitoring periods; during phase 1 and 2 the speed limit remained at 60mph but there was a difference of nearly 2 seconds in headway. Some of this difference is likely to relate to the lower levels of flow (and thus longer headways) as a result of reduced traffic at the weekend. Average headway was consistently higher than the minimum two second distance recommended by the Highway Code (although there is variability in this figure by time of day) and as a result, these data do not suggest that the prevalence of unsafe following distances was impacted by the 60mph speed limit.

The IVD and video data from R-Cam allowed differences in the behaviour of cars and HGVs to be investigated. The results for speed suggest that HGVs typically travelled slightly slower, on average, than cars in both the 50mph and 60mph speed limits. There was also some evidence that cars increased their speed more than HGVs when the speed limit increased to 60mph.

The proportion of HGV drivers who complied with the 60mph speed limit was higher than for car drivers (95% compared to 69%). This is likely to be linked to use of the speed limiter devices on HGVs which are restricted to 56mph (90km/h).

In terms of headway (and gap), the results suggest that in both speed limits headways were, on average, shorter for HGVs than cars. When comparing the proportion of vehicles close following (i.e. with a gap of less than two seconds between vehicles), HGVs were significantly less likely to close follow when the speed limit was 60mph than 50mph (possibly due to the fact that many HGVs are speed limited), whereas there was little change in the amount of close following by cars and vans between the two speed limits.

Although the total number of vehicles in each lane remained relatively unchanged following the speed limit change, there were changes in the distribution by vehicle type. In the 60mph speed limit, HGVs more commonly chose to travel in the inside lane than in the 50mph condition. This indicates fewer HGVs were overtaking in the 60mph speed limit, supportive of differences in average speed between the different vehicle classes.

The scheme provided data for RTCs and breakdowns occurring in the works. No CCTV footage or additional information for any of the RTCs was provided to TRL as the scheme determined that all six RTCs which did occur during the monitoring were minor incidents, so footage was not recorded and retained. Therefore, it was not possible to determine whether the change in speed limit may have been a contributory factor. Two incursions into the roadworks were logged by the scheme onto Highways England's AIRSweb reporting system; neither were linked to the change in speed limit.

A survey was carried out at a local business park to target drivers who are regular users of the scheme. In total, 80 people completed the survey. Responses to statements regarding long term benefits of the roadworks were more negative than those seen for the previous two trials. The local residents who completed this survey may be more impacted by the delays and diversions than the sample recruited for the previous speed limit pilots; this was supported by the overall levels of satisfaction reported by participants. Reasons for their dissatisfaction included the length of the works, the absence of road workers, journey times, road closures, narrow lanes and safety aspects associated with incidents.

Participants were asked to recall the speed limit on each of the two links. Only 18% (14 people) correctly recalled that the speed limit was 60mph between Junction 4a to 5 and

50mph between Junction 5 and 6. The vast majority of drivers (60%, or 48 people) incorrectly believed that the speed limit was 50mph throughout, and a few (3) thought it was 60mph throughout. These figures suggest that despite the additional VMS signage warning of the reduction in speed limit, some drivers still missed that the speed limit had changed between Junction 4a and 5; this might explain why the average speed was 3-5mph lower than the speed limit throughout the trial.

A short choice experiment investigated the relative importance of different attributes of the roadworks (length of roadworks, lane width, enforcement and speed limit) on driver route choice. The results suggested that speed limit was the least important aspect and that the length of the roadworks, the presence of narrow lanes and average speed cameras contributed more to the decisions. This might suggest that, in order to improve customer satisfaction, Highways England should also take steps to improve other aspects of the roadworks.

This is the second 60mph pilot to have trialled a step down in speed limit from 60mph to 50mph; however the signing configuration differed to that used in the previous pilot at the A1 Leeming to Barton (L2B) scheme (Wallbank, Hammond, Myers, & Chowdhury, 2017b) – see Figure 26.

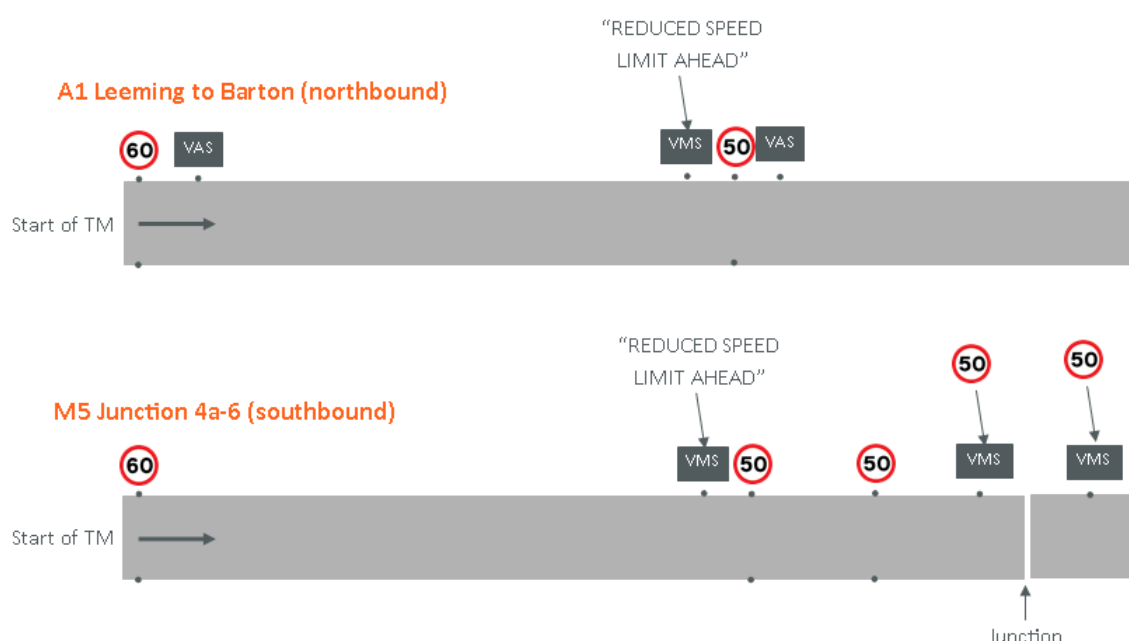


Figure 26: Signing configuration used for the step down in speed limit at each of the 60mph pilots

The A1 L2B scheme had a VAS located at the start of the 60mph speed limit and a second one immediately after the step down. At the M5, the VAS within the 60mph speed limit was omitted and, at the request of the police to help support enforcement after junction 5, the VAS after the step down were positioned much further downstream. Two VAS were used (one before and one after the junction) but both were within the narrow lanes so monitoring did not extend this far.

Average speeds within the 60mph speed limit were comparable across both schemes, typically remaining below the speed limit throughout the trial periods. Compliance was

slightly better at the M5 scheme compared to the A1 L2B scheme (75% of vehicles below the speed limit, compared to 69%); however this may be attributed to differences in the flow and layout of the schemes and cannot necessarily be attributed to the extra VAS present at the A1 L2B scheme.

At the A1 L2B, average speeds after the step down were around 49mph within a few hundred metres, suggesting that the VMS, terminal signs and VAS combination was effective at notifying drivers of the change in speed limit. At the M5, average speeds after the step were around 51-53mph (higher than the 50mph speed limit), suggesting that the VMS and terminal signs alone were not as effective.

Based on these results, it is recommended that signing configurations around the step down are investigated further. Work should be focussed on identifying a signing configuration which maximises effectiveness whilst minimising the burden on traffic management resources, in order to reduce the risk to road users and to road workers who are required to install and remove the signs.

5 Next steps

5.1 Focus groups

In addition to engaging with customers on the Strategic Road Network through the motorway service area survey, it is important to understand the first-hand views of people who were involved with the trial. This is crucial for informing the design of further trials or future roll-out of increased speed limits at roadworks. The next step for this project is therefore to engage with individuals who have experience of working during the 60mph pilot, to understand any challenges faced during the trial and any concerns or risks that need further management in order for increased speed limits at roadworks to be used across the network.

TRL will host a focus group in early May with representatives from the scheme, the TM maintenance crew, the Traffic Officer Service, police and recovery operations. Results from the on-road trials will be included in the focus group agenda to aid discussions on the potential implications for safety. The topic guide will be developed and agreed with Highways England to ensure all relevant subject areas are covered.

5.2 Implementation of 55/60mph at other schemes

This is the third pilot of 60mph at roadworks as part of this project. The first trial, on the M1 J32-35a scheme in late 2016, was a success and is reported in full in Wallbank *et. al.* (2017a). The second, which involved a speed limit change during the 2016/2017 Christmas embargo period on the A1 Leeming to Barton scheme, is reported in Wallbank *et. al.* (2017b).

TRL is working closely with Highways England to implement increased speed limits at other schemes. At the time of writing, the M3 J2-4a scheme is planning to increase the speed limit to 55mph during the operational testing phase of this scheme. This is currently expected to take place in May-June 2017.

The results from each of the trials will be collated together once monitoring is complete and summarised in a single final report, along with the findings from driving simulator trials and stakeholder engagement. This will enable robust recommendations to be made on the basis of holistic evidence from a large and substantial package of work..

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Appendix A TRL's R-Cam System

A.1 Purpose

The road camera system (R-Cam) was developed by TRL for measuring vehicle headways. It consists of portable cameras mounted on overbridges (see Figure 27).



Figure 27: Road user's view of R-Cam in operation

During this trial, the R-Cam system collected data for approximately 4 hours at each of two sites (Grafton Lane Overbridge at marker post 30/6 and Swan Lane Overbridge at marker post 32/4) between approximately 10:30 and 15:00 on Wednesday 8th March 2017 and Wednesday 22nd March 2017. The data were processed to provide information on individual vehicle headways, by vehicle type and lane. Only results from the experimental location (southbound carriageway) are presented in the report.

A.2 Data processing

In order to process the data collected by the cameras, a 'virtual vehicle sensor' was created by selecting a point in each lane on an image taken from the video. The processing software was then used to record how long (in seconds) it takes each vehicle to pass over each of these points, generating a data file which could then be used for the analysis. An example of the output for a single lane is shown in Table 10.

Table 10: Example data output from the R-Cam system

Video Time	Length (s)	Headway (s)
41.65	0.20	11.41
44.51	0.74	2.66
47.66	0.13	2.41
48.64	0.18	0.85
49.83	0.20	1.01
55.32	0.18	5.29

For the purposes of the analysis, vehicles were grouped into two categories; the threshold for these categories was determined by examining the typical vehicle lengths observed in the data. Figure 28 shows the distribution of vehicles by length.

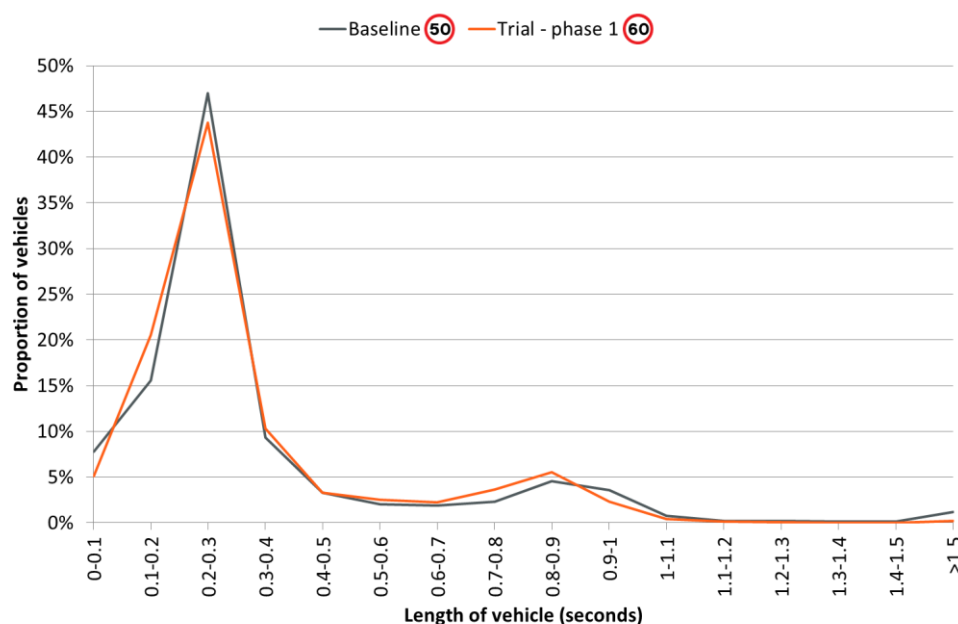


Figure 28: Proportion of vehicles by length

There are two distinct peaks, suggesting that a length between these two points would be a suitable cut-off for the classification. Based on these results, 0.4 seconds was chosen as a suitable cut-off in the 60 mph limit, with vehicles less than 0.4s in length being classified as ‘cars and vans’ and vehicles over this length being classified as ‘HGVs’¹⁴. This threshold was adjusted to 0.448s in the 50 mph limit, based on the lower speeds observed¹⁵.

To ensure that trailers were not reported as close following the towing vehicle, any following distance below 0.2s was treated as a single long vehicle.

¹⁴ Note that this classification differs from that used elsewhere in the report for the portable radar data and IVD (where HGVs are classified as vehicles greater than 24ft in length), since 0.4 seconds equates to approximately 33ft at 56mph. However, differences in the camera angle and height of the overbridge have some impact on the length recorded by the system, and challenges with the granularity of the camera footage mean that vehicle lengths are probably being over-estimated; based on the manual checks carried out (see Appendix A.3) it is reasonable to conclude that this cut-off represents a similar vehicle length to the other results presented in the report.

¹⁵ A vehicle taking 0.4s to pass over a point at 56mph will take 0.448s at 50mph: this is in line with the average speeds recorded by the portable radar.

A.3 Data accuracy

In total, over 9,000 vehicles were observed on both days. Table 11 shows the split by vehicle type.

Table 11: Number of vehicles reported by vehicle type

	Site	Cars/vans	HGVs	Total
Baseline (8 th March)	30/6	10,619	2,189	12,808
	34/2	10,871	2,342	13,213
Trial – phase 1 (22 nd March)	30/6	8,957	1,871	10,828
	34/2	7,783	1,903	9,686

In the baseline period, a single camera was used to record traffic in all three lanes. Manual checking of the results indicated that this method caused some HGVs in lane 3 to be incorrectly recorded as occupying both Lane 3 and Lane 4. During the trial (phase 1) data collection, the methodology was adapted to include an additional camera; however, the number of HGVs using Lane 4 was negligible. As a result, to ensure the results were comparable between the baseline and trial phase 1 periods, all HGVs reported in Lane 4 were removed from the analysis.

Counts of vehicles by lane were verified manually from the video footage for a sample of video sections, chosen to include footage from several sites at different times of day. Accuracy of vehicle detection in the correct lane was good, with an average difference of 5% between automated and manual counts.

A simple comparison to the results from the temporary radar over the same time period suggests that the total vehicle flow was within 5% and the proportion of HGVs recorded by the R-Cam system was comparable to that seen in the portable radar data (see Table 12 below and Figure 4). Thus it is reasonable to conclude that the two systems classified vehicles in a similar manner.

The distribution of vehicles by lane showed some differences, in particular for Lane 4 where the portable radar suggested there were more HGVs than the camera data. Some differences are to be expected, given the inaccuracies in both the camera and radar data collection; where these may have influenced the results presented, caveats are included in the text.

As an indication of HGV classification consistency, the proportion of HGVs on each date was compared between sites, as shown in Table 12.

Table 12: Proportion of HGVs reported by R-Cam at each site

	Site	
	30/6	32/4
Baseline (8 th March)	17%	18%
Trial – phase 1 (22 nd March)	17%	20%

Two trends were apparent:

- There was a slightly larger proportion of HGVs recorded at 32/4 than 30/6. This could be a result of a difference in bridge height or camera angle¹⁶.
- The proportion of HGVs recorded was similar on both dates at MP 30/6, suggesting that the minimum length thresholds selected at each speed were appropriate. There was a slight difference at MP 32/4, which may also be a result of a slight change in camera angle.

The effect of varying the minimum length for a vehicle to be classified as an HGV was examined using a range of values between 0.4s and 0.7s. As expected, this led to a change in the number of HGVs reported in each lane. However:

- The proportion of the total number of HGVs choosing each lane was similar for all length definitions.
- The proportion of HGVs reported as close following was similar.

This suggests that the lane choice and close following behaviour of the longest HGVs is unlikely to be substantially different to those slightly shorter. As a result, the classification chosen is not expected to have an effect on the conclusions of this report.

¹⁶ A similar difference between radar is evident within the portable radar data.

Appendix B Motorway User Survey

MOTORWAY USER SURVEY

- This research is being carried out by TRL (the Transport Research Laboratory) on behalf of Highways England.
- We would be very grateful for your help with the survey (*it should only take around 10 minutes*) but you are under no obligation to do so and you may stop at any time.
- The research aims to improve understanding of driver perceptions of road works.
- There are no 'right' or 'wrong' answers – we are interested in what you think.
- We may wish to use direct quotes from your responses
- If you have any questions about the survey, you can email us at contact@trl.co.uk
- This survey is conducted in accordance with the Market Research Society Code of Conduct.

IF YOU COMPLETE THE SURVEY YOU WILL BE ENTERED INTO A PRIZE DRAW WITH A CHANCE TO WIN A £100 OR £50 AMAZON VOUCHER OR ONE OF FIVE £20 AMAZON VOUCHERS!

For the **terms and conditions** please use the link.

Do you consent to take part in this survey?

☐ Yes

☐ No

Please confirm – have you driven (as a driver, **not a passenger**) southbound through the roadworks between Junctions 4a and 6 of the M5 since 20th March?

- ☐ Yes
- ☐ No [End survey - Sorry, we are looking for responses from drivers who have driven between Junctions 4a and 6]
- ☐ Don't know [End survey - Sorry, we are looking for responses from drivers who have driven between Junctions 4a and 6]

1. Approximately how many miles was your journey in total?

- ☐ 1-20
- ☐ 20-40
- ☐ 40-60
- ☐ 60-80
- ☐ 80-100
- ☐ 100+
- ☐ Don't know

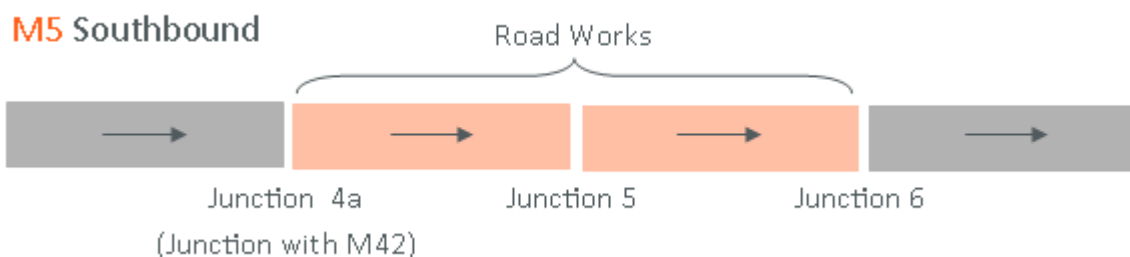
2. What type of vehicle did you drive?

- ☐ Motorcycle
- ☐ Car (includes car-derived vans)
- ☐ Light commercial vehicle (up to and including 7.5 tonnes)
- ☐ Heavy goods vehicle (over 7.5 tonnes)
- ☐ Other (please specify)_____

3. What was the main purpose of your journey?

- ☐ Commuting
 - ☐ Business
 - ☐ Education (including giving others a lift)
 - ☐ Shopping
 - ☐ Other personal business
 - ☐ Visiting friends/family
 - ☐ Holiday
 - ☐ Other (please specify)_____
-

The diagram below illustrates where the road works are located on the M5:



4. Did you know about these road works in advance of your journey?

- ☐ Yes
- ☐ No

5. Typically, how often do you drive between Junctions 4a and 6 of the M5?

- ☐ 5 or more times a week
- ☐ 3-4 times a week
- ☐ 1-2 times a week
- ☐ Once every 2-3 weeks
- ☐ Once every month
- ☐ Once every 2-6 months
- ☐ Once every 7-12 months
- ☐ Less than once a year

6. Did you notice any of the following when driving between Junctions 4a and 6 today?

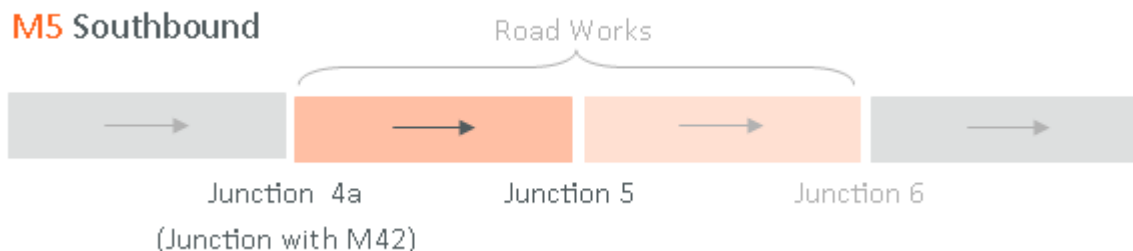
	Yes	No	Don't know / don't remember
a) Work being carried out by road workers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b) Closed lanes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c) Narrowed lanes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d) Speed limit signs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. To what extent do you agree or disagree with the following statements?

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
a) The road works will provide long term benefits to drivers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b) The road works will provide long term benefits to me personally	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c) The long term benefits of the roadworks outweigh the shorter term inconvenience	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Questions 8 to 12 relate to the road works only between Junctions 4a and 5 (as shown in the diagram below). Please try to think back to when you drove this section of road when answering these questions.

M5 Southbound



8. What do you think the speed limit between Junctions 4a and 5 was?

- ☐ 40 mph
- ☐ 50 mph
- ☐ 60 mph
- ☐ 70 mph

The speed limit for this section of the road works was 60mph [message shown after the respondent has answered the question]

9. Thinking about the conditions when you drove between Junctions 4a and 5 just now, do you think the **speed limit** was:

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Much too slow | A little bit too slow | About right | A little bit too fast | Much too fast |

10. Did the presence or speed of other vehicles affect the speed at which you drove between Junctions 4a and 5?

- ☐ Yes – I drove **more slowly** than I would have liked
- ☐ Yes – I drove **faster** than I would have liked
- ☐ No – I was able to drive at the speed that I wanted to drive at

11. When you drove between Junctions 4a and 5, were there any times where the behaviour of other drivers made you feel less safe? *(Please tick all that apply to indicate which behaviours made you feel less safe and who performed those behaviours)*

	Overtaking	Close following	Speeding	Using a mobile phone or other device	Other (please specify below)
Car drivers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lorry drivers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Van drivers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Motorcyclists	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bus/coach drivers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

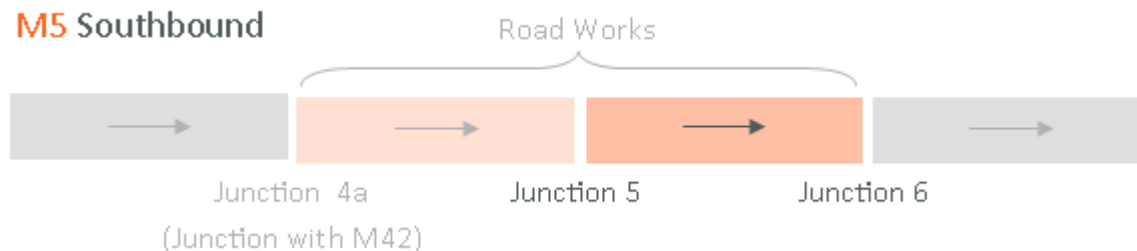
Other behaviours/road users that made you feel less safe:

12. Did you notice any speed cameras between Junctions 4a and 5?

- ☐ Yes
- ☐ No
- ☐ Don't know

Questions 13 to 17 relate to the section of road works only between Junctions 5 and 6 (as shown in the diagram below). Please try to think back to when you drove this section of road when answering these questions.

M5 Southbound



13. What do you think the speed limit between Junctions 5 and 6 was?

- ☐ 40 mph
- ☐ 50 mph
- ☐ 60 mph
- ☐ 70 mph

The speed limit for this section of the road works was 50mph [message shown after the respondent has answered the question]

14. Thinking about the conditions when you drove between Junctions 5 and 6 just now, do you think the speed limit was:

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Much too slow | A little bit too slow | About right | A little bit too fast | Much too fast |

15. Did the presence or speed of other vehicles affect the speed at which you drove between Junctions 5 and 6?

- ☐ Yes – I drove **more slowly** than I would have liked
- ☐ Yes – I drove **faster** than I would have liked
- ☐ No – I was able to drive at the speed that I wanted to drive at

16. When you drove between Junctions 5 and 6, were there any times where the behaviour of other drivers made you feel less safe? *(Please tick all that apply to indicate which behaviours made you feel less safe and who performed those behaviours)*

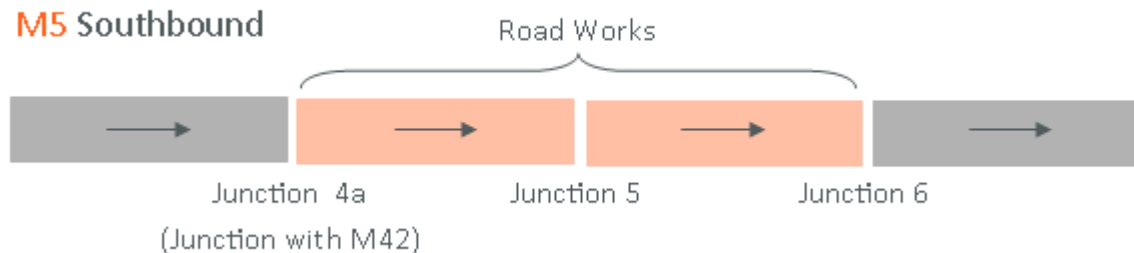
	Overtaking	Close following	Speeding	Using a mobile phone or other device	Other (please specify below)
Car drivers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lorry drivers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Van drivers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Motorcyclists	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bus/coach drivers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other behaviours/road users that made you feel less safe:

17. Did you notice any speed cameras between Junctions 5 and 6?

- ☐ Yes
- ☐ No
- ☐ Don't know

M5 Southbound



18. Please indicate how clearly you remember the part of your journey between Junctions 4a and 6

Not at all clearly	Not very clearly	Quite clearly	Very clearly
<i>I had to guess most of my answers</i>	<i>I had to guess some of my answers</i>	<i>I am confident in most of my answers</i>	<i>I am confident in all of my answers</i>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

19. How much did the presence of the road works between Junctions 4a and 6 affect your overall level of satisfaction with today's journey?

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Much less satisfied	A little less satisfied	No more or less satisfied	A little more satisfied	Much more satisfied

Please give a reason for your answer to the above question:

The next set of questions is concerned with your general perceptions and experiences of motorway driving:

20. Looking back over the last 12 months, how often have you driven on motorways in England?

- ☐ 5 or more times a week
- ☐ 3-4 times a week
- ☐ 1-2 times a week
- ☐ Once every 2-3 weeks
- ☐ Once every month
- ☐ Once every 2-6 months
- ☐ Once every 7-12 months
- ☐ Less than once a year

21. Using a scale of 1 to 10, please indicate how confident you feel about driving on motorways (where 1 means 'not at all confident' and 10 means 'extremely confident').

- ☐ 1 = not at all confident
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7
- ☐ 8
- ☐ 9
- ☐ 10 = Extremely confident

22. Please indicate how strongly you agree or disagree with the following statement about England's motorways '**I enjoy driving on motorways**'.

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neither agree nor disagree
- ☐ Agree
- ☐ Strongly agree

This next set of questions is about your preferences for different types of motorway routes. For each question, please imagine you are driving from A to B and there are two possible motorway routes for you to choose. Both routes have roadworks on them but the roadworks have different characteristics. Which route you would choose?

23. Which route would you choose?

	Route 1	Route 2
Speed limit	70mph	50mph
Roadworks length	10 miles	5 miles
Lane width	Narrow lanes	Standard width lanes
Speed enforcement	Average speed cameras	None
Choice	<input type="checkbox"/>	<input type="checkbox"/>

24. Which route would you choose?

	Route 1	Route 2
Speed limit	50mph	60mph
Roadworks length	5 miles	15 miles
Lane width	Narrow lanes	Standard width lanes
Speed enforcement	None	Average speed cameras
Choice	<input type="checkbox"/>	<input type="checkbox"/>

25. Which route would you choose?

	Route 1	Route 2
Speed limit	60mph	70mph
Roadworks length	15 miles	5 miles
Lane width	Narrow lanes	Standard width lanes
Speed enforcement	None	Average speed cameras
Choice	<input type="checkbox"/>	<input type="checkbox"/>

26. Which route would you choose?

	Route 1	Route 2
Speed limit	60mph	60mph
Roadworks length	5 miles	15 miles
Lane width	Standard width lanes	Narrow lanes
Speed enforcement	Average speed cameras	None
Choice	<input type="checkbox"/>	<input type="checkbox"/>

27. Which route would you choose?

	Route 1	Route 2
Speed limit	50mph	70mph
Roadworks length	10 miles	10 miles
Lane width	Standard width lanes	Narrow lanes
Speed enforcement	Average speed cameras	None
Choice	<input type="checkbox"/>	<input type="checkbox"/>

28. Which route would you choose?

	Route 1	Route 2
Speed limit	70mph	50mph
Roadworks length	15 miles	10 miles
Lane width	Standard width lanes	Narrow lanes
Speed enforcement	None	Average speed cameras
Choice	<input type="checkbox"/>	<input type="checkbox"/>

29. And finally, what is your...

a) Gender

- ☐ Male
- ☐ Female
- ☐ Prefer not to say

b) Age

- ☐ 17-24
- ☐ 25-29
- ☐ 30-34
- ☐ 35-39
- ☐ 40-44
- ☐ 45-49
- ☐ 50-54
- ☐ 55-59
- ☐ 60-64
- ☐ 65-85
- ☐ 85+
- ☐ Prefer not to say

30. Finally, please provide an email address so we can enter you into the prize draw.

If you have any other comments relating to this survey, please write them here:

Thank you for taking the time to complete this survey.

Monitoring and evaluation of the 55/60mph pilots



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