PROJECT REPORT MIS20

Monitoring and evaluation of the 60 mph trials

Report for the on-road trials of 60 mph on the M6 junction 2-4

A Rajasooriya, R Ramnath, S Chowdhury, R Sharp and C Wallbank
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Executive summary

Temporary mandatory speed restrictions are considered for road works on high-speed roads to limit the risks posed to road users from specific traffic management features. Where safe to do so, a change in the speed reduction could bring about potential benefits to road users in the form of improved journey times and increased satisfaction.

This report presents the findings from the on-road investigation of a 60 mph speed restriction on the M6 junction 2-4 scheme. A 60 mph speed restriction was implemented on the southbound carriageway between junction 2 and 3 within the road works, predominantly on Sundays where minimal works activity was carried out within the scheme. The impacts of this change on driver behaviour, customer satisfaction, and scheme costs and delivery were monitored over an extensive monitoring period. To serve as a comparison, the same metrics were also monitored on Mondays, where a 50 mph speed restriction was implemented.

Analysis of the data collected during this monitoring period yielded the following findings:

- Road users responded to the change in speed restriction by increasing their speed; average speeds at the trial location increased from about 44 mph before the speed restriction change, to 48 mph after the speed restriction change. This resulted in an estimated journey time reduction of approximately 24 seconds per road user.

- This increase in average vehicle speed had a positive impact on the levels of speed compliance shown by road users, compliance observed in the 60 mph speed restriction was higher than in the 50 mph speed restriction. The levels of speed compliance remained fairly constant across the baseline and trial period on Mondays (where a 50 mph speed restriction was in place).

- Some statistically significant variations in vehicle composition by lane were found, but these variations were very small in effect size. As such, differences in vehicle composition are unlikely to have affected vehicle speeds and speed compliance.

- The proportion of HGVs engaged in close following (see section 3.2.4) decreased by about 5% as a result of the change in speed restriction. The overall amount of close following observed was not greatly affected by the change in speed restriction; a 2% reduction was observed. The proportion of HGVs engaged in close following also decreased on Mondays (where a 50 mph speed restriction was in place) following the Sundays where a 60 mph speed restriction was trialled.

- The number of incidents (Road Traffic Collisions and breakdowns) was too small to enable statistical analysis. Some variability in the number of incidents was seen between the baseline and trial periods, but this was observed both at the control and experimental locations. As such, there was no evidence to suggest the change in speed restriction had a substantial impact on the number of reported incidents observed at the scheme.

- Responses to the workforce survey were mixed: while some participants felt the 50 mph and 60 mph speed restrictions were too high in terms of safety, others felt the 60 mph speed restriction was about right. An equal share of workforce participants
reported that the speed restrictions either did not affect how safe they felt or made them feel unsafe.

- Responses to the customer satisfaction survey were mixed: most participants felt the speed restriction did not affect their feelings of safety or journey satisfaction, but some participants reported the lane widths made them feel somewhat unsafe and dissatisfied. Additionally, some participants felt the speed restrictions and lane widths were about right in terms of safety and journey satisfaction, whereas others felt the speed restrictions were too low and the lanes were too narrow.

Additional monitoring was carried out during the Christmas embargo period (where a 60 mph speed restriction was in place for an extended period). The findings produced results that closely resembled the main trial monitoring period. The free-flow average speed increased to 48 mph and an improved level of compliance with the speed restriction was observed.

During this period, there were two incidents that required the speed limit to be dynamically lowered to 50 mph. These incidents were studied to examine responsive changes in driver behaviour. However, it was found that there was no significant change in average speeds as a result of the incidents and change in speed restriction. The average speed remained around 50 mph at both the control and experimental locations throughout the period studied.

Based on the collective findings from the investigation, the scheme subsequently implemented a 60 mph speed restriction on Sunday, 23rd of February 2020 for a full 24-hour period.

Results from other investigations undertaken by Highways England at the scheme were as follows:

- Customer audits concluded that all the speed restriction signage was clear and well positioned in all cases. All the signage was easily viewable, all auditors were aware of the speed restrictions in place.

- These same audits also suggested that they felt the utilised speed restrictions were appropriate for the conditions.

- A review of social media ‘conversations’, concluded that for those drivers who did notice the increase in speed to 60 mph feedback was positive towards the change. A desire to further implement on other road work stretches was inherited.

At the time of writing, further investigations into the use of 60 mph speed restrictions are underway. Findings from these additional investigations will be collated with the current findings in a final project report.
1 Introduction

1.1 Background

Safety and customer satisfaction are critical components of Highways England’s vision for the future. As part of this vision, Highways England is committed to improving road user experience through road works by ensuring that road works are implemented with appropriate speed restrictions to minimise disruption for customers, whilst also ensuring risk to road users and road workers is as low as reasonably practicable.

Following on from previous investigations into varying speed restrictions within road works, consultation with stakeholders from across Highways England and the Supply Chain, this project was established to support the safe implementation and monitoring of three new trial scenarios. A key defining feature of many of these scenarios is the trial implementation of a 60 mph speed restriction in road works with narrowed lane width restrictions.

1.2 Contents of this report

This report summarises the findings from the on-road trial of a 60 mph speed restriction on the M6 junction 2-4 scheme during late 2019 to early 2020.

The investigation took place across two sections of the scheme’s traffic management, on the northbound and southbound carriageways. TRL was commissioned by Highways England to monitor driver behaviour (along with customer satisfaction and scheme cost/delivery) to ensure that the safety of road users and road workers was not compromised by the change in speed restriction during the investigation.

This report outlines the scheme and data collection methodology, presents the results from the monitoring, summarises these findings and outlines the next steps required.

1.3 Study objectives

The key objectives of the research were to gather evidence of the impact of changing the speed restriction on the M6 junction 2-4 scheme from 50 mph to 60 mph on:

a) Lane distribution
b) Vehicle speeds
c) The number of non-compliant vehicles
d) The number of incidents
e) The levels of close following (vehicle headway)
f) Customer satisfaction
g) Scheme delivery and cost

An analysis was also carried out to examine the impact of changing the speed restriction during the Christmas embargo period to 60 mph on vehicle flow, speeds and amount of close following. Additionally, during this period, there were two incidents which resulted in the dynamic reduction of the speed restriction from 60 mph to 50 mph and the impact of this on the above metrics was also analysed.
2 Method

2.1 Overview of the scheme

To reduce congestion and smooth the flow of traffic across this key strategic route, works started in March 2018 on upgrading the M6 between junctions 2 to 4 to an all-lane running smart motorway as part of the smart motorway programme. The package of work was planned for several distinct phases and sections, with the timeline for the work on-site running until March 2020.

The design of the scheme provided an opportunity to use a dynamic traffic management scenario to investigate changing the speed restriction from 50 mph to 60 mph. The road works were designed to operate with a 60 mph speed restriction during the implemented traffic management; but was only used during Sundays where no works was carried out. When implemented, the speed restriction between junction 2 and 3 on the southbound carriageway was changed to 60 mph, while the speed restriction across the rest of the scheme and the northbound carriageway remained at 50 mph.

An overview of the monitoring locations used in the investigation is shown in Figure 1.

![Figure 1: Overview of monitoring locations used on the M6 junction 2 - 4 scheme investigation (NB = northbound; SB = southbound)](image)

2.2 Monitoring approach

The on-road investigation sought to monitor the effect of the change in speed restriction on driver behaviour and customer satisfaction. Monitoring took place (principally on Sundays) between the 15th September 2019 and 13th January 2020, with speed restrictions in place as shown in Table 1. Mondays (where a 50 mph speed restriction was in place) were also monitored during both periods to identify whether drivers adjusted their behaviours to comply with the 50 mph speed restriction.
Unlike previous trials such as that on the A1(M) Leeming to Ripon scheme (Rajasooriya, Ramnath, Sharp, & Chowdhury, 2020) and the M1 junction 13-16 scheme (Glaze, Ramnath, Chowdhury, & Sharp, 2019), it was not possible to collect a complete set of baseline data (i.e. at least four Sundays with a 50 mph speed restriction) prior to the commencement of the trial period. The speed restriction which was implemented on any given Sunday was determined by the scheme’s programme of works; as such, in practice this meant that the baseline and trial periods ran concurrently. The analysis presented in Section 3 encompasses data from five baseline Sundays and four trial Sundays.

Throughout the baseline and trial monitoring periods the number of lanes open to traffic and the width of those lanes remained constant. The narrow lanes configuration used featured the following lane widths on both north and southbound carriageways:

![Figure 2: Overview of lane widths on the M6 junction 2 - 4 scheme investigation](image)

Delineation between the work zone and the carriageway was provided by a mixture of cones and temporary vehicle restraint systems (VRS). The set-back between the VRS and the traffic lanes was 500mm.

The composition and placement of the traffic management did not vary during the trial. However, the control and experimental locations are in opposite carriageways so any variations in driver behaviour between the experimental and control locations cannot be attributed solely to the change in speed restriction. Instead such variations must be attributed to a combination of change in speed restriction and change in traffic conditions.
2.3 Risk assessment

As part of the proposed risk management approach and safety governance for the trialling of 60 mph speed restrictions within road works, a programme level safety risk assessment was produced by TRL. This assessment was informed by previous relevant on-road trials, simulator trials, and associated GG 104 risk assessment, and was used to feed into the scheme-specific risk assessments carried out by participating schemes (Fordham & Glaze, 2019).

Prior to implementing the change in speed restriction, Arcadis Jacobs carried out a scheme-specific safety risk assessment in line with GG 104 standards. This assessment examined the risks posed to all affected parties from the change in speed restriction, detailing required mitigation measures to address the potential increase in risks posed from the anticipated increase in vehicle speed as part of the investigation on the M6 junction 2-4 scheme.

This assessment concluded that if the change in speed restriction was adopted, the introduction of several additional mitigations must accompany it. Details of these additional mitigations are outlined within the following section (2.3.1).

In accordance with the safety governance requirements outlined within GG 104, the schemes existing project safety control review group (PSCRG) reviewed the scheme-specific assessment. This led to a decision to trial a 60 mph speed restriction for four weeks between junctions 2 and 4 on both carriageways from mid July 2019.

The PSCRG is a cross-functional group that reviews ‘safety work’ to agree that the safety risks are correctly identified, reviewed and managed appropriately (Highways England, 2015). The group is required to comprise of principal and specialist members. Principal members collectively determine decisions taken and endorse evidence presented to the group. Specialist members provide additional subject matter expertise to the group. A list of required roles for each member type can be seen in 0.

2.3.1 Scheme-specific mitigations

Several additional mitigations, above those already outlined within the programme level risk assessment, were identified as being required to manage risks as part of the scheme-specific risk assessment. These additional mitigations were implemented on the scheme prior to the start of the on-road investigations; they are outlined below.

2.3.1.1 Vehicle restraint system

A N2W2 containment vehicle restraint system (VRS) appropriate for a 60 mph design speed to be in place. Furthermore, the implemented VRS was to be suitable for containing higher speed errant vehicles by in part using a Quest or VECU-STOP crash cushion, both of which are tested to in excess of 60 mph (Arcadis Jacobs, 2019).

2.3.1.2 Remote-controlled speed restriction signs

The provision of remote-controlled speed restriction signs to reduce the exposure of road workers working alongside live traffic (Arcadis Jacobs, 2019). Resilience was required to be built into the technology to ensure that a speed restriction was always displayed.
2.3.1.3  **Encouraging appropriate lane-use**

The provision of signing advising wide vehicles to span Lanes 1 and 2 consistent with normal D3M operations (Arcadis Jacobs, 2019).

2.3.1.4  **The use of Variable Message Signs (VMS)**

The provision of VMS to provide additional information to motorists without compromising the impact of the trial.

2.4  **Safety reviews and abort process**

During the trial monitoring period, weekly safety reports were provided outlining changes in the average speed of vehicles during free-flow¹ periods, the proportion of vehicles over the posted speed restriction during free-flow periods and the proportion of vehicles over the enforcement threshold during free-flow periods. These weekly reports fed into an agreed abort process. The details of this process are outlined in the scheme-specific safety risk assessment; Figure 3 below provides a summary.

![Driver Behaviour Monitoring - Weekly Cycle](image)


**Figure 3: Abort process summary**

Data from the radar units (outlined later in Section 2.5.1) were issued weekly to TRL and the Safety Reports were created and issued by TRL before the end of the working day. A scheduled

¹ ‘Free-flow’ was defined as any period where the one-minute averaged speed of all vehicles across the carriageway was greater or equal to 40 mph.
review call was carried out and during this call the review group discussed the reported safety proxies and any weekly incidents. These review calls acted as the abort decision points outlined within Figure 3 above. An emphasis was placed on any feedback from the Traffic Management Supplier and work crews.

During the trial monitoring period, the abort process was not implemented at any point.

2.5 Data collection and statistical comparisons
To achieve the objectives of this research (see Section 1.3), several different data sources were used:

▪ Radar data
▪ Incident data
▪ Survey data
▪ Workshop data

These data sources and any statistical comparisons which were made are outlined in more detail in the following sections. Suitable statistical comparisons were undertaken only when a sufficient sample of data was available.

2.5.1 Radar data
To monitor speed, flow, headway and lane choice during the baseline and trial periods, two temporary radar installations were installed at the scheme. Each radar installation was capable of monitoring traffic on a single carriageway, down to the level of individual vehicles. For each investigation two separate installations were used to monitor the control and experimental locations.

2.5.1.1 Location of radar installations
The radar installations were situated on the side of their respective carriageways within the work zone. These positions are depicted in Figure 4 below.

![Figure 4: Location of radar installations](image-url)
2.5.1.2 Data collected

The radar installations provided data on vehicle flow, speed and headway for each carriageway and lane. These metrics were recorded for each vehicle passing the unit and captured data on vehicle length which was used to classify vehicle types.

2.5.1.3 Data processing

To understand the potential impact of the speed restriction change on vehicle speeds, data on driver behaviour were required for periods when drivers were free to choose their own speed. This required conditions with free-flowing traffic. Periods with congested traffic were therefore removed; defined as periods when the average speed of vehicles in a lane across a minute was lower than 40 mph. This resulted in the removal of just over 5% of the available data.

To classify vehicles by type, the following definitions were used:

- Car/LGV (≤25ft)
- HGV (>25ft)

2.5.1.4 Comparison of flow

It was essential to understand how vehicle flow changed between the baseline and trial periods, since any changes in vehicle flow can affect the behaviour of road users and impact their speed. The following comparisons were made:

1. A comparison of overall and daily average vehicle flows between the baseline and trial periods at both experimental and control locations, on both Sundays and Mondays (where a 50 mph speed restriction was always in place).

2. A comparison of average vehicle flow split by vehicle class between the baseline and trial periods.

3. A comparison of average vehicle flow composition by lane at the experimental location.

The results of these comparisons are presented in sections 3.2.1 and 3.3.1.

2.5.1.5 Comparison of speed

The following comparisons were made using the one-minute average speed data collected from the radars:

1. A comparison of average speed between the baseline and trial periods by monitoring location on both Sundays and Mondays (where a 50 mph speed restriction was always in place).

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2 Headway was defined as the time separation between vehicles, measured from the front bumper of the first vehicle to the front bumper of the following vehicle, averaged over one-minute intervals.
2. Comparison of average speed by lane between the baseline and trial periods at the experimental location.

3. A comparison of average speed by vehicle type between the baseline and trial periods at the experimental location.

4. A comparison of compliance with the posted speed restriction between the baseline and trial periods by monitoring location.

The results of these comparisons are presented in sections 3.2.2 and 3.3.2.

2.5.1.6 Comparison of congestion

Data collected during periods of congestion were removed from the comparisons of flow and vehicle speed. This allowed for the impact of the speed restriction change to be explored, since comparisons were focused on free-flow conditions where drivers had free choice of speed. It was however also important to understand the impact of the speed restriction change on the levels of congestion seen at the scheme. A comparison of average daily periods of congestion between the baseline and trial periods by monitoring location was made. The results of this comparison are presented in sections 3.2.3 and 3.3.3.

2.5.1.7 Comparison of close following

The following comparisons were made using the IVD collected from the radars:

1. A comparison of close following\(^3\) between the baseline and trial periods by monitoring location on both Sundays and Mondays (where a 50 mph speed restriction was always in place).

2. Comparison of close following by vehicle type between the baseline and trial periods at the experimental location.

The results of these comparisons are presented in sections 3.2.4 and 3.3.4.

2.5.1.8 Statistical comparisons

To determine if driver behaviour changed following the implementation of the 60 mph speed restriction, appropriate statistical tests were used to test for significant differences between data recorded during the baseline and trial periods. Three types of statistical tests were used, depending on the type of data available:

- **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 vehicle flows between the baseline and trial periods.

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\(^3\) A vehicle was defined as engaging in ‘close following’ if there was a gap of less than two seconds to the vehicle in front.
Analysis of Variance (ANOVA) was 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.

Two-proportion z-tests were used to test for a difference in proportions, for example to test for a difference in percentage of vehicles close following.

Results were classified as ‘statistically significant’ if the p-value was less than 0.05 (a common standard in behavioural sciences). The p-value is a measure of probability and a value of less than 0.05 implies that any differences between the groups being tested has a less than 5% chance that the difference occurred at random.

It must be noted that when the sample size is extremely large (as it is in this study), even very small differences could result in statistical significance. In such cases, an effect size is calculated to measure the magnitude of the phenomenon or the degree of association between two variables. Generally, an effect size of less than 0.2 denotes a small effect, 0.5 is a medium effect and 0.8 denotes a large effect. Throughout the report, the effect size has been reported if any result is statistically significant to understand if the effect is due to large sample sizes or a strong relationship between two variables.

2.5.2 Incident data

Throughout both the baseline and trial phases of the investigation, incidents which occurred within the confines of the scheme traffic management were documented and collated by the scheme’s traffic management contractor. These logs identified the type of reported incidents (breakdowns and road traffic collisions) along with the location of the incident (carriageway and marker post number) and the date it took place.

Comparisons of the number of incidents between the baseline and trial phase were made; a summary of these data is presented in section 3.4.

2.5.3 Workforce survey data

To provide further insight into the potential impact of changing the speed restriction at the scheme from 50 mph to 60 mph, a workforce survey was conducted during the investigation. The survey aimed to capture insight from project managers, site workers and members of the workforce who operate within the carriageway environment.

Comparisons of the survey responses between the baseline and trial periods are presented in section 3.6.

2.5.4 Customer satisfaction survey data

Throughout the on-road investigation, surveys were used to collect information on the impact of increasing the speed restriction on the satisfaction levels of road users travelling through the scheme. These surveys were administered to individuals who had identified themselves as having travelled through the scheme during either the baseline or trial periods.

Targeting of these individuals was achieved using a social media advertising campaign, with individuals within a 50km radius of both junctions 2 and 4a of the M6 being targeted to take
part in the study. The adverts were also shared with multiple special interest groups on social media platforms, such as a group of people with a shared interest in the M6 motorway. This approach ensured the recruitment of individuals who regularly drove the route over the duration of the investigation.

The surveys collected data on customers’ feelings of safety affected by both the posted speed restriction and the width of the scheme’s lanes. Levels of journey satisfaction and how they were affected by the posted speed restriction and the width of the lanes were also captured. Comparisons of the survey responses between the baseline and trial periods are presented in section 3.7.

### 2.5.5 Delivery and cost impacts

To understand the impact of the change in speed restriction on the scheme’s delivery and costs, a lessons-learned workshop was held after the monitoring periods had ended. The session sought to capture details on any impacts to the scheme associated with implementing the change in speed restriction. Attendees included the scheme’s Highways England Project Manager, Principal Contractor, Traffic Management Supplier, Traffic Officers, Communications Manager and Risk Contractor.

A summary of the findings of this workshop is presented in Section 3.8.
3 Results

3.1 Overview

This section provides an overview of the findings from the on-road trial and the impact of the change in speed restriction on:

- Driver behaviour
- Incidents and breakdowns
- Journey times
- Welfare of the workforce
- Customer satisfaction
- The scheme’s delivery and cost

The main findings are summarised in Table 2 below, with full results from the detailed analysis presented in the succeeding sections.

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<th>Vehicle flow</th>
<th>Sundays</th>
<th>Mondays</th>
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<tr>
<td>There was a statistically significant difference in average vehicle flow between the control and experimental locations and between the baseline and trial periods. There was, however, some irregularity noticed during Sunday 2 (20/10/2019 and 29/09/2019) and Sunday 3 (27/10/2019 and 06/10/2019) of both the baseline and trial period where reduced flows were observed. The reasons for these irregularities are unknown but may be due to technical issues with the radar units.</td>
<td>There was statistically significant difference in average vehicle flow between the control and experimental locations and between the baseline and trial periods. There was, however, some irregularity noticed during Trial Monday 2 (30/09/2019) and Trial Monday 3 (07/10/2019) at the control location; and Baseline Monday 3 (28/10/2019) at the experimental location, where reduced flows were observed. The reasons for these irregularities are unknown but may be due to technical issues with the radar units.</td>
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<table>
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<tr>
<th>Vehicle speed</th>
<th>Sundays</th>
<th>Mondays</th>
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<tr>
<td>The free-flow average speed increased from around 44 mph in the baseline period to 48 mph in the trial period at the experimental location. The compliance rates improved for all vehicles when the speed restriction was 60 mph on Sundays compared with 50 mph. Compliance remained fairly constant.</td>
<td>The free-flow average speed remained fairly constant at around 47 mph throughout the baseline and trial period at the experimental location. Similarly, the compliance rates also remained fairly constant for all vehicles on the trial Mondays (following the trial Sunday where the speed restriction was 60 mph).</td>
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<td>Section</td>
<td>Sundays</td>
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<td>remained relatively constant at the control location where the speed restriction remained at 50 mph.</td>
<td>compared with baseline Mondays (following the baseline Sunday where the speed restriction was 50 mph). Compliance also remained relatively constant at the control location where the speed restriction remained at 50 mph.</td>
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<td><strong>Congestion</strong></td>
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<td>There was minimal routine congestion at the scheme. During the baseline and trial monitoring periods, 7.1% and 3.0%, respectively, of the total time was classified as congested at the experimental location.</td>
<td>There was some routine congestion at the scheme. During both the baseline and trial monitoring periods, 18% of the total time was classified as congested at the experimental location.</td>
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<td><strong>Close following</strong></td>
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<td>During the baseline period the proportion of vehicles close following was 37% at the experimental location, but slightly lower (35%) during the trial period. Likewise, the proportion of HGVs engaged in close following decreased from 24% during the baseline period, to 19% during the trial period. These differences were statistically significant, but the effect size was very small.</td>
<td>During the baseline period the proportion of vehicles close following was 39% at the experimental location, but slightly lower (37%) during the trial period. Likewise, the proportion of HGVs engaged in close following decreased from 27% during the baseline period, to 22% during the trial period. These differences were statistically significant, but the effect size was very small.</td>
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<td><strong>Incidents and breakdowns</strong></td>
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<td>No safety concerns were raised by the scheme around the number of reported incidents during the trial. The number of incidents (Road Traffic Collisions, RTCs, and breakdowns) was too small to enable statistical analysis. Some variability in the number of incidents was seen between the baseline and trial periods, but this was observed both at the control and experimental locations.</td>
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<td><strong>Journey time</strong></td>
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<td>Increasing the speed restriction from 50 mph to 60 mph on Sundays decreased the average journey time by around 24 seconds per driver at the experimental location. No real change in journey time was observed at the control location or on Mondays, where the speed restriction remained consistent throughout both monitoring periods.</td>
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<td><strong>Workforce satisfaction</strong></td>
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<td>For the workforce satisfaction survey, there were 2 responses relating to the 50 mph speed restriction and 4 responses relating to the 60 mph speed restriction. Results were mixed: while some participants felt the 50 mph and 60 mph speed restrictions were too high in terms of safety, others felt the 60 mph speed restriction was about right. Equal amounts of participants reported that the speed restrictions either did not affect how safe they felt or made them feel unsafe.</td>
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<td><strong>Customer satisfaction</strong></td>
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<td>For the customer satisfaction survey, 9 responses during the baseline period and 4 responses during the trial period were analysed. Results were</td>
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### Scheme delivery

Feedback from the scheme suggested that the delivery of the work activities was not impacted by the 60 mph speed restriction. The scheme did acknowledge, however, that delivery was impacted as it took time to resolve all the challenges of using dynamic speed restrictions.

### Scheme cost

An additional cost was incurred by the scheme to implement the trial of the 60 mph speed restriction.

## 3.2 Sunday driver behaviour

This section presents the driver behaviour data collected on the M6 J2-4 on Sundays on both the northbound and southbound carriageway. The 60 mph speed restriction was trialled predominantly on Sundays and was activated following the conclusion of works on a Saturday night. The following section examines data for a 24-hour period starting from 00:00h on each of the trial Sundays.

### 3.2.1 Vehicle flow

Figure 5 shows the average daily vehicle flow across the baseline and trial monitoring periods between the control and experimental monitoring locations on the M6 between junction 2 and 4.
The daily vehicle flow varied over the course of the investigation at both the control and experimental locations. The control location had an average daily flow of 37,603 during the baseline period and 27,323 during the trial period. In contrast, the experimental location had a lower average daily flow of 30,146 during the baseline period and a much higher flow of 39,705 during the trial period. There was some irregularity noticed during Sunday 2 (20/10/2019 and 29/09/2019) and Sunday 3 (27/10/2019 and 06/10/2019) of both the baseline and trial period where reduced flows were observed. The reasons for these irregularities are unknown but may be due to technical issues with the radar units.

A chi-square test was conducted to test for statistically significant differences between the average daily vehicle flow by monitoring period and location. The test found a statistically significant difference in flow between the control and experimental locations and between the baseline and trial periods ($p < 0.01$), with a small effect size of 0.14. This suggests that any changes in average speed or compliance with the change in speed restriction may be attributed to changes in driver behaviour rather than changes in flow.

A comparison of the proportion of HGVs by monitoring location and period is presented in Figure 6. This shows that the proportion of HGVs remained reasonably constant at both locations throughout the investigation. The average proportion of HGVs at the experimental location was 11% of all traffic during the baseline period and 10% during the trial period. The proportion of HGVs at the control period was similar throughout the trial with an average of 10% during the baseline period and 11% during the trial period.

![Figure 6: Proportion of HGVs by week and location](image)

A two-proportion z-test indicated that the small difference in the HGV proportions at the experimental location between the baseline and trial periods was statistically significant ($p < $
Tests also showed that there were significant differences ($p < 0.03$) in HGV proportion between the control and experimental locations during both periods. However, in both cases, the effect size was extremely small (0.01) and therefore, this difference is unlikely to have had a significant impact on driver behaviour.

The distribution of vehicles between Lanes 1, 2 and 3 within the experimental location is shown in Table 3.

### Table 3: Distribution of vehicles by lane and monitoring period at the experimental location

<table>
<thead>
<tr>
<th>Monitoring period</th>
<th>Vehicle type</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline period</td>
<td>All vehicles</td>
<td>45%</td>
<td>39%</td>
<td>16%</td>
</tr>
<tr>
<td>Trial period</td>
<td>All vehicles</td>
<td>40%</td>
<td>40%</td>
<td>20%</td>
</tr>
</tbody>
</table>

The distribution of vehicles across the three available lanes at the experimental location changed slightly between the baseline and trial periods.

A two-proportion z-test showed that the small variation in vehicle distribution between the baseline and trial periods for each lane at the experimental location was statistically significant ($p < 0.05$) but with a very small effect sizes of 0.11, 0.02 and 0.10 for the three lanes respectively.

The proportions of each vehicle type in Lanes 1, 2 and 3 within the experimental location is shown in Table 4.

### Table 4: Composition of vehicle by lane and monitoring period at the experimental location

<table>
<thead>
<tr>
<th>Monitoring period</th>
<th>Vehicle type</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline period</td>
<td>Cars + LGVs</td>
<td>87%</td>
<td>90%</td>
<td>94%</td>
</tr>
<tr>
<td></td>
<td>HGVs</td>
<td>13%</td>
<td>10%</td>
<td>6%</td>
</tr>
<tr>
<td>Trial period</td>
<td>Cars + LGVs</td>
<td>85%</td>
<td>92%</td>
<td>96%</td>
</tr>
<tr>
<td></td>
<td>HGVs</td>
<td>15%</td>
<td>8%</td>
<td>4%</td>
</tr>
</tbody>
</table>

The vehicle composition of Lane 1 at the experimental location remained similar between the baseline and trial periods. A chi-square test showed that the small variation in vehicle composition between the baseline and trial periods at the experimental location was statistically significant ($p < 0.01$) but with a very small effect size of 0.02.

Likewise, the composition of vehicles in Lane 2 remained reasonably constant between the baseline and trial periods. Like Lane 1, a chi-square test showed that there was a significant difference ($p < 0.01$), but with a small effect size of 0.04.

The composition of vehicles in Lane 3 also remained similar between baseline and trial periods. A chi-square test showed that there was a statistically significant difference ($p < 0.05$), but the effect size was very small (0.05).
Taken together these results suggest that the statistical significance can be attributed to the large sample sizes rather than a large difference in vehicle composition between monitoring periods, as outlined earlier in section 2.5.1.8. As such, any changes identified in vehicle speeds and speed compliance are unlikely to have resulted from differences in vehicle composition.

### 3.2.2 Vehicle speed

To ensure that comparisons of vehicle speed were not conflated by the presence of small numbers of high-speed vehicles, the one-minute average speed data were weighted by vehicle flow. This ensured that more weight was given to data from periods when the flow was higher, compared to times when there were fewer vehicles (low flow), since averages calculated from small numbers of vehicles may be more greatly biased by high speed outliers.

Comparisons were made between control and experimental locations to account for background factors (aside from the speed restriction change) which may have influenced driver behaviour between the two monitoring periods.

Figure 7 shows the free-flow average speeds at the control and experimental locations across the two monitoring periods.

![Figure 7: Free-flow average speed during the monitoring period by location](image)

Free-flow average speed at the control location remained similar throughout the investigation, at around 47 mph. At the experimental location, there was an increase in free-flow average speed from around 44 mph in the baseline period to around 48 mph in the trial period.
A statistical test (ANOVA) confirmed that there was a significant difference in free-flow average speed ($p < 0.01$) between the baseline and trial periods at the experimental location, explaining around 96% of the total variance. There was no significant difference in average speeds between baseline and trial periods at the control location ($p = 0.10$) as such no effect size can be reported.

As the difference in flow between monitoring periods and monitoring locations was not significant, changes in speed are unlikely to have been impacted by differences in flow.

The free-flow average speeds by lane are shown in Table 5.

**Table 5: Free-flow average speed (mph) by monitoring period and lane at the experimental location**

<table>
<thead>
<tr>
<th>Monitoring period</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline period</td>
<td>42.0</td>
<td>44.4</td>
<td>46.5</td>
</tr>
<tr>
<td>Trial period</td>
<td>44.8</td>
<td>49.1</td>
<td>51.6</td>
</tr>
</tbody>
</table>

In both periods, speeds were highest in Lane 3, followed by Lane 2 and then Lane 1. Table 5 shows that the free-flow average speed in Lane 1 at the experimental location increased by 2.8 mph between the baseline and trial periods and in Lane 2 there was an increase of 4.7 mph. Lane 3 had an increase of 5.1 mph between the baseline and trial period. Although not shown here, there was little change in the average speeds by lane at the control location.

Figure 8 shows the comparison between the average speed for cars/LGVs and HGVs across the monitoring periods at the experimental location.

![Figure 8: Average speed by vehicle type at the experimental location](image-url)
The free-flow average speed of HGVs during the baseline period was around 42 mph - slightly lower than the free flow average speed of cars and LGVs at 43mph. In the trial period, HGVs were travelling at an average speed of 46 mph and the average speed of cars and LGVs was 48mph.

To understand the compliance of road users with the posted speed, data were separated into speed bins. These speed bins (0-40, 40-50, 50-57, 57-60, 60-68, 68+mph) allow for vehicles to be identified as travelling: below the speed restriction, above the speed restriction but below the enforcement limit and above the enforcement limit (10% of speed restriction +2 mph).

Figure 9 and Figure 10 show the proportion of vehicles recorded in each speed bin across the two monitoring periods at the experimental location.

The grey bars show the proportion of vehicles travelling below the speed restriction; the orange bars show the proportion of vehicles travelling above the speed restriction but below the enforcement threshold (10% of speed restriction +2 mph); and the red bars show vehicles travelling above the enforcement threshold.

**Figure 9: Proportion of vehicles in each speed bin during the baseline period at the experimental location**
The proportion of vehicles travelling above the posted speed restriction at the experimental location changed slightly between the baseline and trial periods, dropping from 2% to near 0% (141 vehicles). The proportion of vehicles travelling above the enforcement limit remained constant at near 0% across the two periods.

When looking at the differences in the proportion of vehicles in each category (below speed restriction, above speed restriction but below enforcement threshold and above enforcement threshold), two-proportion z-tests showed that, for all three categories, the proportion of vehicles in the category was significantly different ($p < 0.01$) between the baseline and trial periods at the experimental location. Additionally, the three tests showed small effect sizes of 0.01, 0.08 and 0.01, respectively.

Figure 11 and Figure 12 show the proportion of vehicles recorded in each speed bin across the two monitoring periods at the control location.
Figure 11: Proportion of vehicles in each speed bin during the baseline period at the control location

Figure 12: Proportion of vehicles in each speed bin during the trial period at the control location
The proportion of vehicles in each speed bin at the control location remained fairly consistent between the baseline and trial periods. This is expected as the posted speed restriction remained the same during both periods at the control location, and further demonstrates that the changes observed at the experimental location were due to the change in speed restriction.

Even though statistical tests showed that the proportion of vehicles in each of the three speed categories were significantly different ($p < 0.05$) between the baseline and trial period, the effect sizes were negligible (0.09, 0.08 and 0.04 respectively).

Figure 13 and Figure 14 show the proportion of cars and LGVs (namely, the figures above repeated but with HGVs excluded) recorded in each speed bin across the two monitoring periods at the experimental location.

![Figure 13: Proportion of cars and LGVs in each speed bin during the baseline period at the experimental location](image-url)
The proportion of cars and LGVs travelling above the posted speed restriction at the experimental location changed slightly between the baseline and trial periods, dropping from 2% to 0%. The proportion of vehicles travelling above the enforcement limit decreased from 5% to 0%.

When looking at the differences in the proportion of vehicles in each category (below speed restriction, above speed restriction but below enforcement threshold and above enforcement threshold), two-proportion z-tests showed that, for all three categories, the proportion of vehicles in the category was significantly different ($p < 0.01$) between the baseline and trial periods at the experimental location. Additionally, the three tests showed medium to small effect sizes of 0.28, 0.01 and 0.01, respectively.

Figure 15 and Figure 16 show the proportion of HGVs recorded in each speed bin across the two monitoring periods at the experimental location.
Report for the on-road trials of 60 mph on the M6 junction 2-4

Figure 15: Proportion of HGVs in each speed bin during the baseline period at the experimental location

Below speed restriction | Above speed restriction but below enforcement limit | Above enforcement limit

<table>
<thead>
<tr>
<th>Speed bin</th>
<th>Below restriction (%)</th>
<th>Above speed restriction but below enforcement limit (%)</th>
<th>Above enforcement limit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-40mph</td>
<td>12%</td>
<td>87%</td>
<td>1%</td>
</tr>
<tr>
<td>40-50mph</td>
<td>87%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>50-57mph</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>57-60mph</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>60-68mph</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>68+mph</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Figure 16: Proportion of HGVs in each speed bin during the trial period at the experimental location

Below speed restriction | Above speed restriction but below enforcement limit | Above enforcement limit

<table>
<thead>
<tr>
<th>Speed bin</th>
<th>Below restriction (%)</th>
<th>Above speed restriction but below enforcement limit (%)</th>
<th>Above enforcement limit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-40mph</td>
<td>6%</td>
<td>83%</td>
<td>11%</td>
</tr>
<tr>
<td>40-50mph</td>
<td>83%</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>50-57mph</td>
<td>11%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>57-60mph</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>60-68mph</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>68+mph</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
The proportion of HGVs travelling above the posted speed restriction at the experimental location changed slightly between the baseline and trial periods, dropping from 1% to 0%. The proportion of HGVs travelling above the enforcement limit remained constant at 0% across the two periods.

When looking at the differences in the proportion of vehicles in each category (below speed restriction, above speed restriction but below enforcement threshold and above enforcement threshold), two-proportion z-tests showed that, for all three categories, the proportion of vehicles in the category was significantly different ($p < 0.01$) between the baseline and trial periods at the experimental location. The effect sizes were around 0.14, 0.02 and 0.01, respectively.

In summary, these data show that compliance rates improved for all vehicles when the speed restriction was 60 mph compared with 50 mph and that compliance remained relatively constant at the control location where the speed restriction remained at 50 mph.

### 3.2.3 Congestion

A check was conducted on the total duration of congestion observed during the investigation. At the experimental location, 7.1% of the total time during the baseline period and 3.0% of the total time during the trial period was classified as congested; defined as any period where the one-minute average speed of all vehicles in a lane was less than 40 mph. At the control location, 1.0% of the total time was classified as congested. Figure 17 outlines the average speeds per hour of the day, by monitoring period and location.

![Figure 17: Average hourly vehicle speed by location and monitoring period](image)

This figure shows that average speed was generally higher during the day (between 08:00 and 16:00) and lower during the night at the experimental location during the trial period. The
experimental location in the baseline period and the control location (in both periods) show an opposite trend, with higher speeds noticed overnight (between 18:00 and 06:00) and lower speeds during the day. Although this was significant, the effect size was relatively small. As the hourly average speed did not fall below 40 mph it can be concluded that there was minimal routine congestion at the scheme. As such the introduction of a 60 mph speed restriction did not appear to have an impact on the amount of congestion seen through the scheme.

3.2.4 Close following

A vehicle was defined as engaging in ‘close following’ if there was a headway of less than two seconds to the vehicle in front. This section presents comparisons of close following between monitoring period and location; both for all vehicles and split by vehicle class.

Figure 18 shows the proportion of total vehicles close following across the course of the trial at both the control and experimental locations.

![Figure 18: Proportion of vehicles close following by monitoring period and location](image)

During the baseline period the proportion of vehicles close following was 34% at the control location but slightly higher (37%) at the experimental location. During the trial period, the proportion decreased slightly at both locations to 32% at the control location and 35% at the experimental location.

A two-proportion z-test indicated that the small difference in the proportion of vehicles close following at experimental location between the baseline and trial periods was statistically significant ($p < 0.01$), but with a very small effect size of 0.06.
Figure 19 shows the split of HGVs and cars/LGVs close following at the experimental location. HGVs are defined as any vehicle over 25ft long.

![Figure 19: Proportion of vehicles close following by period and vehicle type at the experimental location](image)

A significantly higher proportion of cars/LGVs were close following at the experimental location ($p < 0.05$) than HGVs, with medium effect sizes (0.28 during the baseline and 0.30 during the trial period). At the experimental location:

- 37% of cars/LGVs were close following in baseline period
- 35% of cars/LGVs were close following in the trial period
- 24% of HGVs were close following in the baseline period
- 19% of HGVs were close following in the trial period

A two-proportion z-test indicated that these differences were statistically significant ($p < 0.01$) but with a very small effect size of 0.04 and 0.12.

### 3.3 Monday driver behaviour

This section presents the driver behaviour data collected on the Mondays. The speed restriction on Mondays was 50 mph across the baseline and trial period at both the control and experimental location.
3.3.1 Vehicle flow

Figure 20 shows the daily vehicle flow for the baseline and trial monitoring periods between the control and experimental monitoring locations.

The daily vehicle flow varied over the course of the investigation at both the control and experimental locations. The control location had an average daily flow of 46,110 during the baseline period and 35,917 during the trial period. Again, there was some irregularity noticed during Trial Monday 2 and Trial Monday 3 where reduced flows were observed. The reasons for these irregularities are unknown but may probably be due to technical issues with the radar units.

The experimental location had a lower average daily flow of 39,564 during the baseline period and 46,375 during the trial period. Once again, technical issues with the radar unit at the experimental location on Baseline Monday 3 (where a reduced flow is observable) may explain the irregular flows between the baseline and trial periods. Statistical tests showed that there was a significant difference (p < 0.01) in average vehicle flow between the baseline and trial period at the experimental location, with an effect size of 0.1.

A comparison of the proportion of HGVs by monitoring location and period is presented in Figure 21. This shows that the proportions of HGVs remained fairly constant at the experimental and control location throughout the trial: 23% during the baseline period at both locations, and 24% and 25% during the trial period at the experimental location and control location, respectively.
A two-proportion $z$-test indicated that the difference in the HGV proportions at the experimental location between the baseline and trial periods was statistically significant ($p < 0.01$). However, the effect size was small (0.04) and therefore, this difference is unlikely to have had a significant impact on driver behaviour.

The distribution of vehicles between Lanes 1, 2 and 3 within the experimental location is shown in Table 6.

**Table 6: Distribution of vehicle by lane and monitoring period at the experimental location**

<table>
<thead>
<tr>
<th>Monitoring period</th>
<th>Vehicle type</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline period</td>
<td>All vehicles</td>
<td>43%</td>
<td>37%</td>
<td>20%</td>
</tr>
<tr>
<td>Trial period</td>
<td>All vehicles</td>
<td>43%</td>
<td>37%</td>
<td>20%</td>
</tr>
</tbody>
</table>

The distribution of vehicles across the three available lanes at the experimental location varied between the baseline and trial periods.

A chi-square test showed that the small variation in vehicle distribution between the baseline and trial periods for all lanes at the experimental location was statistically significant ($p < 0.05$) but with a very small effect size of 0.02.

The proportions of each vehicle type in Lanes 1, 2 and 3 within the experimental location is shown in Table 7.
Table 7: Composition of vehicle by lane and monitoring period at the experimental location

<table>
<thead>
<tr>
<th>Monitoring period</th>
<th>Vehicle type</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline period</strong></td>
<td>Cars + LGVs</td>
<td>74%</td>
<td>73%</td>
<td>91%</td>
</tr>
<tr>
<td></td>
<td>HGVs</td>
<td>26%</td>
<td>27%</td>
<td>9%</td>
</tr>
<tr>
<td><strong>Trial period</strong></td>
<td>Cars + LGVs</td>
<td>72%</td>
<td>72%</td>
<td>93%</td>
</tr>
<tr>
<td></td>
<td>HGVs</td>
<td>28%</td>
<td>28%</td>
<td>7%</td>
</tr>
</tbody>
</table>

The vehicle composition in Lane 1 at the experimental location remained similar between the baseline and trial periods. A chi-square test showed that the small variation in vehicle composition between the baseline and trial periods at the experimental location was statistically significant ($p < 0.01$) but with a very small effect size of 0.01.

Similarly, the composition of vehicles in Lane 2 remained fairly consistent between the baseline and trial periods. There was no significant difference in vehicle composition between the baseline and trial periods at the experimental location ($p = 0.30$).

The composition of vehicles in Lane 3 also remained similar between baseline and trial periods. A chi-square test showed that the difference was statistically significant ($p < 0.05$). However, the effect size was very small (0.03).

As with the Sunday data, the variations in vehicle composition by lane at the experimental location, even though statistically significant, were found to be very small in terms of effect size. As such, differences in vehicle composition are unlikely to have impacted on vehicle speeds and speed compliance.

### 3.3.2 Vehicle speed

As explained above, to ensure that comparisons of vehicle speed were not conflated by the presence of small numbers of high-speed vehicles, the one-minute average speed data were weighted by vehicle flow.

Comparisons were made between control and experimental locations to account for background factors (aside from the speed restriction change) which may have influenced driver behaviour between the two monitoring periods.

Figure 22 shows the free-flow average speeds on the control and experimental locations across the two monitoring periods.
Free-flow average speed at both locations remained fairly constant throughout the investigation, at around 46 mph and 44 mph at the experimental location and control location, respectively.

A statistical test (ANOVA) confirmed that there was a significant difference in free-flow average speed ($p < 0.01$) between the baseline and trial periods at the experimental location, explaining around 95% of the total variance. There was no significant difference in average speeds between baseline and trial periods at the control location ($p = 0.21$).

As the difference in flow between monitoring periods and monitoring locations was not significant, changes in speed are unlikely to have been impacted by differences in flow.

Free-flow average speeds by lane are shown in Table 8.

<table>
<thead>
<tr>
<th>Monitoring period</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline period</td>
<td>42.0</td>
<td>44.1</td>
<td>45.9</td>
</tr>
<tr>
<td>Trial period</td>
<td>42.2</td>
<td>44.2</td>
<td>45.6</td>
</tr>
</tbody>
</table>

In both periods, speeds were highest in Lane 3, followed by Lane 2 and then Lane 1. Table 8 shows that the free-flow average speed in Lane 1 at the experimental location increased by 0.2 mph between the baseline and trial periods. Lane 2 had an increase of 0.1 mph between the two periods, while Lane 3 had a 0.3 mph speed difference. Although not shown here, there was little change in the average speeds by lane in the control location.

Figure 23 shows the comparison between free-flow average speed for cars/LGVs and HGVs across the monitoring periods at the experimental location.
The free-flow average speed of HGVs during the baseline period (41 mph) was slightly lower than the free-flow average speed of cars and LGVs at 42 mph. In the trial period, free-flow average speed for cars and LGVs was 41 mph, while HGVs were travelling at an average free-flow speed of 40 mph.

To understand the compliance of road users with the posted speed, data were separated into speed bins. These speed bins (0-40, 40-50, 50-57, 57-60, 60-68, 68+ mph) allow for vehicles to be identified as travelling: below the speed restriction, above the speed restriction but below the enforcement threshold (10% of speed restriction +2 mph), and above the enforcement threshold.

Figure 24 and Figure 25 show the proportion of vehicles recorded in each speed bin across the two monitoring periods at the experimental location.

The grey bars show the proportion of vehicles travelling below the speed restriction; the orange bars show the proportion of vehicles travelling above the speed restriction but below the enforcement threshold (10% of speed restriction +2 mph); and the red bars show vehicles travelling above the enforcement threshold.
Below speed restriction | Above speed restriction but below enforcement limit | Above enforcement limit

<table>
<thead>
<tr>
<th>Speed bin</th>
<th>Proportion of vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-40mph</td>
<td>13%</td>
</tr>
<tr>
<td>40-50mph</td>
<td>85%</td>
</tr>
<tr>
<td>50-57mph</td>
<td>2%</td>
</tr>
<tr>
<td>57-60mph</td>
<td>0%</td>
</tr>
<tr>
<td>60-68mph</td>
<td>0%</td>
</tr>
<tr>
<td>68+mph</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Figure 24:** Proportion of vehicles in each speed bin during the baseline period at the experimental location

Below speed restriction | Above speed restriction but below enforcement limit | Above enforcement limit

<table>
<thead>
<tr>
<th>Speed bin</th>
<th>Proportion of vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-40mph</td>
<td>13%</td>
</tr>
<tr>
<td>40-50mph</td>
<td>83%</td>
</tr>
<tr>
<td>50-57mph</td>
<td>3%</td>
</tr>
<tr>
<td>57-60mph</td>
<td>0%</td>
</tr>
<tr>
<td>60-68mph</td>
<td>0%</td>
</tr>
<tr>
<td>68+mph</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Figure 25:** Proportion of vehicles in each speed bin during the trial period at the experimental location
The proportion of vehicles travelling above the posted speed restriction at the experimental location remained fairly constant across the baseline and trial periods, witnessing a slight change from 2% to 3%. Similarly, the proportion of vehicles travelling above the enforcement limit remained constant at 0% between the two periods.

When looking at the differences in the proportion of vehicles in each category (below speed restriction, above speed restriction but below enforcement threshold and above enforcement threshold), two-proportion z-tests showed that, for all three categories, the proportion of vehicles in the category was significantly different ($p < 0.01$) between the baseline and trial periods at the experimental location. Additionally, the three tests showed small effect sizes of 0.08, 0.06 and 0.02, respectively.

Figure 26 and Figure 27 show the proportion of vehicles recorded in each speed bin across the two monitoring periods at the control location.

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**Figure 26: Proportion of vehicles in each speed bin during the baseline period at the control location**
The proportion of vehicles recorded as traveling above the posted speed restriction at the control location changed from 9% to 10% between the baseline and trial periods. The proportion of vehicles over the enforcement threshold remained constant at 1% across both periods.

Figure 28 and Figure 29 show the proportion of cars and LGVs recorded in each speed bin across the two monitoring periods at the experimental location.
Figure 28: Proportion of cars and LGVs in each speed bin during the baseline period at the experimental location.

Figure 29: Proportion of cars and LGVs in each speed bin during the trial period at the experimental location.
The proportion of cars and LGVs travelling above the posted speed restriction at the experimental location changed slightly between the baseline and trial periods, increasing from 2% to 4%. The proportion of vehicles travelling above the enforcement limit remained constant at 0% between the two periods.

When looking at the differences in the proportion of vehicles in each category (below speed restriction, above speed restriction but below enforcement threshold and above enforcement threshold), two-proportion z-tests showed that, for all three categories, the proportion of vehicles in the category was significantly different ($p < 0.01$) between the baseline and trial periods at the experimental location. Additionally, the three tests showed small effect sizes of 0.11, 0.12 and 0.04, respectively.

Figure 30 and Figure 31 show the proportion of HGVs recorded in each speed bin across the two monitoring periods at the experimental location.

**Figure 30:** Proportion of HGVs in each speed bin during the baseline period at the experimental location.
The proportion of HGVs travelling above the posted speed restriction at the experimental location remained constant across the baseline and trial periods, at 1%. Similarly, the proportions of HGVs travelling above the enforcement limit remained constant at 0% between the two periods.

When looking at the differences in the proportion of vehicles in each category (below speed restriction, above speed restriction but below enforcement threshold and above enforcement threshold), two-proportion z-tests showed that, for all three categories, the proportion of vehicles in the category was significantly different \((p < 0.01)\) between the baseline and trial periods at the experimental location. The effect sizes were small 0.04, 0.01, 0.01, respectively.

### 3.3.3 Congestion

A check was conducted on the total duration of congestion observed during the investigation. At the experimental location, 18% of the total time from both monitoring periods was classified as congested; defined as any period where the one-minute averaged speed of all vehicles across a lane was less than 40 mph. Figure 32 outlines the average speeds per hour of the day, by monitoring period and location.

Figure 32 shows that average speed was generally higher during the night (between 20:00 and 06:00) and lower during the day. This pattern appears consistent across the baseline and trial periods at both locations. However, the average speed dips slightly at the control location during the baseline period at 23:00 but returns to normal at the start of the new hour. As on
average the hourly average speed did not fall below 40 mph it can be concluded that there was minimal routine congestion at the scheme.

![Average hourly vehicle speed by location and monitoring period](image)

**Figure 32: Average hourly vehicle speed by location and monitoring period**

### 3.3.4 Close following

A vehicle was defined as engaging in ‘close following’ if there was a headway of less than two seconds to the vehicle in front. This section presents comparisons of close following between monitoring period and location; both for all vehicles and split by vehicle class.

Figure 33 shows the proportion of total vehicles close following across the course of the trial at the experimental and control locations.
During the baseline period the proportion of vehicles close following was 39% at the experimental location, but slightly lower (36%) at the control location. During the trial period, the proportion reduced to 37% at the experimental location and 33% at the control location.

A two-proportion z-test indicated that the small difference in the proportion of vehicles close following at experimental location between the baseline and trial periods was statistically significant ($p < 0.01$), but with a small effect size of 0.04.

Figure 34 shows the split of HGVs and cars/LGVs close following at the experimental location. HGVs are defined as any vehicle over 25ft long.
About 42% of cars/LGVs and 27% of HGVs were close following at the experimental location during the baseline period. These percentages reduced during the trial period to 41% for cars and LGVs and to 22% for HGVs.

A two-proportion z-test indicated that the difference in the proportion of both cars/LGVs and HGVs close following at the experimental location between the baseline and trial periods was statistically significant ($p < 0.01$) with a small effect size of 0.02 and 0.1, respectively.

### 3.4 Incidents and breakdowns

In total 34 incidents were reported across both the Sunday and Monday investigations: 16 of which were in the baseline monitoring periods and 18 in the trial monitoring periods. A summary of these reported incidents is presented in Figure 35 and Figure 36.
The number of reported incidents varied between the baseline and trial period at both the control and experimental locations on the Sunday investigations. At the experimental location, where the speed restriction changed between monitoring periods, the total number of reported incidents was two during the baseline period and one during the trial period. At the control location, where the speed restriction remained consistent across the investigation, the total number of reported incidents was four during both the baseline period and trial period.
Looking specifically at road traffic collisions (RTCs), at the experimental location, the figures showed one RTC during the baseline period and no RTCs during the trial period. At the control location there were no reported RTCs during both the baseline period or trial period.

The number of reported incidents also varied between the baseline and trial period at both the control and experimental locations on the Monday investigations. At the experimental location, where the speed restriction remained consistent across the monitoring periods, the total number of reported incidents was four during the baseline period and seven during the trial period. At the control location, where the speed restriction also remained consistent, the total number of reported incidents was six during both the baseline and trial period.

Looking specifically at RTCs, at the experimental location there were no RTCs during the baseline period and three during the trial period. At the control location there was also one reported RTC during the baseline period and two during the trial period.

Given the small sample size, statistical tests were not carried out. The marginal differences in the number of reported RTCs cannot be confidently attributed to the change in the speed restriction.

3.5 Journey time

Estimates of the average journey time were calculated for the baseline and trial monitoring periods on Sundays. This was based on the length of the speed restriction and a single aggregated free-flow average speed of vehicles using the radar data.

Table 9 shows the estimated average journey time during the baseline and trial periods.

<table>
<thead>
<tr>
<th>Monitoring location</th>
<th>Length (km)</th>
<th>Average vehicle speed (mph)</th>
<th>Journey time (seconds)</th>
<th>Difference (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline</td>
<td>Trial</td>
<td>Baseline</td>
</tr>
<tr>
<td>Southbound carriageway</td>
<td>Experimental</td>
<td>5.65</td>
<td>44</td>
<td>48</td>
</tr>
</tbody>
</table>

The results suggest that changing the speed restriction from 50 mph to 60 mph decreased the average journey time by around 24 seconds. Relative to the journey time through the 5.65km scheme, this represents about an 8% reduction in the trial period compared with the baseline period. When considering the approximately 30,000 drivers who travelled through the scheme each day, the time savings are notable.

No real change in journey time was observed at the control location or on Mondays, where the speed restriction remained consistent throughout both monitoring periods. This is because the average vehicle speed remained fairly constant throughout the investigation at around 47 mph at the control location on the monitored Sundays; and 46 mph and 44 mph at the experimental and control locations, respectively, on the monitored Mondays.
3.6 Workforce survey

In total, four individuals completed the workforce survey during the investigation; two reported on the 50 mph speed restriction and all four reported on the 60 mph speed restriction. A summary of their responses is presented below. Due to the limited number of responses, it was not possible to conduct any statistical analyses and caution should be taken when interpreting the results presented in this section.

Participants from the workforce were asked to rate how they thought the speed restriction affected their safety (see Figure 37).

![Figure 37: Responses to question “How do you think the speed restriction affected your safety? Did it make you feel...?”](image)

Across the investigation:

- 1 out of 2 participants reported the 50 mph speed restriction did not affect how safe they felt and 2 out of 4 participants reported the 60 mph speed restriction did not affect how safe they felt.
- 1 out of 2 participants reported the 50 mph speed restriction made them feel either very or slightly unsafe and 2 out of 4 participants reported the 60 mph speed restriction made them feel either very or slightly unsafe.
- No participants reported that either the 50 mph or 60 mph speed restriction made them feel either slightly or very safe.

Participants were then asked to rate how appropriate they thought the speed restriction was in terms of their own safety. Responses are shown in Figure 38.
Across the investigation:

- No participants reported the 50 mph speed restriction was about right in terms of safety and 2 out of 4 participants reported the 60 mph speed restriction was about right in terms of safety.
- No participants reported that either the 50 mph or 60 mph speed restriction was too slow in terms of safety.
- 2 out of 2 participants reported the 50 mph speed restriction was too high in terms of safety and 2 out of 4 participants reported the 60 mph speed restriction was too high in terms of safety.

Finally, in an open question, participants were asked to provide further comments on how the speed restriction affected their feelings of safety when they last worked on the scheme. Table 10 shows themes that represent general patterns observed in participants’ qualitative responses.
### Table 10: Themes from participants’ comments on the effects of the speed restrictions on their feelings of safety when they last worked on the scheme

<table>
<thead>
<tr>
<th>Positive comments</th>
<th>50 mph speed restriction</th>
<th>60 mph speed restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Compared with a 50 mph speed restriction, the 60 mph speed restriction discouraged HGV drivers from exceeding the speed restriction.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Negative comments</th>
<th>50 mph speed restriction</th>
<th>60 mph speed restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The speed restriction was too high. Drivers exceeded the speed restriction.</td>
<td>The speed restriction was too high. Drivers exceeded the speed restriction. Compared with a 50 mph speed restriction, it is more difficult to lower the posted speed restriction from 60mph if necessary.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Suggestions to improve safety</th>
<th>50 mph speed restriction</th>
<th>60 mph speed restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Educate drivers of the risks posed to themselves and the workforce when drivers exceed the speed restriction.</td>
<td></td>
</tr>
</tbody>
</table>

As well as comments about the effects of the speed restriction on feelings of safety, one participant also suggested that the implementation of crash cushions in live running lanes promoted feelings of safety, regardless of the posted speed restriction.

### 3.7 Customer satisfaction

In total, 20 participants were identified from the customer satisfaction survey as eligible for inclusion in the investigation. Of those, 12 reported their last journey as being through the scheme during the baseline period when a 50 mph speed restriction was in place and eight participants reported that their last journey was through the scheme during the trial period when either a 50 mph or 60 mph speed restriction was in place. Table 11 shows a breakdown of these responses by day of the week and location.

#### Table 11: Breakdown of customer satisfaction survey responses by period, day of the week and location

<table>
<thead>
<tr>
<th></th>
<th>Baseline period</th>
<th>Trial period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mondays</td>
<td>Sundays</td>
</tr>
<tr>
<td>Control location</td>
<td>2 responses</td>
<td>1 response</td>
</tr>
<tr>
<td>Experimental location</td>
<td>5 responses</td>
<td>4 responses</td>
</tr>
</tbody>
</table>

To answer the research question, responses only from individuals who last drove through the scheme at the experimental location were analysed; resulting in a total sample of 13 responses. A summary of their responses is presented in the following sections. Other survey responses were excluded for the following reasons:

- Participants reported that they did not regularly drive through the experimental location
- Participants reported that their most recent journey through the scheme was neither during the baseline period nor the trial period
- Participants reported that they did not drive through either the experimental location or it was not possible to determine whether they had driven through the experimental location (based on their responses to the survey questions that ask where they joined and exited the motorway)

- Participants reported that they did not clearly remember the journey

Due to the limited number of responses, it was not possible to conduct any statistical analyses and caution should be taken when interpreting the results presented in the following sections.

### 3.7.1 Feelings of safety

Participants were asked to rate how they thought the speed restriction affected their safety. Responses are shown in Figure 39.

![Figure 39: Responses to question: “How do you think the speed restriction affected your safety? Did it make you feel...?”](image)

Across the investigation:

- During the baseline period, 8 out of 9 individuals reported the speed restriction did not affect how safe they felt. During the trial period, 4 out of 4 individuals reported the speed restriction did not affect how safe they felt.

- During the baseline period, 1 out of 9 individuals reported the speed restriction made them feel slightly unsafe. During the trial period, no individuals reported the speed restriction made them feel either very or slightly unsafe.
During both the baseline and trial period, no individuals reported the speed restriction made them feel either slightly or very safe.

Participants were also asked to rate how appropriate they thought the speed restriction was, in terms of safety. Responses are shown in Figure 40.

**Figure 40: Responses to question “In terms of safety, do you think the speed restriction was...?”**

Across the investigation:

- During the baseline period, 4 out of 9 individuals reported the speed restriction was about right in terms of safety. During the trial period, 3 out of 4 individuals reported the speed restriction was about right in terms of safety.

- During the baseline period, 5 out of 9 individuals reported the speed restriction was too slow in terms of safety. During the trial period, 1 out of 4 individuals reported the speed restriction was too slow in terms of safety.

- During both the baseline and trial period, no individuals reported the speed restriction was too high in terms of safety.

As well as the effect of the speed restriction on perceived safety, participants were asked to comment on how the width of the running lanes within the scheme’s road works affected their feelings of safety. Responses are shown in Figure 41.
Figure 41: Responses to question: “How do you think the lane widths affected your safety? Did it make you feel...?”

Across the investigation:

- During the baseline period, 5 out of 9 individuals reported the lane widths did not affect how safe they felt. During the trial period, 1 out of 4 individuals reported the lane widths did not affect how safe they felt.

- During the baseline period, 4 out of 9 individuals reported the lane widths made them feel either very or slightly unsafe. During the trial period, 3 out of 4 individuals reported the lane widths made them feel slightly unsafe.

- During both the baseline and trial period, no individuals reported the lane widths made them feel either slightly or very safe.

Participants were also asked to rate how appropriate they thought the lane widths were in terms of safety. Responses are shown in Figure 42.
Across the investigation:

- During the baseline period, 3 out of 9 individuals reported the lane widths were about right in terms of safety. During the trial period, 1 out of 4 individuals reported the lane widths were about right in terms of safety.

- During the baseline period, 6 out of 9 individuals reported the lane widths were too narrow in terms of safety. During the trial period, 3 out of 4 individuals reported the lane widths were too narrow in terms of safety.

- During both the baseline and trial period, no individuals reported the lane widths were too wide in terms of safety.

Finally, in an open question, participants were asked to provide further comments on their feelings of safety when they last drove between Junctions 2 and 4 of the M6. Participants who last drove through the experimental location on a Sunday during the baseline period provided the following comments about how the speed restriction negatively impacted feelings of safety:

- Other drivers (including HGV drivers) exceeded the speed restriction.
- The speed restriction encouraged other drivers to hog the middle lane.
- The speed restriction encouraged HGV drivers to tailgate and overtake other vehicles.

Participants who last drove through the experimental location on a Monday during the trial period felt the 60 mph speed restriction (compared with a 50 mph speed restriction) discouraged HGV drivers from exceeding the speed restriction and from overtaking other vehicles.
There were no comments in relation to the width of the lanes.

### 3.7.2 Journey satisfaction

Participants were asked to rate how they thought the speed restriction affected their journey satisfaction. Responses are shown in Figure 43.

![Graph showing journey satisfaction](image)

**Figure 43: Responses to question: “How satisfied or dissatisfied were you with the speed restriction?”**

Across the investigation:

- During the baseline period, 5 out of 9 individuals reported the speed restriction did not affect their journey satisfaction. During the trial period, 1 out of 4 individuals reported the speed restriction did not affect their journey satisfaction.

- During the baseline period, 4 out of 9 individuals reported the speed restriction made them feel either very or somewhat dissatisfied. During the trial period, 1 out of 4 individuals reported the speed restriction made them feel somewhat dissatisfied.

- During the baseline period, no individuals reported the speed restriction made them feel either very or somewhat satisfied. During the trial period, 2 out of 4 individuals reported the speed restriction made them feel either very or somewhat satisfied.

Participants were also asked to rate how appropriate they thought the speed restriction was, in terms of their own journey satisfaction. Responses are shown in Figure 44.
Figure 44: Responses to question: “In terms of journey satisfaction, do you think the speed restriction was...?”

Across the investigation:

- During the baseline period, 4 out of 9 individuals reported the speed restriction was about right in terms of journey satisfaction. During the trial period, 2 out of 4 individuals reported the speed restriction was about right in terms of journey satisfaction.

- During the baseline period, 5 out of 9 individuals reported the speed restriction was too slow in terms of journey satisfaction. During the trial period, 2 out of 4 individuals reported the speed restriction was too slow in terms of journey satisfaction.

- During both the baseline and trial periods, no individuals reported the speed restrictions were too high in terms of journey satisfaction.

Participants were asked to rate how they thought the lane widths affected their journey satisfaction. Responses are shown in Figure 45.
Across the investigation:

- During the baseline period, 3 out of 9 individuals reported the lane widths did not affect their journey satisfaction. During the trial period, 2 out of 4 individuals reported the lane widths did not affect their journey satisfaction.

- During the baseline period, 6 out of 9 individuals reported the lane widths made them feel somewhat dissatisfied. During the trial period, 2 out of 4 individuals reported the lane widths made them feel somewhat dissatisfied.

- During both the baseline and trial periods, no individuals reported the lane widths made them feel either very or somewhat satisfied.

Participants were also asked to rate how appropriate they thought the lane widths were, in terms of their own journey satisfaction. Responses are shown in Figure 46.
Across the investigation:

- During the baseline period, 3 out of 9 individuals reported the lane widths were about right in terms of journey satisfaction. During the trial period, 1 out of 4 individuals reported the lane widths were about right in terms of journey satisfaction.

- During the baseline period, 6 out of 9 individuals reported the lane widths were too narrow in terms of journey satisfaction. During the trial period, 3 out of 4 individuals reported the lane widths were too narrow in terms of journey satisfaction.

- During both the baseline and trial periods, no individuals reported the lane widths were too wide in terms of journey satisfaction.

Finally, participants were asked to comment on their journey satisfaction when they last drove between Junctions 2 and 4 of the M6. In relation to the speed restriction, one participant who drove through the experimental location on a Monday during the trial period mentioned that the 60 mph speed restriction improved traffic flow compared with a 50 mph speed restriction. There were no comments in relation to the width of the lanes.

Participants also made other general comments about their levels of journey satisfaction:

- One participant who drove through the experimental location during the baseline period on a Sunday expressed satisfaction with the lack of congestion.

- One participant who drove through the experimental location during the trial period on a Monday expressed satisfaction with other drivers behaving well.
3.8 Scheme delivery and cost

3.8.1 Delivery
Overall the scheme indicated that delivery of the work activities was not negatively impacted by the 60 mph speed restriction. Discussions recorded as part of the lessons learned workshop concluded that the trial and implementation of a 60 mph speed restriction had not negatively impacted on the delivery schedule of the specific phase of work in question. The scheme did acknowledge, however, that delivery was impacted as it took time to resolve all the challenges of using dynamic speed restrictions.

3.8.2 Cost
To safely implement the 60 mph speed restriction between junction 2 and 3 of the scheme’s traffic management, several additional key mitigations and activities were required. These included:

- Higher containment vehicle restraint systems and end terminals.
- Mobile variable message signs used for incident management.
- Additional static signing (speed restriction signs).

Along with the costs of these additional mitigations, an additional cost was incurred by the scheme to implement the trial of a 60 mph speed restriction:

- Temporary radar installations used for monitoring traffic during the investigation.
4 Conclusions

This section summarises the conclusions from the investigation. These conclusions are based on the findings from a single investigation undertaken at a specific scheme. Both the design and implementation of the scheme’s traffic management and trial mitigations impact greatly on the behaviours identified. As such, caution should be taken when using these conclusions to inform decisions about implementing future 60 mph speed restrictions on schemes with different designs.

As part of the final project report, the conclusions from this report will be brought together with those from other participating schemes. Further details about this final report are outlined in section 6.2.

4.1 Impact of change in speed restriction on driver behaviour

Analysis of driver behaviour during periods of free-flowing traffic showed that, on average, drivers appeared to respond to the increase in speed restriction from 50 mph to 60 mph by increasing their travelling speed (resulting in average speeds increasing from about 44 mph in the baseline period to 48 mph in the trial period). The increase in average vehicle speed was consistent across all three carriageway lanes with the offside lanes seeing the highest speeds. This increase in average vehicle speed resulted in an estimated average journey time reduction of around 24 seconds per driver.

The speed differentials between vehicle classes were also affected by the change in speed restriction. During the trial period, the difference between the observed average vehicle speeds of cars and LGVs compared to HGVs marginally increased. On the Sunday investigation, the speed differentials between the two classes of vehicles increased by around 2 mph.

Whilst average speeds increased, overall compliance with the posted speed restriction was marginally higher in monitoring sections with the 60 mph speed restriction than the 50 mph speed restriction. About 2% of the drivers observed during the Sunday investigation were travelling above 50 mph in the baseline period, but 0% of drivers chose to travel above 60 mph in the trial period.

A similar trend was observed in the behaviours of HGV drivers; overall compliance with the posted speed restriction was higher in the sections with a 60 mph speed restriction than the 50 mph speed restriction. During the Sunday investigation, around 1% of HGV drivers travelled above 50 mph in the baseline period, but 0% of HGV drivers travelled above 60 mph during the trial period. The levels of speed compliance remained fairly constant across the baseline and trial period on Mondays (where a 50 mph speed restriction was in place).

The scheme in general experienced relatively consistent levels of close following between vehicles across the investigation, but there was a minor change due to the change in speed restriction; around a 2% reduction. The proportion of HGVs close following also dropped marginally across the monitoring periods. The Sunday investigation saw a drop from 24% in the baseline period to 19% in the trial period. The Monday investigation saw a drop from 27% to 22% between monitoring periods. This change was likely related to the difference in average vehicle speeds and compliance after the change of speed restriction. In particular, the reduction in speed differentials between vehicle classes may explain the reduction in close
following. The change in speed restriction appeared to have no impact on the number of reported incidents during the investigation. The numbers of reported incidents marginally varied during the investigation, but overall numbers of incidents were low suggesting it was unlikely to be a result of the change in speed restriction. It must be noted that although the results were statistically significant, in most cases the effect sizes were small (below 0.2) suggesting that any changes in driver behaviour, between 50 mph and 60 mph, were negligible. Therefore, the significance from the statistical analysis is likely to be attributed to the fact that large sample sizes were obtained, rather than signifying there was a large change in driver behaviour.

4.2 Impact of change in speed restriction on workforce and customer satisfaction

Overall, a small number of responses were received for both the workforce survey and customer satisfaction survey, and those responses were mixed. While some workforce survey participants felt the 50 and 60 mph speed restrictions were too high in terms of safety, others felt the 60 mph speed restriction was about right. There were also mixed perceptions of safety across the workforce; an equal share of participants reported that the speed restrictions either did not affect how safe they felt or made them feel unsafe. Results from the customer satisfaction survey indicated that most participants felt the speed restriction did not affect their feelings of safety or journey satisfaction, but some participants felt that the lane widths made them feel somewhat unsafe and dissatisfied. Additionally, some participants felt the speed restriction and lane widths were about right in terms of safety and journey satisfaction, whereas other participants felt the speed restriction was too low and the lanes were too narrow. Qualitative feedback obtained during the customer satisfaction survey suggests that the 60mph speed restriction was welcomed by several participants.

Due to the small number of responses for both the workforce survey and customer satisfaction survey, it was not possible to test for any statistically significant changes in perceptions between the 50 mph and 60 mph speed restrictions. Therefore, there is no robust evidence to show either an increase or a decrease in self-reported customer satisfaction due to the 60mph speed restriction.

4.3 Impact of change in speed restriction on scheme cost and delivery

Feedback from the scheme suggested that the introduction and application of a 60 mph speed restriction had no negative impact on the schedule and delivery of the works. However, it was reported that due to delays caused by changing the established practice for risk assessments, less time for use of 60 mph was available on the scheme. Several large fixed costs were also incurred to implement additional risk mitigations, such as higher containment vehicle restraint systems. This information will be used to inform future use of 60 mph speed restrictions within road works and will be presented alongside future guidance material.
5 Other investigations

5.1 Highways England customer audits

Separate to this investigation, Highways England’s insight team investigated the impact of the change in speed restriction on customer satisfaction by undertaking customer audits of the scheme. For ease of reference, and with permission from Highways England, a copy of the report can be seen in Appendix D.

These customer audits, undertaken by Ipsos and Pell Frischmann, utilised briefed ‘Auditors’ (members of the public) who lived in the vicinity of the scheme. These Auditors were given a full written brief detailing where they needed to go, what they needed to look out for and a preview of the survey questionnaire. Auditors were instructed to drive through the scheme and undertake a survey within 24 hours. These surveys sought to identify the impact of the speed restriction change on both customer safety and customer satisfaction. A total of 33 surveys were completed, 18 whilst the scheme was in the baseline trial period and 15 during the trial period.

Survey responses were then filtered via a quality control process by a validation team. This team looked for contradictions and irregularities within the responses of each survey. If completed surveys were deemed to be of inadequate quality, they would not be included in the top line results. No surveys were reported to have failed this quality control process for the investigations on the M6.

The headline findings from these customer audits are summarised below. Some caution is advised in the extrapolation of these results since a small sample of Auditors was used (18 in the control phase and 15 in the trial phase). In addition, no details are provided in the “Top Line Results” report with regard to whether statistically significant differences were identified between the 50 mph and 60 mph phases; therefore, it is not possible to draw robust conclusions from these data regarding the impact of the increased speed restriction.

Key points noted in the “Top Line Results” report (Appendix D) are as follows:

- 16 out of 18 Auditors (89%) felt 50 mph was appropriate for the conditions and 11 out of 15 Auditors (73%) felt 60 mph was appropriate.
- 18 out of 18 Auditors (100%) reported that the signage was easy to see in the control (50 mph) phase and 15 out of 15 (100%) reported it was easy to see in the trial (60 mph) phase.
- 18 out of 18 Auditors (100%) indicated that they felt safe traveling at 50 mph and 15 out of 15 (100%) said they felt safe traveling at 60 mph.
- 12 out of 18 Auditors (67%) were very satisfied with the 50 mph speed restriction and 8 out of 15 (53%) were very satisfied with the 60 mph speed restriction.
- 16 out of 18 Auditors (89%) felt the 50 mph speed restriction was about right but the remaining 2 Auditors (11%) felt it was too slow. 11 out of 15 Auditors (73%) felt the 60 mph speed restriction was about right but the remaining 4 Auditors (27%) felt it was too slow.
Highways England social media listening

Separate to this investigation Highways England’s insight team investigated the impact of the change in speed restriction on customer satisfaction by monitoring social media postings using a ‘TalkWalker’; a specialist social listening tool. The tool utilised a search query, containing the following key words:

- “M6” or “Coventry” or “Hinkley” or “Birmingham” or “Leicester” or “Nuneaton” or “Bedworth” or “NEC” or “J2” or “junction 2”; and
- “smart motorway” or “roadworks”; and
- “speed” or “limit*” or “50” or “60” or “50 mph” or “60 mph” or “end”

During the investigation, a total of 18 relevant mentions in relation to the speed restriction were found. Whilst there were positive comments about the change from the 50 mph speed restriction to the 60 mph speed restriction, other comments suggested that a 50 mph speed restriction was still in place during the trial period (Highways England, 2020). Additionally, one individual expressed concern about the increased speed restriction and one individual expressed frustration with HGV drivers tailgating when a 50 mph speed restriction was in place (Highways England, 2020).
6  Next steps

6.1  Continued use of 60 mph at the M6 junction 2-4 scheme

Upon completion of the trial of 60 mph between junctions 2 and 4, a review and validation exercise was undertaken by the scheme to determine if the 60 mph speed restriction could be implemented across the remainder of the verge phase of works.

In line with the agreed monitoring process, detailed in the scheme-specific risk assessment, available data were reviewed to determine if the safety objectives had been met during the trial. Based on this review the continued use of the 60 mph speed restriction between junctions 2 and 4 was approved and confirmation was received that the scheme further implemented a 60 mph speed restriction on Sunday, 23rd of February 2020 for a full 24-hour period.

6.2  Implementation of 60 mph at other schemes

This is the sixth investigation of a 60 mph speed restriction within road works as part of this project. TRL is working closely with Highways England to implement 60 mph speed restrictions at other schemes on the Strategic Road Network. Several additional lessons learned were captured as part of this investigation; these have been outlined in Appendix C and should be considered when implementing the 60 mph speed restriction on other schemes in the future.

The results from future investigations (each to be presented in their own report) will be collated together (in a final report) once the monitoring programme is complete.

The final report will enable robust recommendations to be made based on a large and substantial evidence base, with findings being used to inform guidance material into the used of appropriate speed restrictions within road works.
Acknowledgements
The following individuals (or organisations) contributed directly to the investigation of a 60 mph speed restriction within the M6 junction 2-4 road works:

- Rana Ghosal – Arcadis
- Peter Franklin – Jacobs
- Keith Smith and Cengiz Guner – Chevron Traffic Management
- James Jarrett, Nick Barnett and Roger Poeth – Highway Resource Solutions
- Matthew Richards, Jim Ditchburn, Andrew Naylor and Richard Turnbull – Balfour Beatty Vinci
- Daniel Faultless-Hodgson, David Croser-Drake, Janice Allen and Syed Abbas – Highways England
- Neal Westwood and Gary Hollis – Warwickshire Police
References


IPSOS. (2020). *Customer audits - speed trials - M6 2-4 Top line results.*

Appendix A  PSCRG members

Principal members:

- A senior Highways England Project Manager and/or Senior Responsible Owner
- Lead consultancy support, with relevant risk assessment knowledge, competence, design understanding and experience with Highways England safety governance procedures
- Network Delivery and Development Senior User
- Customer Operations Senior User
- Competent Designer Safety / Operations Expert
- Project Construction, Design and Management Coordinator
- Contractor representative (when appointed)
- Professional and Technical Solutions Safety Risk and Governance representative

Specialist members:

- Additional technical support (Professional and Technical Solutions specialists or external subject matter experts, as required)
- The Design Team Project Manager
- Asset Support Contract representative
- Maintenance representative, including technology
- Stakeholder representative (for instance, other RCC/Traffic Officer Service representatives)
Appendix B  Additional monitoring

As described in Section 2, the M6 J2-4 scheme implemented a dynamic use of the speed restriction, operating with a 60 mph speed restriction during days of minimal works activities. This included Sundays, Bank Holidays and during holiday shutdowns.

Analysis of the period during the Christmas holiday shutdown (embargo) was excluded from the main analysis (Section 3) since this period is expected to vary from ‘normal’ traffic conditions. However, as the embargo resulted in a period of consecutive non-working days where the speed restriction on the experimental carriageway was 60 mph, there is some merit in reviewing these data as a separate study objective. This appendix presents the results of an investigation into the impact of the difference in speed restriction between carriageways during the embargo period on:

- Lane distribution of vehicles
- Vehicle speeds
- The number of non-compliant vehicles
- The levels of close following

The results for this analysis are presented in Appendix B.1.

To mitigate the risks posed to all affected parties during a live lane incident the speed restriction across the trial section of the scheme could be changed, typically from 60 mph to 50 mph. During the scheme’s use of the 60 mph speed restriction over the Christmas embargo, two such instances were identified when the speed restriction was changed dynamically from 60 mph to 50 mph. This is the first time during the wider phase of trials that this mitigation has been implemented and as a result, this has also been investigated further. Results are presented in Appendix B.2.

B.1  Christmas embargo period

Monitoring during the embargo covered a single period which took place between 06:00 on the 22\textsuperscript{nd} December 2019 and 05:00 in the 5\textsuperscript{th} January 2020. During this time, the control location (northbound carriageway) had a speed restriction of 50 mph whilst the experimental location (southbound carriageway) was changed to 60 mph.

The analysis presented here compares the vehicle flow, speeds and amount of close following between the two locations (carriageways).

B.1.1  Comparison of flow

Figure 47 shows the average daily vehicle flow for the control and experimental monitoring locations.
The average daily vehicle flow varied over the embargo period at both the control and experimental locations, with the lowest daily flows experienced on 26th December (Boxing Day). Note that flows on 22nd December and 5th January are not representative of the entire day, as this analysis only considers time within the embargo period – after 6am on 22nd December and before 5am on 5th January. Flows were typically slightly higher on the experimental (southbound) carriageway than the control (northbound) carriageways and chi-square tests showed that there was a significant difference ($p < 0.01$) between locations however the effect size was tiny ($< 0.01$).

A comparison of the proportion of HGVs by monitoring location and date is presented in Figure 48.
This shows that the proportions of HGVs varied over the embargo period (from a minimum of 2% on 26th December to 21% on 4th January), however this changed similarly on the control and experimental carriageways. As above, HGV proportions for 22nd December and 5th January are not representative of the entire day, as this analysis only considers time within the embargo period. A two-proportion z-tests indicates that over the whole embargo period there was a significant difference ($p < 0.01$) in HGV proportion between the control and experimental locations. However, the effect size was extremely small (0.02).

The distribution of vehicles between Lanes 1, 2 and 3 is shown in Table 12.

**Table 12: Distribution of vehicle by lane and location**

<table>
<thead>
<tr>
<th>Location</th>
<th>Vehicle type</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>All vehicles</td>
<td>47%</td>
<td>39%</td>
<td>14%</td>
</tr>
<tr>
<td>Experimental</td>
<td>All vehicles</td>
<td>44%</td>
<td>39%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Results across the two locations were similar. A chi-square test showed that the variation in vehicle distribution between the control and experimental locations was significant ($p < 0.01$) but with a very small effect size of 0.03.

The proportions of each vehicle type in Lanes 1, 2 and 3 by location is shown in Table 13.
Table 13: Composition of vehicle by lane and location

<table>
<thead>
<tr>
<th>Location</th>
<th>Vehicle type</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Cars + LGVs</td>
<td>85%</td>
<td>87%</td>
<td>93%</td>
</tr>
<tr>
<td></td>
<td>HGVs</td>
<td>15%</td>
<td>13%</td>
<td>7%</td>
</tr>
<tr>
<td>Experimental</td>
<td>Cars + LGVs</td>
<td>80%</td>
<td>89%</td>
<td>94%</td>
</tr>
<tr>
<td></td>
<td>HGVs</td>
<td>20%</td>
<td>11%</td>
<td>6%</td>
</tr>
</tbody>
</table>

The vehicle composition in each lane was similar at the two locations. Chi-square tests for the distribution of vehicles within each of the lanes showed that the variation in vehicle composition between the control and experimental locations was statistically significant ($p < 0.01$ for all lanes), but with a very small effect sizes of 0.07, 0.03 and 0.01, respectively.

As shown in this section, there were significant differences in overall levels of flow, and the composition of flow between the control and experimental location; however, the effect sizes of these differences were small suggesting that the impact on driver behaviour might also be small. When interpreting the results in the following sections, this impact should be considered as any differences in average speed or compliance between the two carriageways might be linked to both differences in the flow and differences in the speed restriction.

B.1.2 Comparison of speed

As in the main analysis (see Section 3), to ensure that comparisons of vehicle speed were not conflated by the presence of small numbers of high-speed vehicles, the one-minute average speed data were weighted by vehicle flow.

Figure 49 shows the free-flow average speeds at the control and experimental locations.
Figure 49: Free-flow average speed by location and date (data for 22/12/2019 is from 6am onwards, data for 05/01/2020 is only until 5am)

Free-flow average speed at the control location remained fairly constant throughout the investigation, at around 46 mph. At the experimental location, the free flow average speed was only 2 mph higher (despite a 10 mph difference in the speed restriction between this carriageway and the control carriageway) at 48 mph. A statistical test (ANOVA) confirmed that there was a significant difference in free-flow average speed ($p < 0.01$) between the control and experimental locations. This model explained 8% of the variance.

As the difference in flow between monitoring locations was significant, these changes in speed may have been impacted by differences in flow.

Free-flow average speeds by lane are shown in Table 14.

<table>
<thead>
<tr>
<th>Location</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>44.5</td>
<td>46.9</td>
<td>49.0</td>
</tr>
<tr>
<td>Experimental</td>
<td>45.4</td>
<td>49.8</td>
<td>52.5</td>
</tr>
</tbody>
</table>

Unsurprisingly, at both locations, speeds were highest in Lane 3, followed by Lane 2 and then Lane 1.

Figure 50 shows the comparison between free-flow average speed for cars/LGVs and HGVs by date for the experimental (60 mph) location only.
The free-flow average speed of HGVs was consistently slightly lower than the free-flow average speed of cars and LGVs. There was relatively little change in average speeds for either vehicle type over the period studied.

To understand the compliance of road users with the posted speed, data were separated into speed bins. These speed bins (0-40, 40-50, 50-57, 57-60, 60-68, 68+ mph) allow for vehicles to be identified as travelling: below the speed restriction, above the speed restriction but below the enforcement threshold (10% of speed restriction +2 mph).

Figure 51 and Figure 52 show the proportion of vehicles recorded in each speed bin for the two monitoring locations. The grey bars show the proportion of vehicles travelling below the speed restriction; the orange bars show the proportion of vehicles travelling above the speed restriction but below the enforcement threshold (10% of speed restriction +2 mph); and the red bars show vehicles travelling above the enforcement threshold.

**Figure 50: Free-flow average speed by vehicle type and date (data for 22/12/2019 is from 6am onwards, data for 05/01/2020 is only until 5am. Experimental location data only)**
The proportion of vehicles travelling above the posted speed restriction at the experimental location was considerably smaller than at the control location (1% compared with 10%). There were very few vehicles travelling above the enforcement threshold at either location. Chi-
squared tests showed the distribution of vehicles across the three categories (below speed restriction, below enforcement threshold and above enforcement threshold) was significantly different ($p < 0.01$, with a small to medium effect size of 0.15) between the control and experimental locations.

Figure 53 and Figure 54 show the proportion of cars and LGVs recorded in each speed bin for the two monitoring locations.

![Figure 53: Proportion of cars and LGVs in each speed bin at the control location](image)
As with all vehicles, the proportion of cars and LGVs travelling above the posted speed restriction at the experimental location was considerably smaller than at the control location (1% compared with 10%). Statistical tests showed the distribution across the three categories was significantly different ($p < 0.01$, with a small to medium effect size of 0.15) between the two locations.

Figure 55 and Figure 56 show the proportion of HGVs recorded in each speed bin for the two monitoring periods.
Figure 55: Proportion of HGVs in each speed bin at the control location

Figure 56: Proportion of HGVs in each speed bin at the experimental location

Very few (<1%) HGVs were travelling above 50 mph at either location. Statistical tests showed the distribution across the three categories was significantly different ($p < 0.01$, with a small to medium effect size of 0.12) between the two locations.
B.1.3 Comparison of close following

A vehicle was defined as engaging in ‘close following’ if there was a headway of less than two seconds to the vehicle in front. Figure 57 shows the proportion of total vehicles close following by location and date.

![Graph showing proportion of vehicles close following by location and date](image)

**Figure 57: Proportion of vehicles close following by location and date (data for 22/12/2019 is from 6am onwards, data for 05/01/2020 is only until 5am)**

The proportion of vehicles close following was similar across the two locations (31% overall for the control location and 33% for the experimental). However, this proportion did vary by day with the lowest figures recorded on boxing day (23%) when the flows were lowest (see Figure 47). A two-proportion z-tests indicates that over the whole embargo period there was a significant difference ($p < 0.01$) in the proportion of vehicles close following between the control and experimental locations. However, the effect size was extremely small (0.01).

As the difference in flow between monitoring locations was significant, these changes in close following may have been impacted by differences in flow.

Figure 34 shows the split of HGVs and cars/LGVs close following at the experimental location.
Figure 58: Proportion of vehicles close following by vehicle type. Experimental location only

About 35% of cars/LGVs and 19% of HGVs were close following at the experimental location over the embargo period. A two-proportion z-test indicated that over the whole embargo period the difference in the proportion of HGVs and cars/LGVs close following at the experimental location was statistically significant ($p < 0.01$) with a small effect size of 0.11.

B.1.4 Summary of findings

During the Christmas embargo the control location (northbound carriageway) had a speed restriction of 50 mph, whilst the experimental location (southbound carriageway) had a speed restriction of 60 mph. Comparison of the flows, speeds and close following on both carriageways during this time shows:

- Flow was slightly higher on the experimental carriageway, as was the HGV proportion. Although the differences between carriageways were significant, the effect size was very small suggesting that the impact on driver behaviour might also be small.

- On both carriageways the free-flow average speed was below 50 mph: at the control location it was around 46 mph and at the experimental location around 48 mph (only 2 mph higher despite a 10 mph difference in the speed restriction). This difference was significant.

- The proportion of vehicles travelling above the posted speed restriction at the experimental location was significantly smaller than at the control location (1% compared with 10%); the majority of these vehicles were cars. There were very few vehicles travelling above the enforcement threshold at either location.
There was a significant difference in the proportion of vehicles close following between the control and experimental locations; however, the effect size was extremely small. A higher proportion of cars/LGVs were close following than HGVs.

### B.2 Incident management

As outlined above, during the scheme’s use of the 60 mph speed restriction over the Christmas embargo, two instances were identified when the speed restriction was changed dynamically from 60 mph to 50 mph. These incidents are examined as two separate case studies in this section.

Monitoring covers three periods per incident; a 1-hour ‘pre-incident’ monitoring period during which the monitoring location retained a 60 mph speed restriction, an ‘incident’ monitoring period in which the 50 mph speed restriction was implemented; and a 1-hour ‘post-incident’ monitoring period when the 60 mph speed restriction was reinstated (see Table 15).

**Table 15: Timelines for monitoring investigation**

<table>
<thead>
<tr>
<th>Description of activity</th>
<th>Speed restriction</th>
<th>Case study 1</th>
<th>Case study 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-incident monitoring period</td>
<td>60</td>
<td>31st Dec 2019 10:35:09-11:35:09</td>
<td>2nd Jan 2020 11:05:15-12:05:15</td>
</tr>
</tbody>
</table>

In addition to a review of the radar data for each incident, incident data from the scheme has also been reviewed to identify additional details such as the location and type of incident, and details of the emergency traffic management implemented.

#### B.2.1 Case study 1

This incident took place on 31st December at 11:10. It involved a coach breaking down (due to mechanical issues) in Lane 1 within the roadworks on the southbound carriageway. The road and weather conditions were dry and no congestion was reported as a result of the incident.

Upon arrival at the scene at 11:24, the recovery vehicle made a request to decrease the speed restriction from 60 mph to 50 mph. Confirmation of the speed restriction change occurred at 11:35 and the recovery commenced shortly after.

Traffic Safety and Control Officers (TSCO) and an Impact Protection Vehicle (IPV) all attended the scene the vehicle was cleared by 12:01. Following this, a request was made at 12:05 to revert the speed restriction back to 60 mph and the speed restriction was changed at 12:09.

#### B.2.1.1 Comparison of flow
Figure 59 shows the vehicle flow per minute by lane on the southbound carriageway. The grey area highlights the time period in which the speed restriction signs were changed from 60 mph to 50 mph.

![Graph showing vehicle flow per minute by lane on the southbound carriageway. The grey area highlights the time period during which the speed restriction was reduced to 50 mph.]

Figure 59: Case study 1: Vehicle flow per minute by lane (grey area highlights the time during which the speed restriction was reduced to 50 mph). Experimental location only

There was a slight upwards trend in vehicle flow across the whole period but no obvious step change in vehicle flow during or after the incident took place.

Figure 60 shows the average flow per minute (across all lanes) in each of the periods of interest and compares the changes on the control (northbound) carriageway to those on the experimental (southbound) carriageway, where the incident and speed restriction change took place.
Although there was a slight increase in average flow across the period, this was replicated on the control carriageway where no speed restriction changes took place. A chi-squared test showed there was no significant difference ($p = 0.32$) detected in the distribution of flow across the three periods between the control and experimental locations.

Figure 61 shows the proportion of vehicles which were HGVs during each of the periods of interest on both carriageways.
Around 16% of vehicles were HGVs at the experimental location pre-incident and during the incident itself. Although this dropped slightly to around 13% post-incident (a proportion tests shows this was significant ($p < 0.01$) but with a small effect size 0.03), this change was replicated on the control carriageway and may be due to the changes in overall levels of flow (see Figure 60).

The distribution of vehicles by lane is shown in Table 16.

**Table 16: Case study 1: Distribution of vehicles by lane and period of interest.**

<table>
<thead>
<tr>
<th>Period of interest</th>
<th>Vehicle type</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-incident</td>
<td>All vehicles</td>
<td>47%</td>
<td>42%</td>
<td>12%</td>
</tr>
<tr>
<td>Incident</td>
<td>All vehicles</td>
<td>42%</td>
<td>42%</td>
<td>17%</td>
</tr>
<tr>
<td>Post-incident</td>
<td>All vehicles</td>
<td>37%</td>
<td>40%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Due to the location of the broken-down vehicle in Lane 1, the proportion of vehicles travelling in this lane decreased slightly during the incident and increased in Lane 3. However, surprisingly, post-incident the proportion of vehicles in Lane 1 decreased further. A chi-square test showed that the variation in vehicle distribution between the lanes was significant ($p < 0.01$) but with a very small effect size of 0.07.

**B.2.1.2 Comparison of speed**

Figure 62 shows the average vehicle speed by lane on the southbound carriageway. The grey area highlights the time period in which the speed restriction signs were reduced from 60 mph to 50 mph.

![Figure 62: Case study 1: Average speed per minute by lane (grey area highlights the time during which the speed restriction was reduced to 50 mph). Experimental location only](image-url)
There was no obvious change in average speeds as a result of the incident and change in speed restriction. Figure 63 shows the average for each period of interest on both carriageways.

![Graph showing average speed by location and period of interest](image)

**Figure 63: Case study 1: Average speed by location and period of interest**

As above, this summarised data shows that very small changes in average speed were observed on both carriageways suggesting that the change in speed restriction had little effect on the speeds of vehicles travelling through the works: in all three periods the average speed was already below 50 mph. A statistical test (ANOVA) confirmed that there was no significant difference in the change in average speed across the three periods between the two carriageways ($p = 0.57$).

Table 17 shows the change in average speed by lane.

<table>
<thead>
<tr>
<th></th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Period of interest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-incident</td>
<td>46.0</td>
<td>51.2</td>
<td>54.4</td>
</tr>
<tr>
<td>Incident</td>
<td>45.6</td>
<td>50.7</td>
<td>54.1</td>
</tr>
<tr>
<td>Post-incident</td>
<td>44.8</td>
<td>50.0</td>
<td>53.0</td>
</tr>
</tbody>
</table>

**Table 17: Case study 1: Average vehicle speed (mph) by lane and period of interest. Experimental location only**

Average speeds decreased very slightly in all three lanes across the periods. Results by vehicle type are shown in Figure 64.
No observable differences in speed for either cars & LGVs or HGVs are evident.

Figure 65 shows the proportion of vehicles recorded in each speed bin during the three periods. The grey bars show the proportion of vehicles travelling below the speed restriction; the orange bars show the proportion of vehicles travelling above the speed restriction but below the enforcement threshold (10% of speed restriction +2 mph); and the red bars show vehicles travelling above the enforcement threshold.
These charts indicate that the proportion of vehicles in each speed bin remained largely unchanged over the periods of interest. As a result, due to the speed restriction change nearly half of drivers were driving faster than the speed restriction (50 mph) during the incident itself. Chi-squared tests show the distribution of vehicles across the three categories (below speed restriction, below enforcement threshold and above enforcement threshold) was significantly different ($p < 0.01$, with a small to medium effect size of 0.19) between the three periods.

Figure 66 shows this distribution for cars and LGVs and Figure 67 for HGVs.

As for all vehicles, very little change in the distribution of speeds was shown for either cars/LGVs or HGVs but due to the speed restrictions on HGVs, a smaller proportion of these vehicles were travelling above the speed restriction. Statistical tests showed the car speed distribution across the three categories was significantly different ($p < 0.01$, with a medium effect size of 0.31) between the three periods, as was the distribution for HGV speeds ($p < 0.01$, with a small to medium effect size of 0.15).

**B.2.1.3 Comparison of close following**
The proportion of vehicles close following (defined as being a headway of less than two seconds to the vehicle in front) is shown in Figure 68 on the control and experimental carriageways.

![Graph showing proportion of vehicles close following](image)

**Figure 68: Case study 1: Proportion of vehicles close following by location and period of interest**

The proportion of vehicles close following slightly increased across the periods of interest (with a significant p-value ($p < 0.01$) but a small effect size 0.06). However, this change was replicated on both carriageways suggesting that it was unrelated to the incident itself.

Close following by vehicle type is shown in Figure 69.
A significantly higher proportion of cars ($p < 0.01$, with a small effect size of 0.14) were close following than HGVs across all three periods and the increasing trend can be seen for both vehicle types.

**B.2.2 Case study 2**

The second incident took place on 2nd January 2020. Traffic Officers requested the speed restriction reduction for a rolling roadblock to carry out a temporary pothole repair on the southbound (experimental) carriageway. The speed restriction reduction was implemented for just over half an hour from 12:05.

The rolling roadblock was implemented 2.5km downstream of the radar unit and thus no congestion due to the roadblock can be observed within the data presented below.

**B.2.2.1 Comparison of flow**

Figure 70 shows the vehicle flow per minute by lane on the southbound carriageway. The grey area highlights the time period in which the speed restriction signs were reduced from 60 mph to 50 mph.
As expected, due to the location of the roadblock relative to the radar unit, there is no obvious change in vehicle flow during or after the incident took place.

Figure 71 shows the average flow per minute (across all lanes) in each of the periods of interest and compares the changes on the control (northbound) carriageway to those on the experimental (southbound) carriageway, where the incident and speed restriction change took place.
Although there was an increase in average flow across the period, this was replicated on the control carriageway where no speed restriction changes took place. A chi-squared test showed there was no significant difference ($p = 0.60$) detected in the distribution of flow across the three periods between the control and experimental locations.

Figure 72 shows the proportion of vehicles which were HGVs during each of the periods of interest on both carriageways.

![Percentage of HGVs by location and period of interest](image)

**Figure 72: Case study 2: HGV proportion by location and period of interest**

Around 5% of vehicles were HGVs at the experimental location throughout all three periods. A proportion tests shows the minor change across the three periods was not significant ($p = 0.59$).

The distribution of vehicles by lane is shown in Table 18.

<table>
<thead>
<tr>
<th>Period of interest</th>
<th>Vehicle type</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-incident</td>
<td>All vehicles</td>
<td>54%</td>
<td>40%</td>
<td>7%</td>
</tr>
<tr>
<td>Incident</td>
<td>All vehicles</td>
<td>45%</td>
<td>44%</td>
<td>11%</td>
</tr>
<tr>
<td>Post-incident</td>
<td>All vehicles</td>
<td>43%</td>
<td>43%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Across the three periods the proportion of vehicles in Lane 1 decreased, and the proportion in Lane 3 increased. This was likely due to the increases in flow experienced (see Figure 71).
A chi-square test showed that the variation in vehicle distribution between the lanes was significant ($p < 0.01$) but with a very small effect size of 0.06.

**B.2.2.2 Comparison of speed**

Figure 73 shows the average vehicle speed by lane on the southbound carriageway. The grey area highlights the time period in which the speed restriction signs were reduced from 60 mph to 50 mph.

![Average speed per minute by lane](image)

**Figure 73:** Case study 2: Average speed per minute by lane (grey area highlights the time during which the speed restriction was reduced to 50 mph). Experimental location only

There was no obvious change in average speeds as a result of the incident and change in speed restriction. Figure 74 shows the average for each period of interest on both carriageways.
These data shows that very small changes in average speed were observed on both carriageways: in all three periods the average speed was around 50 mph at the experimental location and around 46 mph at the control. A statistical test (ANOVA) confirmed that there was no significant difference in the change in average speed across the three periods between the two carriageways ($p = 0.42$).

Table 19 shows the change in average speed by lane.

**Table 19: Case study 2: Average vehicle speed (mph) by lane and period of interest.**

<table>
<thead>
<tr>
<th>Period of interest</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-incident</td>
<td>46.6</td>
<td>50.8</td>
<td>46.6</td>
</tr>
<tr>
<td>Incident</td>
<td>46.4</td>
<td>50.7</td>
<td>46.4</td>
</tr>
<tr>
<td>Post-incident</td>
<td>46.3</td>
<td>50.4</td>
<td>46.3</td>
</tr>
</tbody>
</table>

Average speeds decreased very slightly in all three lanes across the periods.

Results by vehicle type are shown in Figure 75.
No observable differences in speed for either cars & LGVs or HGVs are evident. Figure 76 shows the proportion of vehicles recorded in each speed bin during the three periods. The grey bars show the proportion of vehicles travelling below the speed restriction; the orange bars show the proportion of vehicles travelling above the speed restriction but below the enforcement threshold (10% of speed restriction +2 mph); and the red bars show vehicles travelling above the enforcement threshold.

These charts indicate that the proportion of vehicles in each speed bin remained largely unchanged over the periods of interest. As a result, due to the speed restriction change over
half (60%) of drivers were driving faster than the speed restriction (50 mph) during the incident itself. Chi-squared tests show the distribution of vehicles across the three categories (below speed restriction, below enforcement threshold and above enforcement threshold) was significantly different ($p < 0.01$, with a small to medium effect size of 0.24) between the three periods.

Figure 77 shows this distribution for cars and LGVs and Figure 78 for HGVs.

As for all vehicles, there was very little change in the distribution of speeds was shown for cars/LGVs. Statistical tests show the car speed distribution across the three categories was significantly different ($p < 0.01$, with a medium effect size of 0.34) between the three periods.

For HGVs, the distribution across the speed bins did appear to change during the speed restriction (incident) period; however, the number of HGVs during this period was very small (44) and hence caution should be taken when interpreting this result. Statistical tests show
the HGV speed distribution was significantly different \( (p < 0.01, \text{ with a small to medium effect size of 0.18}) \) between the three periods.

\[ B.2.2.3 \quad \text{Comparison of close following} \]

The proportion of vehicles close following (defined as being a headway of less than two seconds to the vehicle in front) is shown in Figure 79 on the control and experimental carriageways.

![Figure 79: Case study 2: Proportion of vehicles close following by location and period of interest](image)

The proportion of vehicles close following slightly increased across the periods of interest (with a significant p-value \( (p < 0.01) \) but a small effect size 0.09). However, this change was replicated on both carriageways suggesting that it was unrelated to the incident itself.

Close following by vehicle type is shown in Figure 80.
A significantly higher proportion of cars ($p < 0.01$, with a small to medium effect size of 0.21) were close following than HGVs across all three periods.

### B.2.3 Summary of findings

Case study 1 involved a coach breaking down in Lane 1 within the roadworks on the southbound (experimental) carriageway. The recovery team requested a reduction in the speed restriction from 60 mph to 50 mph in order to clear the scene. The 50 mph speed restriction was in place for 34 minutes.

For case study 2, Traffic Officers requested the speed restriction reduction for a rolling roadblock to carry out a temporary pothole repair on the southbound (experimental) carriageway. The roadblock was implemented 2.5km downstream of the radar so no congestion effect due to the roadblock can be seen in the data.

The results for the two case studies were similar:

- For both incidents, there was a slight increase in average flow across the period studied, but this was replicated on the control carriageway where no speed restriction changes took place.
- For case study 1 the HGV proportion dropped significantly, but this was likely related to the increase in overall flow. For case study 2, no significant change in the vehicle composition was detected.
- There was no significant change in average speeds as a result of the incidents and change in speed restriction. The average speed remained around 50 mph at both locations throughout the period studied.

Figure 80: Case study 2: Proportion of vehicles close following by vehicle type and period of interest. Experimental location only
The proportion of vehicles in each speed bin remained largely unchanged over the periods of interest. As a result, due to the speed restriction change around half of drivers were driving faster than the limit (50 mph) during the incidents themselves. This was especially true for cars and LGVs; HGVs typically travelled slower due to speed restrictions on these vehicles.

For both incidents, the proportion of vehicles close following significantly increased across the periods of interest; however, this change was replicated on both carriageways suggesting that it was unrelated to the incidents.
Appendix C  Lessons learned

To understand the impact of the change in speed restriction on the scheme’s delivery and costs, a lessons-learned meeting was held after the trial had ended. This session sought to capture details on any impacts to the scheme associated with implementing the change in speed restriction. Attendees included: the scheme’s Highways England Assistant Project Manager, Principal Contractor and Traffic Management Supplier. The opportunity was provided for those unable to attend to supply comments by email.

A set of questions and other prompts, including action points identified by the scheme early during trial planning, were used to guide discussions. The key points identified during the meeting are summarised below. They may not reflect the views from all industry stakeholders.

GG104, Departures and TTRO

- For the GG104 process, several iterations looking at different options were considered. It was necessary to find the opportunity of where a 60 mph speed restriction could be used.
- Departure applications followed a standard process.
- The Departures process was a challenge as it is not done in business as usual. Designers might find it easier.
- Although two Departure applications were made, only the departure for barrier setback was used.
- The TTRO application was changed to include both speed restrictions. The application was undertaken early, as it is a lengthy process to change or apply for a new Order.

Planning

- The original plan was to always use a higher specification barrier due to the limited working space.
- Consideration of 60 mph was necessary at an earlier stage, feeding into the traffic management plan.
- The concept at the very beginning was to implement the 60 mph restriction, the challenges were in making it happen.
- Developing the technology was a challenge as it did not exist at the start of the project.
- It took a long time to resolve all the challenges with the use of dynamic speed restrictions.
- The decision-making process took time.
- Confusion existed around what other schemes were doing, decisions made by them may have been different. Weekly update calls with other schemes were beneficial.
- At a senior level there was communication that helped.
- A challenge was to ensure that Highways England procurement was aware of the varying costs of traffic management. However, additional funding was provided to support the trials in both equipment and personnel.
There is a decision tree for dynamically changing the speed restriction, developed for this scheme.

Having a robust procedure allowed the decision makers to be empowered to have the control over the speed restriction.

Police were very vocal about dynamic control of the speed restriction for incident management.

With blue light services, it was only operational police that raised concerns.

The scheme developed a good working relationship with Warwickshire police, which helped the enforcement aspects of the planning process. This engagement was used as a good example for other schemes.

Power supply for speed restriction signs has three levels of redundancy to reduce the likelihood of failure.

There was good testing of technology ahead of time, and again when on-site in location.

There were feelings of confidence that everything was in place for the trial and when it was implemented it was fine.

Access and egress north of the trial location was modified to save usage.

**Implementation**

- Managing the bigger signs within a construction site was a challenge.
- Maintenance of the signs was a problem; more training could be a positive move. Things such as ballast can be important.
- Generally, only maintenance and recovery crews would be working at the national speed restriction, so 60 mph was mainly considered ‘business as usual’.
- Weekly safety discussions were held with the workforce. Concerns about general safety was covered off early, with explanations about why 60 mph was going to be used. A typical challenge received was: “What do you mean you care about safety; you are upping the speed restriction?” Points about investing in safety equipment and dynamic application of speed restrictions were used help resolve those challenges.
- The command and control elements appeared to work without serious challenges – the calling on and off of the signs being implemented to show the dynamic speed setting worked well.
- There were no major issues with the signing, if there were any “glitches” then information was passed on promptly.
- The request for 60 mph working windows was generally well planned, although there were two occasions when the request for a weekend operations log to be set up was requested quite late in the week, so planning might have been earlier (within the trial using all opportunities to run at 60).

**Conclusions on trial**
No incidents were attended by police during trial.

Dynamic control of signs was used twice during the Christmas / New Year embargo period and appeared to work well.

A single recovery took place at 60 mph, operatives appeared to be happy with operating at 60 mph.

A clear process was in place for when the restriction would and would not be used.

Dynamic 60 mph was a positive element for non-working periods.

Equipment used for monitoring did not cause any issues, other than the loss of data for the first weekend. Access to radar units was restricted at certain times due to their locations, but overall it was fine.

The workforce would not have noticed the very small change in working width. No negative feedback from the change in design.

Early concerns that 60 mph on a non-working day would affect the compliance on the following working day did not materialise. There was a plan to utilise more signing if required.

The trial was a relatively short length of works.

There has been no negative impact on the scheme delivery schedule, although there were additional costs for resource and equipment.

Additional measures were introduced in construction meetings to ensure the entire team were aware of what was going on.

Additional resource was required for project management, risk assessment and to support Highway Resource Solutions (HRS). If these things had been considered at the beginning, there would not have been any additional cost.

Being able to monitor power of signs remotely has ensured that maintenance of signs has been minimal once signs are set up. Signs have not been designed to be moved and all signs within roadworks will need to be moved at some point.

It is expected that safety of customers on non-working days is probably better than before and satisfaction likely to be better.

Engagement with all stakeholders and the overall group’s attitude has been very positive from those involved within the scheme.

Scheme specific control room staff have not raised any concerns and were happy to take on the additional role.

Future schemes

There is an open mind on implementing 60 mph during working periods, but evidence needs to be collected.

The main issue appears to be with site access and egress, especially from centre reservation works, due to potential higher speed of passing traffic and the narrower offside lane adjacent to works.
Has information on access and egress within 50 mph restrictions been baselined?

Lack of harmonisation of scheme planning within the Smart Motorways Alliance construction process could cause challenges. Creating a harmonised process could simplify planning (barriers, signs, etc.) for future smart motorway conversions.

Could the dynamic restriction be used daily to manage work periods rather than daily?

Placing all signs away from the workforce (for instance, on a single side of the carriageway rather than staggered as is currently required) would mitigate the problems with moving signs to facilitate works activities.

More visibility across a group of projects would be useful. For this trial, there was a lack of visibility, which is likely going to happen increasingly in the future.

Smart motorway technology used within a road works environment.
Appendix D  Ipsos customer audits

Highways England

Customer Audits – Speed Trials – M6 2-4

Top Line Results

January 2020
Contents

- Introduction & Methodology
- Results
- Conclusions & Recommendations
Report for the on-road trials of 60 mph on the M6 junction 2-4

**Research Methodology**

**Schemes**
Customer Audits conducted across the following schemes:

- M6 J2-4 over August 2019 to January 2020
- Highways England have been trialling a new 60mph speed limits whilst going through the M6 J2-4 scheme.
- Auditors were specifically briefed to undertake the usual customer audit but also look out for/observe the speed limit and provide their perception on the limits.

**Measurement**
Scheme audits assessing:

- The auditors perception of the 50mph/60mph speed limit that was in place.
- The audits were split evenly to gain an understanding of a customer’s perception of both speed limits.

**Sample Base**
M6 J2-4 n=33
50mph Tests n=18
60mph Tests n=15
(7 visits were unable to be completed within the timeframes for the 50/60mph tests)

This work was carried out in accordance with the requirements of the international quality standard for market research, ISO 20252 and with the Ipsos MORI Terms and Conditions.
Results
The 50mph tests were seen as more appropriate for the conditions

Did you feel the speed limit in place was appropriate for the conditions?

**50 MPH**

<table>
<thead>
<tr>
<th>% Yes</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>89%</td>
<td>18</td>
</tr>
</tbody>
</table>

“The motorway was free flowing at the time of my journey with only a light to medium amount of traffic. Maintaining the 50mph speed limit was not easy as not only was the motorway fairly light of traffic, there was a long downhill section heading towards Jct 4 and 50mph just felt too slow.”

**60 MPH**

<table>
<thead>
<tr>
<th>% Yes</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>73%</td>
<td>15</td>
</tr>
</tbody>
</table>

“(I didn’t feel it was appropriate) As there were no workers present and there were cones placed on the side of the motorway, the road had 3 clear lanes to use for the majority of the time.”
In addition, the signage was easy to see

Was the signage displaying the speed limit easy to see?

50 MPH

% Yes

100%

"The signage was immediate; whilst waiting to join the slip road from the island at Jct 2 there were clear signs showing the 50mph zone and roadworks were taking place in the carriageway."

Base: n=18

60 MPH

% Yes

100%

"The signage was easy to see there was a sign one side of the carriageway and then a short distance later a sign the other side of the carriageway."

Base: n=15
The higher speed limit felt as safe as the lower limit, but traffic effected the average speed of the tests.

Did you feel safe travelling at the speed limit through the scheme?

50 MPH

% Yes

100%

Average speed recorded by the auditor = 45 mph

60 MPH

% Yes

100%

Average speed recorded by the auditor = 50 mph

Base: n=18

The average speed was provided by the auditors verbatim based on what they recorded during the journey.

Base: n=15
The auditors felt that the 60mph limits were too slow at times of very low traffic.

**Did you think the speed limit was too high / too low / about right?**

<table>
<thead>
<tr>
<th>Speed Limit</th>
<th>% About Right</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 MPH</td>
<td>11%</td>
<td>89% stated the speed limit was too slow</td>
</tr>
<tr>
<td>60 MPH</td>
<td>27%</td>
<td>73% stated the speed limit was too slow</td>
</tr>
</tbody>
</table>

“I was over taken by a lot of traffic while driving this stretch of road.”
Base: n=18

Where the scheme was mentioned for being too slow it was due to very low levels of traffic.
Base: n=15
Both limits were seen positively overall. Where dissatisfaction occurred on the 60mph journeys it was due to very low traffic. This made drivers feel they could go faster...

How satisfied were they with the speed limit?

**50 MPH**

- Very Satisfied: 67%
- Satisfied: 28%
- Neither Satisfied: 6%
- Dissatisfied: 0%
- Very Dissatisfied: 0%

“I think it (50mph) is about right to ensure safety although not everyone kept to it.”

**60 MPH**

- Very Satisfied: 53%
- Satisfied: 27%
- Neither Satisfied: 13%
- Dissatisfied: 7%
- Very Dissatisfied: 0%

“I think electronic temporary signs should be in place instead of the static signs. This would keep the traffic moving at a safe speed and reduce speed when workers are present. Being electronic they could also be linked to networks for updates etc.

This would allow the workers to change the speed limit when they start and finish shift.”
Recommendations & Conclusions
Recommendations & Conclusions

When traffic levels are low, everyone wants to go through the scheme quicker...

The 60mph tests saw on occasion very few road users on the scheme. This made them feel that even the 60mph limit was not higher enough. However, regardless to this signage was clear and easy to see and everybody felt safe at both speeds.

Some 50mph users noted that they were being overtaken a lot

Whilst everyone did feel safe, the 50mph journeys saw auditors mentioning they were being overtaken a lot (and undertaken in some cases). Many cars were not adhering to the limit. The results did not report this as a safety issue but should be considered when reviewing the results as it could cause accidents.
The purpose of this trial was to understand the impact of changing the speed restriction within the M6 2-4 scheme from 50 mph to 60 mph on driver behaviour, customer satisfaction and the scheme’s cost and delivery. The findings from this investigation will be used, along with other investigations, to inform the development of guidance material for future road works design.

The investigation involved monitoring of data from ‘control’ and ‘experimental’ locations, positioned within the road works scheme. Several different data sources were used for both locations across a ‘baseline period’ (when both locations were subject to a 50 mph speed restriction) and a ‘trial period’ (when the control location was subject to a 50 mph speed restriction and the experimental location was subject to a 60 mph speed restriction). These data sources included roadside radar data, scheme incident logs, and online surveys from both customers and the scheme workforce. Feedback from the workforce was also gathered during workshops with scheme representatives.

The change in speed restriction resulted in increased average speeds, reduced average journey times and reductions in the proportion of drivers travelling over the speed restriction. Little impact on drivers’ self-reported levels of satisfaction was identified. Further findings are detailed within the report.