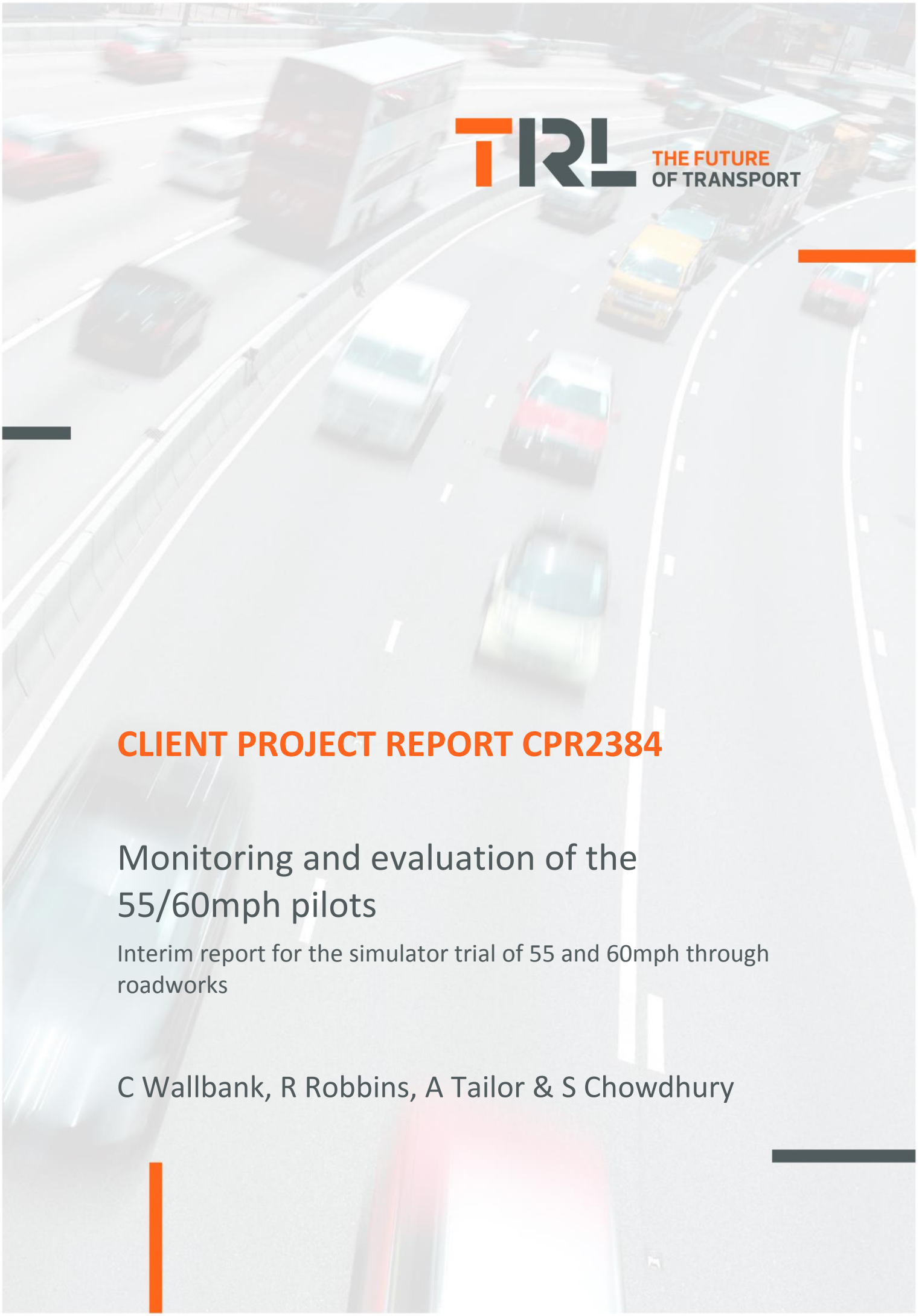

THE FUTURE OF TRANSPORT

CLIENT PROJECT REPORT CPR2384

Monitoring and evaluation of the 55/60mph pilots

Interim report for the simulator trial of 55 and 60mph through roadworks

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Executive Summary

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

A speed limit of 55mph is not currently used on the network and thus there is no evidence regarding how this speed limit might affect driver behaviour, perceptions or performance, in particular in the vicinity of roadworks. Similarly, current guidance (Department for Transport, 2009) specifies that the minimum speed limit reduction appropriate at roadworks would be -20mph, meaning that 60mph speed limits are relatively uncommon at roadworks compared to 50mph. As a result, a driving simulator study was required to understand the likely impact of these alternative speed limits on safety and customer satisfaction.

TRL's advanced driving simulator (DigiCar) was used to compare driver behaviour and subjective impressions of safety and satisfaction between four different drives which displayed a single speed limit throughout the roadworks (50mph, 55mph, 60mph or 70mph), and an additional four drives with a single change of speed limit (step) within the works.

Thirty-six drivers participated in the simulator trial. The 60mph limit was perceived favourably, scoring significantly higher for journey satisfaction than the current 50mph speed limit typically used at roadworks. On average, drivers' chosen speeds were just below the speed limit (57-58mph) and headway was slightly longer than in the 50mph speed limit. When asked what speed they would prefer to see in roadworks, the most popular answer (given by over 30% of respondents) was 60mph. The current 50mph speed limit was also popular (22%), whilst some participants suggested that the speed limit should change depending on the conditions.

The 55mph speed limit was not as popular (satisfaction scores were not statistically different from the rating for the current 50mph limit) and some participants reported finding it difficult to maintain their speed in this condition. In particular, a few drivers reported that the unmarked position of 55mph on the speedometer caused them to spend more time looking away from the road, suggesting that there may be a concern with driver distraction. There was some evidence that headway was slightly more variable at this speed than in the other single speed limit conditions. Increased headway variability could suggest greater cognitive load, possibly due to the novelty of the 55mph speed limit, or increased visual demand when looking at the speedometer in this condition. However, workload and visual distraction were not measured directly in this study, so further work is required to fully understand the impact of the 55mph speed limit on these phenomena.

For the drives with a change in speed limit, in general, participants did notice the change and adjust their speeds accordingly. However, for a small number of drivers there was a delay between passing the gateway signs and adjusting their speed, suggesting that they may have initially missed the change in speed limit. Generally steps up in speed were perceived more positively than steps down.

1 Introduction

1.1 Background

Safety and customer satisfaction are Key Performance Indicators and critical components of Highways England's vision for the future. As part of this vision, Highways England is committed to improving the customer satisfaction at roadworks, maximising safety (for both road users and road workers) and minimising disruption caused by roadworks schemes.

One potential measure to achieve improvements in customer satisfaction at roadworks is challenging the approach to speed management that is usually applied at major schemes. This approach usually results in applying a 50mph speed limit throughout the entire roadworks scheme, which has an adverse impact on customer satisfaction scores. This requires monitoring and evaluation of the safety and customer satisfaction (and operational challenges) associated with raising the speed limit through roadworks to 55mph or 60mph.

A speed limit of 55mph is not currently used on the Strategic Road Network (SRN) and so there is no evidence regarding how this speed limit might affect driver behaviour, perceptions or performance, in particular in the vicinity of roadworks. Similarly, current guidance (Department for Transport, 2009) specifies that the minimum speed limit reduction appropriate at roadworks would be -20mph[1], leading to a speed limit of 50mph; as a result, 60mph speed limits are relatively uncommon at roadworks. In order to provide an understanding of driver behaviour at these alternative speed limits (55mph and 60mph), driver performance was evaluated in a driving simulator, where the effects of the new speed limit can be tested in a safe, reproducible, cost-effective and scientifically valid environment.

The purpose of this Work Package (Work Package 1, or WP1) was to conduct a simulator study to obtain safety evidence for Highways England regarding any future increase in the speed limit and demonstrate any effect of such a change on customer satisfaction at roadworks on motorways.

This simulator study compared driver behaviour between four different drives[2], each presenting a single speed limit throughout the roadworks (Scenario A: 50mph, 55mph, 60mph or 70mph), and also examined how drivers responded to a second scenario (Scenario B, presented via an additional four drives) where a single change of speed limit (*step*) was present within the roadworks.

This study used a simulated four-lane all lane running (ALR) Smart Motorway, with major scheme roadworks closing Lane 1 after the first 4.9km of the route.

[1] Table 3.5 in paragraph D3.7.26 shows the recommended appropriate speed reduction to limit the risks associated with specific traffic management features on high speed roads. 20mph is the recommended speed reduction if there are narrow lanes, lane restrictions in traffic other than light flow and when the hard shoulder is being used as a running lane.

[2] The term 'drive' in this context refers to driving a single route in the simulator from beginning to end.

1.2 Research questions addressed in this report

The main research questions for this simulator trial were:

1. How does driver behaviour (e.g. speed choice, lane position) change in response to:
    a. a single speed limit throughout the works (Scenario A)?
    b. changes in the speed limit within roadworks (Scenario B)?
2. How are driver subjective impressions (e.g. feelings of safety) affected by:
    a. a single speed limit throughout the works (Scenario A)?
    b. changes in the speed limit within roadworks (Scenario B)?

This report outlines the work undertaken to answer these research questions, presenting the simulator trial methodology (Section 2), the findings related to driver behaviour (Section 3), results from the questionnaire (Section 4) and conclusions and next steps from these findings (Section 5).

2 Method

All participants drove eight separate drives (four per scenario of fixed speed limit and single change (step) speed limit) in a repeated measures (or within-participants) design.

Participants were asked to complete a short questionnaire to understand how feelings of safety and satisfaction (amongst other measures) changed across each drive.

2.1 Participant sample

The participant sample was drawn from TRL's participant database, which includes over 2,500 drivers throughout Berkshire, Surrey and Hampshire. Thirty-six people[3] took part in the trial (17 males and 19 females).

Figure 1 show participants' age compared with those of the population of full car (Category B) driving licence holders in Great Britain in March 2016 (data.gov.uk, 2016).

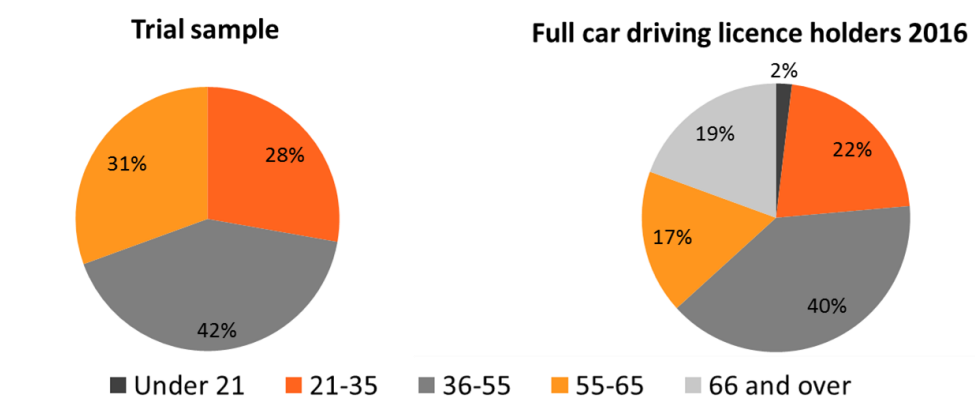

Figure 1: Comparison of the age distribution of the trial sample and full car driving licence holders in Great Britain 2016

The percentage of 21 to 35 year olds and 36 to 55 years olds were comparable between the trial sample and the population of licence holders. Licence holders aged from 56 to 65 appear to be overrepresented in the sample, with licence holders aged 66 and over underrepresented. However, older drivers tend not to drive as often (GB licence data is not necessarily the most representative source of data relating to drivers on the road) and, in addition, this group are also at greater risk of simulator sickness so participants tend not to be recruited from this older group.

Figure 2 shows how the average annual mileage for the trial sample compares to the average annual mileage for 4-wheeled cars in England in 2015 (Department for Transport, 2016).

[3] This sample size was selected to be appropriate based on experience of similar trials in the past.

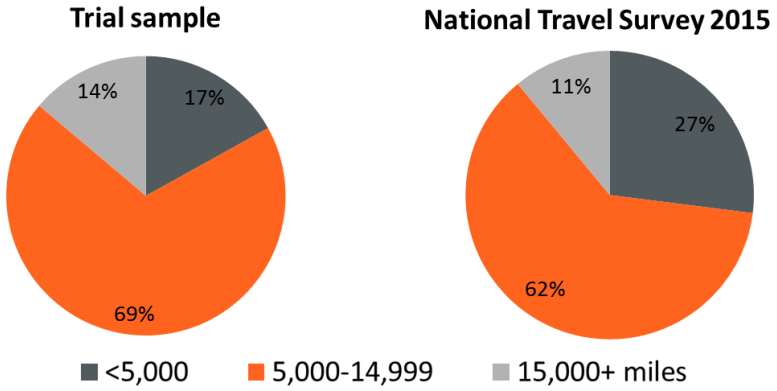

Figure 2: Comparison of the average annual mileage of the trial sample and the figures reported in the National Travel Survey for England in 2015

This figure shows that the average annual mileage of the sample is similar to that of the population. Based on these comparisons, there is a good level of confidence that this sample is reflective of the general driving population.

On average, participants have held a driving licence for 24.2 years (with a standard deviation of 13.2).

The majority of participants reported driving on motorways at least once week (Figure 3).

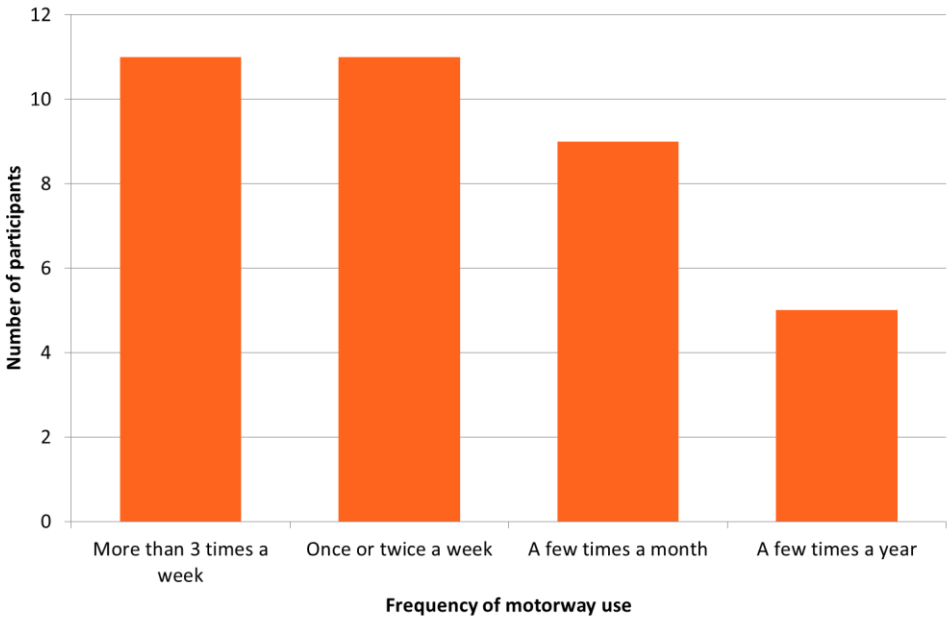

Figure 3: Reported frequency of motorway use

Despite being asked at the recruitment stage to verify that they drove on motorways at least once or twice a month, five participants reported only driving on them a few times a year. Nevertheless, it is still possible to be confident that all participants had experience of driving on motorways.

2.2 Route layout

Both scenarios were implemented in a Smart Motorway ALR environment. In both cases, the simulated Smart Motorway environment was not 'fully operational'; instead, the route was simulated to be within the 'Operational Regime Testing' phase of development[4]. Therefore, traffic management (TM) was present and the variable signs and signals (VSS) were blank. As a result, the speed limits were displayed on ground level fixed-plate signs.

The total length of the route was 22.7km. In Scenario A (fixed speed limit) this comprised of a 3.3km 'approach' section, followed by a 1.6km 'lead-in' section (marking the section between the 'roadworks 1 mile ahead' static traffic sign and the end of the entry taper), a 14.5km 'work zone' (where Lane 1 is coned off and a speed limit is in place), and a 1.6km 'end' section beyond the end of the lane closure (see Figure 4).

Figure 4: Diagram of layout for Scenario A

A similar layout was used for Scenario B (stepped speed limits). In this case, the work zone was split into two 7.2km sections and the speed limit changed at the transitionary point between these two sections (see Figure 5).

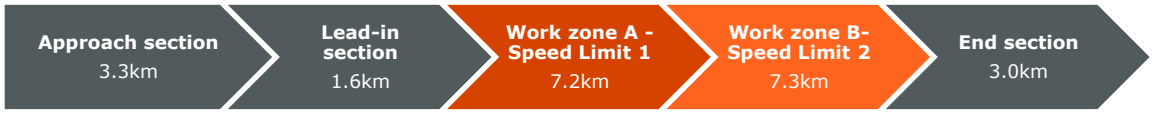

Figure 5: Diagram of layout for Scenario B

The 3.3km approach and 1.6km end sections were included firstly to ensure participants experience the minimum distance between roadworks given in the Traffic Signs Manual (TSM) Chapter 8. The minimum distance between roadworks when either scheme is a standard scheme is 10km, which equates to approximately six minutes of driving time at 60mph. Participants experienced at least six minutes between each set of works, due to the length of the approach and end zones and the time taken to load the next drive. Secondly, including the approach section ensured that there was sufficient time for participant behaviour in the simulator to normalise before encountering the lane closure.

Each drive took approximately 15 minutes to drive at an average of 60mph, with drives at 55mph and 50mph being slightly longer. The drives all took place under daytime conditions.

[4] See IAN 182/14 for a full description of this phase.

2.2.1 Temporary traffic management

All temporary traffic management (TTM) was configured to comply with TSM Chapter 8 layouts for standard works. The simulated TTM was set out to close Lane 1 and leave three open lanes throughout the closure; this allows participants to choose which lane they prefer to use.

A map of the TTM layout used in the simulator trials can be seen in Appendix A.

2.2.2 Speed limits

Four different speed limits were tested during Scenario A: 50mph, 55mph, 60mph and 70mph. These speed limits can be seen in Table 1.

Table 1: Speed limit in each section of the route, for each drive in Scenario A

Drive	Approach	Taper lead-in	Work zone	End section	Step in speed
1	70	50	50	70	None
2	70	55	55	70	None
3	70	60	60	70	None
4	70	70	70	70	None

The four drives in Scenario B each included a single 'step' in the speed limit. These were either an increase in the speed limit (in two cases) or a reduction in the speed limit (in the other two cases). This is shown in Table 2.

Table 2: Speed limit in each section of the route, for each drive in Scenario B

Drive	Approach	Taper lead-in	Work zone A	Work zone B	End section	Step in speed
5	70	50	50	55	70	Up
6	70	50	50	60	70	Up
7	70	60	60	55	70	Down
8	70	60	60	50	70	Down

2.2.3 Enforcement

The simulated roadworks sections included average speed cameras and the associated signs to simulate speed enforcement. This replicated, as far as possible, the conditions typically experienced when driving through long-term roadworks on the Highways England Strategic Road Network.

Separate 'enforcement' was required for each speed limit in Scenario B. This was achieved by including four average speed cameras within the simulation environment used for each drive; one pair were situated at the beginning and end of work zone A and another at the

beginning and end of work zone B (see Appendix A). In Scenario A (where there was no change in speed limit) there were also four cameras in order to avoid the number of cameras present being a confounding factor in the data collected.

2.2.4 Simulated traffic

Within the simulation, traffic was designed to behave in a realistic manner to ensure that the behaviours observed in the driving simulator can be generalised to real roads. The vehicles within the simulator were controlled by an Artificial Intelligence (AI) 'engine' which was carefully programmed using three parameters: traffic volume, speed, and lane merge behaviour.

A low traffic volume (approximately 600 vehicles/hour/open lane) was selected to ensure that conditions were free-flowing, so that participants could drive at their preferred speed.

The traffic was programmed to behave similarly to traffic on real roads with differentials in speeds between vehicles and lanes to ensure naturalistic traffic flow. Vehicles were not permitted to undertake other vehicles; therefore average speeds observed in each lane increased from the nearside to the offside lanes. Table 3 and Table 4 show the maximum speed permitted for AI vehicles in each lane for each section of the route in Scenario A and Scenario B respectively.

Table 3: AI vehicle maximum permitted speeds by lane and section of the route for each drive in Scenario A

Drive	Lane	Approach	Taper lead-in	Work zone	End section
1	1	70	52	-	70
	2	70	52	52	70
	3	75	55	55	75
	4	80	58	58	80
2	1	70	57	-	70
	2	70	57	57	70
	3	75	60	60	75
	4	80	63	63	80
3	1	70	60	-	70
	2	70	60	60	70
	3	75	66	66	75
	4	80	69	69	80
4	1	70	70	-	70
	2	70	70	70	70
	3	75	75	75	75
	4	80	80	80	80

Table 4: AI vehicle maximum permitted speeds by lane and section of the route for each drive in Scenario B

Drive	Lane	Approach	Taper lead-in	Work zone A	Work zone B	End section
5	1	70	52	-	-	70
	2	70	52	52	57	70
	3	75	55	55	60	75
	4	80	58	58	63	80
6	1	70	57	-	-	70
	2	70	57	52	60	70
	3	75	60	55	66	75
	4	80	63	58	69	80
7	1	70	60	-	-	70
	2	70	60	60	57	70
	3	75	66	66	60	75
	4	80	69	69	63	80
8	1	70	70	-	-	70
	2	70	70	60	52	70
	3	75	75	66	55	75
	4	80	80	69	58	80

On approach to the works (and at the end of the works), the maximum speed in Lanes 1 and 2 matched the posted speed limit (i.e. 70mph), with each additional open lane being subject to a limit 5mph higher than the previous lane.

Through the taper lead-in, work zone A and work zone B the speeds were reduced from the normal traffic speed in line with the speed limit shown. For example, when the speed limit was 60mph the maximum speed of vehicles in Lane 2 was 60mph, in Lane 3 it was 66mph (i.e. speed limit + 10%) and in Lane 4 it was 69mph (i.e. speed limit + 10% + 2mph). These speeds were chosen to represent speeds which were at or below the level at which the speed limit would be enforced.

Different vehicle types were also configured to have different maximum speeds. For example, when in a 50mph speed limit, the majority of the HGVs were subject to a maximum speed of 57mph (a few HGVs had speeds lower than this to simulate compliant drivers and/or variability in tachograph calibration). In a 55, 60 or 70mph speed limit the maximum speed of HGVs was set to 63mph. These figures were chosen to replicate the perceived behaviour of HGVs on road which are thought to travel at or just below the enforcement threshold (57mph) in a 50mph speed limit, but on their speed limiter (approximately 63mph) when the speed limit is increased to 60mph. Cars were subject to the maximum speed limit defined by the lane occupied (defined in Table 3). As a result of these differences in vehicle speeds, when the HGV had a maximum speed greater than the maximum lane speed it moved into the lane to the right (except in the case of Lane 4 where no HGVs are present). If there was a car ahead of the HGV travelling slower, this car moved into the lane to the left to let the HGV overtake.

Maximum speeds did not apply to the participant's vehicle. Traffic in Lane 4 was programmed to move naturally into Lane 3 if the participant's vehicle approached; this ensured that the participant was free to drive at whatever speed they choose when travelling in Lane 4, and speed choice was not affected by other traffic.

Lane merge behaviour of the AI vehicles at the taper was programmed to be as realistic as possible. The distance at which this occurred was based on data collected on real roads as part of the on-road trial programme carried out by TRL.

2.3 Trial procedure and data collection

The order in which participants completed the drives was counterbalanced to reduce any effects on participants' behaviour of the order of presentation of the experimental conditions.

Two types of data were collected from the trials: driver behaviour data recorded by the simulator and questionnaire data. The simulator collects a wide range of driver behaviour data, measuring each value twenty times per second (i.e. 20Hz). This allows detailed analysis of:

- Speed on the approach to and through the roadworks
- Lane choices
- Headway
- Variation of position within a lane

The questionnaire (see Appendix B) was split into four sections (A-D). Section A asked demographic questions to obtain information on age, gender and driving experience. After each drive, participants completed Section B of the questionnaire which explored their experiences and subjective impressions including:

- Their understanding of the speed limit
- Subjective perceptions of safety, comfort and ease
- Understanding of enforcement measures

After their final drive finished, participants completed Section C which allowed them to give information on preferences and opinions on speed limits and speed enforcement, and Section D to give opportunity to provide general comments and feedback on the trial.

2.4 Data analysis

2.4.1 Simulator data processing

The raw 20Hz simulator data were processed to summarise the data from each section (approach, taper, work zone A, work zone B and end) of each of the eight drives for all 36 participants.

The following reporting variables were calculated:

- Average speed (measured in mph)
- Standard deviation of speed
- Average headway (measured in metres)
- Standard deviation of headway
- Average of lateral lane position (measured in metres with an average lateral lane position of 1.8m representing someone who remains in the centre of the 3.6m lanes for the majority of the drive)
- Standard deviation of lateral lane position
- Proportion of time spent in each of the four lanes
- Collision involvement (Yes or No)
- Proportion of time spent above the speed limit
- Proportion of time spent above the enforcement guideline limit (speed limit + 10% + 2mph[5])

In addition, specific points in the drive were studied to monitor:

- For drives in Scenario B where the speed limit changed:
    - The distance after the change in speed limit at which the speed of the participant first reduced (or increased, depending on the condition).
    - This distance was defined as the first point at which the speed reached the average speed for the whole of work zone B for that participant.
- Changes in speed around the average speed camera:
    - Spot speed measurements were taken every 25m from 100m upstream of the camera to 100m downstream in order to monitor the speed profile of drivers around the cameras.

2.4.2 Simulator data analysis method

The data collected from TRL's driving simulator, DigiSim, was analysed using two-way repeated measures[6] analysis of variance (ANOVA) which tests for a significant difference in the mean response for each of the eight conditions (or drives) and two sections (work zones

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

[6] A 'repeated measures' or 'within participants' design is required since participants completed each of the eight drives.

A and B) and the interaction between conditions and sections. The assumptions of ANOVA were tested prior to commencing the analysis, and it was concluded that the data were approximately normally distributed so analysis could proceed.

If the interaction between drives and sections was significant, the ANOVA was repeated for work zone A and B separately with post-hoc tests[9] in order to determine which drives differed significantly from each other. Throughout the analysis, results were considered significant if the p-value[7] was less than 0.05, a typical standard in the behavioural literature.

2.4.3 Questionnaire data analysis method

Similarly to the simulator data, the quantitative questionnaire data was analysed using one-way repeated measures[8] ANOVA, which tests for a significant difference in the mean response for each of the eight conditions (drives). If the data were not normally distributed then these were transformed before applying the tests. Post-hoc tests[9] were performed on the significant results.

For the qualitative questions, the key themes were identified and responses were grouped according to these themes. Throughout the analysis (Section 4), quotes from participants are used to support the findings.

[7] A p-value <0.05 indicates that there is a 95% chance that the comparison being made has arisen due to the variable under investigation, and not simply random fluctuations ('noise') in the data.

[8] A 'repeated measures' or 'within participants' design is required since participants completed the same questions for each drive.

[9] These tests test for a difference between each pairwise combination. The Bonferroni correction is applied to these tests to control for the effect of multiple comparisons.

3 Simulator data results

This section presents the results of the analysis of data collected using TRL's driving simulator. A number of key measures are presented including:

- Average speed (Section 3.2),
- Proportion of time speeding (Section 3.3),
- Headway (Section 3.4),
- Lane choice (Section 3.5),
- Lateral lane position (Section 3.6),
- The number of collisions (Section 3.7),
- Driver behaviour following the change of speed limit (Section 3.8)
- Driver behaviour in the vicinity of the average speed cameras (Section 3.9)

These results are summarised in Section 3.10.

3.1 Overall drive

Prior to considering the key parts of each drive (specifically, roadworks zones A and B), this section gives an overview of how participants approached and drove through the different conditions. Figure 6 shows how the average speeds (in mph) for the 36 participants varied across each of the eight different drives.

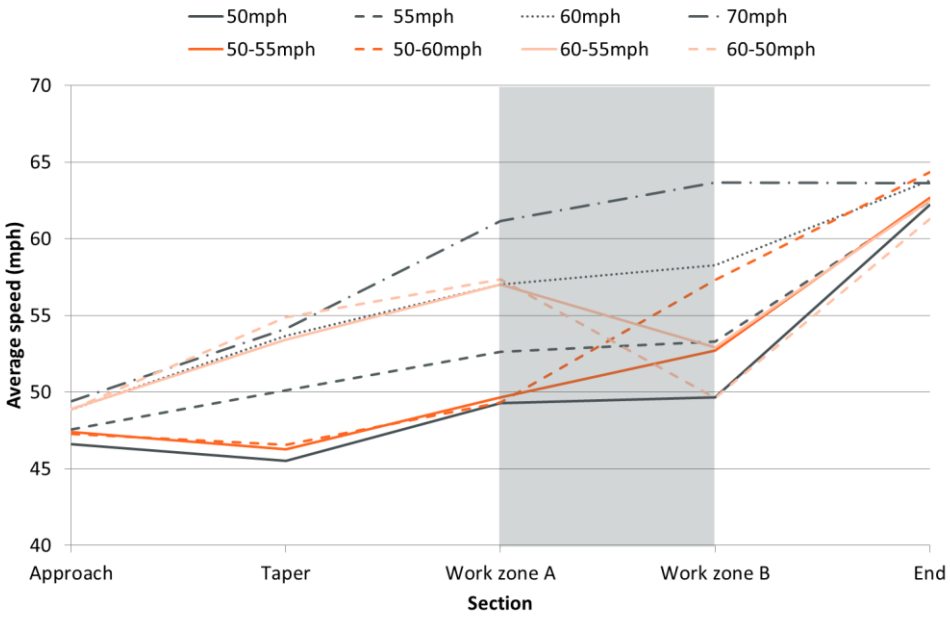

Figure 6: Average speed (in mph) per drive and section

The area shaded in grey in the diagram indicates where the main roadworks are in place. The changes in speed seen in these four drives between work zone A and B align with the changes in speed limit.

Approach section

Within the eight drives, on average across the 36 participants, the speed in the approach section was between 46mph and 50mph. However, this figure was highly variable suggesting that some participants chose to travel, on average, much faster than this, whilst others chose to travel much slower. This section was right at the beginning of the drive and incorporated the time taken by drivers to start the car, begin driving and accelerate to their preferred speed. As a result, although this average was much lower than the speed limit for this section (national speed limit, 70mph), this is not unusual, neither is the high variability in this figure.

Taper section

By the time participants reach the taper they will have seen the first of the speed limit restriction signs. However, at this point, speed is still likely to be unrepresentative of the speed at which they will choose to travel through the works, as they will be negotiating other vehicles as they move out of the closed lane 1 into lanes 2, 3 and 4. Participants may also be carrying out lane change manoeuvres themselves. Average speeds during this section vary considerably less than in the approach zone.

Work zones section

There are differences in the average speeds seen in work zone A and B through each of the drives; these are broadly in line with what was expected with faster average speeds in the conditions with higher speed limits and reductions/increases in speed within the stepped speed limit conditions. The average speeds in work zones A and B will be discussed in detail in the next part of this report (Section 3.2).

End section

Within the end section of the drive, the average speed was between 62mph and 64mph. However, there was large variation in this between participants. This suggests that, having exited the roadworks into the national speed limit, participants take varying amounts of time to accelerate to their new preferred speed.

The area of interest for this research is driver behaviour and understanding of the speed limits during the roadworks itself. As a result, the remainder of this report focuses on driver behaviours in work zones A and B (the area shaded in grey in Figure 6).

3.2 Average speed

Figure 7 shows how the average speed varies in work zones A and B by condition.

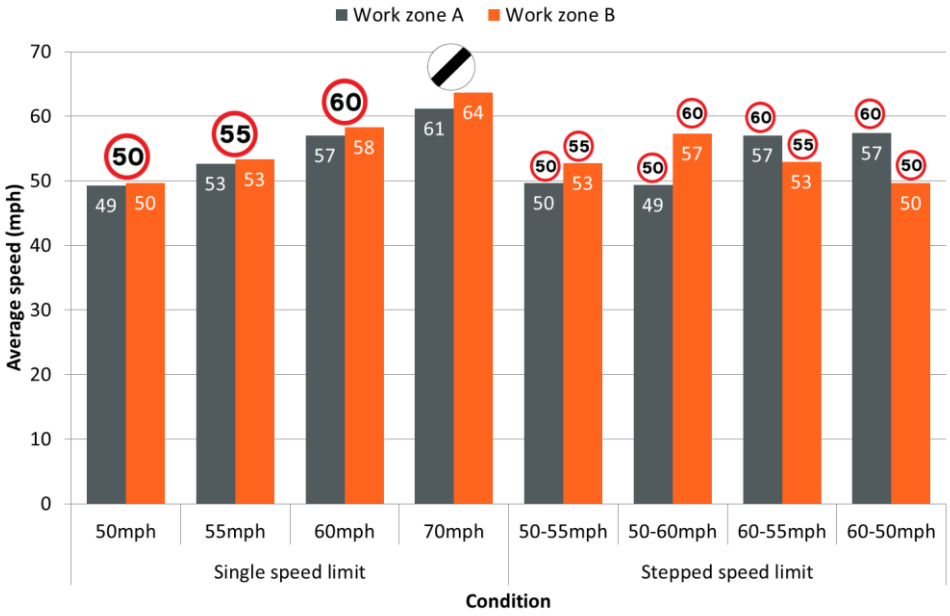

Figure 7: Average speed (in mph) in work zones A and B by condition

On average, drivers travelled at or below the speed limit for the section of roadworks in which they were travelling.

For the single speed limit conditions, the average speeds tended to increase slightly in the second half of the roadworks, suggesting that the driver's tendency was to speed up slightly to get through the roadworks faster.

The average speeds in the stepped speed limit condition suggest that, in general, drivers adjusted their speed up or down in line with the change in speed limit. For the two conditions with a 5mph change in speed limit, the average speed typically increased or decreased by 3-4mph. For the two conditions with a 10mph change in speed limit, the average speed typically changed by around 7-8mph. This suggests that drivers observed the change in speed limit, but did not always speed up or slow down by the full amount allowed by the difference between the two speed limits.

For each participant, the variability in speed within each section was also measured. On average, within work zone A in the single speed limit conditions, the speed was most variable in the 70mph condition and least variable when the speed limit was 50mph. The amount of variability in speed decreased from work zone A to work zone B, suggesting that drivers became used to the driving task. This decrease was smallest in the 55mph condition, which may suggest that the reduction in cognitive load as the speed limit became familiar to the driver was smaller for some drivers at this speed limit.

A two-way repeated measures ANOVA was conducted to test whether there were significant differences in average speed across the eight conditions and two sections (work

zones A and B). The analysis[10] showed that the average speeds were significantly different between conditions (F = 146.18, p < 0.001, partial Eta squared = 0.97) and sections (F = 11.92, p < 0.001, partial Eta squared = 0.26). The interaction between conditions and sections was also significant (F = 112.7, p < 0.001, partial Eta squared = 0.96). The partial Eta squared values suggest that the condition (or drive) explains the majority of the variation in average speed, implying that the change in speed limit was the dominant factor in the average speeds observed. In order to understand the interaction between conditions and sections, the ANOVA was repeated for work zones A and B separately. Both tests were significant.

Post-hoc tests for work zone A show that the average speeds were significantly different in all drives expect for those with the same speed limit: drives one, five and six (all of which had a speed limit of 50mph) and drives three, seven and eight (all of which had a speed limit of 60mph).

Similarly, for work zone B, post hoc tests showed that all the drives were significantly different from each other except for those with the same speed limit: drives one and eight (with a 50mph speed limit); drives two, five and seven (with a 55mph limit); and drives three and six (with a 60mph limit).

3.3 Proportion of time speeding

Participants speed was recorded every 20Hz during each drive. These data were used to count the number of times the speed was recorded as being over the speed limit (or over the enforcement limit, based on the 'speed limit + 10% + 2mph' guidelines) for each participant. This was converted to a percentage and then averaged over all 36 participants to give the average proportion of time spent travelling about the speed limit in Figure 8.

Note that this measure is quite coarse; if participants are aiming to drive at exactly the speed limit, there will inevitably be periods in time when they travel just below the speed limit and other periods of time where they travel just above the speed limit. These latter periods of time will have been counted in the figure below.

[10] One participant was excluded from the analysis as their average speed was much lower than the other participants (and was consistently low across drives). Outliers such as this can have a big influence on the results so it is recommended that they are removed prior to performing statistical tests.

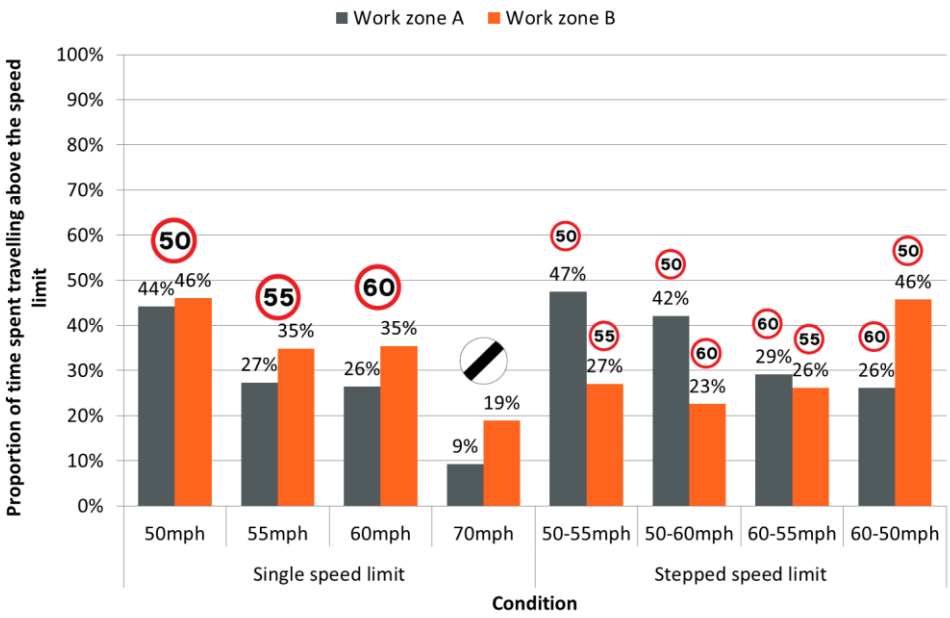

Figure 8: Proportion of time spent travelling above the speed limit in work zones A and B by condition

Overall, the proportion of time above the speed limit was highest (on average around 42-47%) when the speed limit was 50mph and lowest (on average around 9-19%) when the speed limit was 70mph. In the 55mph and 60mph limits, the proportions were similar (on average around 23-35%). This suggests that at the lower speed limits more participants are aiming to travel at exactly the speed limit, whilst in the national speed limit condition more drivers are happy to maintain a speed below the 70mph limit (resulting in a smaller proportion of time, on average, at which they travel faster than this).

For the single speed limit conditions, on average, participants drove over the speed limit for a greater proportion of time in work zone B than in work zone A, despite the speed limits not changing. This aligns with the findings from Figure 7 which show that drivers tend to speed up through the works.

Within the stepped-up speed limit drives, the proportion of time above the speed limit was similar to the corresponding speed limits in the single speed limit conditions. This suggests that for each speed limit there is a particular speed at which participants are aiming to maintain and suggests that (assuming the natural deviation in speed is comparable) this speed is closer to the speed limit in the 50mph limit than in the 55mph or 60mph limits. This also starts to suggest that higher speed limits are perhaps viewed as more credible than lower speed limits in the environment trialled (leading to better inherent compliance).

In addition to the proportion of time spent over the speed limit, the proportion of time spent over the enforcement threshold (speed limit + 10% + 2mph) was also investigated (Figure 9).

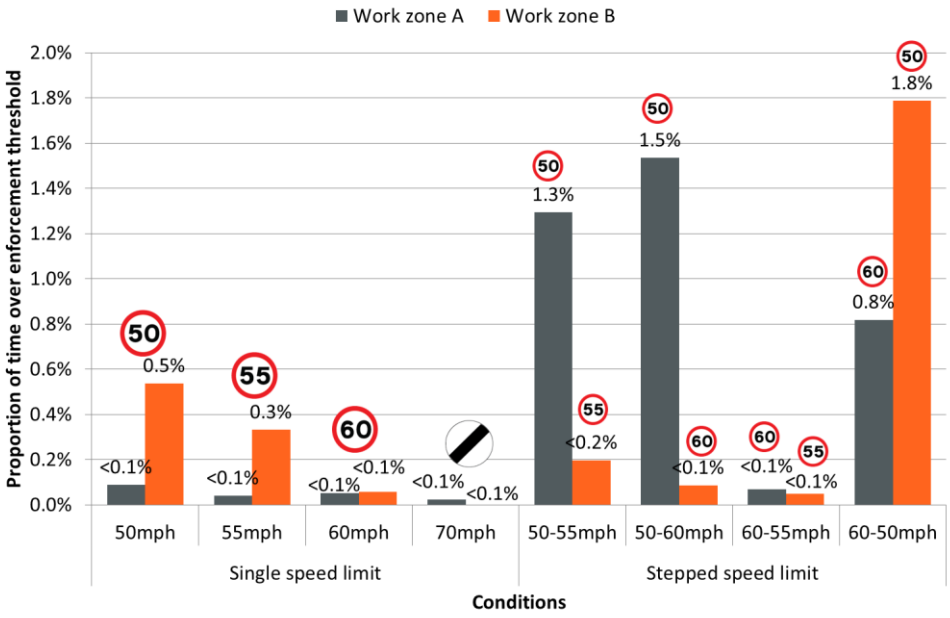

Figure 9: Proportion of time spent travelling over the enforcement threshold in work zones A and B by condition

Overall, the proportion of time over the enforcement threshold was very small (less than 2% for all conditions).

For the single speed limit conditions, the proportion of time spent travelling over the enforcement threshold increased slightly in work zone B compared to work zone A; this aligns with the slight increase in average speed seen in Figure 7. In the 70mph condition, very few drivers recorded any speeds over 79mph and therefore the proportion is close to zero.

For the stepped speed limit conditions, as the speed limit increased (from 50mph to 55mph or 60mph) there was a drop in proportion of time over the enforcement threshold. The larger proportion in the 50mph speed limit is due to a small number of participants who spent slightly longer over the speed limit; there was no clear reason for this.

In contrast, the proportion of time over the enforcement threshold increased as the speed limit changed from 60mph to 50mph. This could suggest that participants took a while to adjust to the 10mph drop in speed limit, spending a proportion of time at the start of the work zone B still travelling close to 60mph. This will be investigated further in Section 3.8.

3.4 Headway

Headway measures the distance between the participant's vehicle and the AI vehicle travelling in front in the same lane. The maximum headway recorded by the simulator is 250m; distances beyond this are recorded as null.

Across all eight conditions, the average headway ranged from 106m to 134m in the approach and end sections of the drives but was substantially lower (between 67m and 90m) in the taper section. This is to be expected as participants change lanes as they prepare to enter the roadworks and reduced lane capacity results in higher per-lane flow.

The average headway (in metres), across all participants, in work zones A and B is presented in Figure 10.

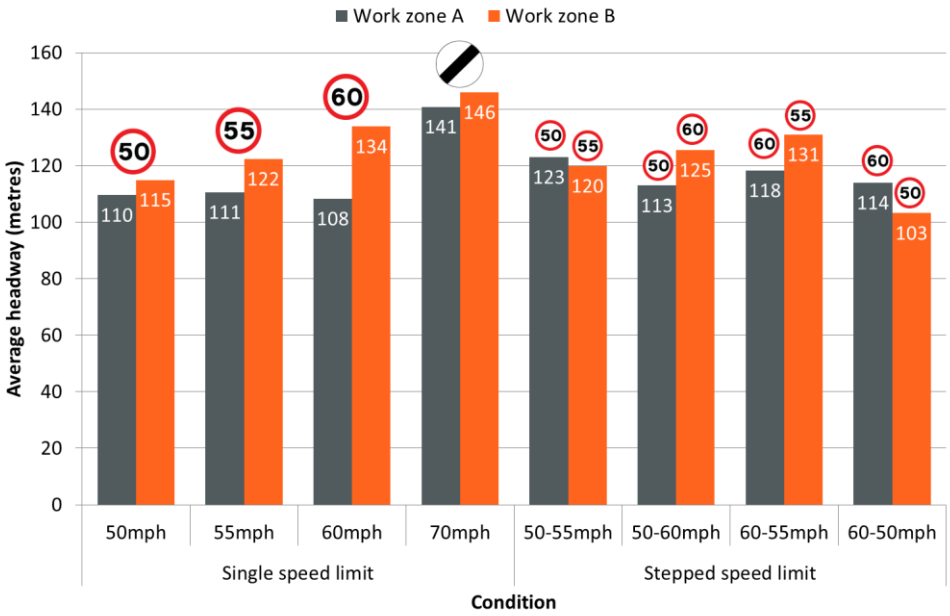

Figure 10: Average headway (in metres) in work zones A and B by condition

Within the single speed limit conditions, the average headway increased between work zones A and B. This aligns with the increase in average speed seen in Figure 7, suggesting that as a participant's average speed increased, the distance between vehicles was also increased to compensate.

Considering the work zone B figures (which show a stronger trend than for work zone A), the average headway was the lowest (115m) for the 50mph speed limit and highest (146m) in the national speed limit condition. This suggests that for lower speed limits, drivers tend to drive closer to vehicles in front. However, these measurements exceed the recommended stopping distances presented in the Highways Code (53m at 50mph and 96m at 70mph), suggesting that drivers were, on average, allowing enough distance between them and the vehicle in front to pull up safely if it suddenly slowed down or stopped.

For the stepped speed limit conditions, the average headway does not follow a clear pattern. However, on average, headway was between 103m and 131m which exceeds the stopping distances recommended in the Highway Code for these speeds.

The variability in headway across each section suggests that, on average, participant's headway was slightly more variable when the speed limit was a constant 55mph compared to the other single speed limits. This might suggest that drivers found it harder to maintain the same headway when the speed limit was 55mph.

A two-way repeated measures ANOVA was conducted to test for significant differences in average headway across the eight conditions and the two work zone sections[11]. The analysis

[11] 14 participants were excluded from this analysis due to missing values for average headway (i.e. headway was larger than the maximum recorded by the simulator).

showed that average headway was significantly different across drives (F = 6.5, p < 0.05, partial Eta square = 0.75). However, the difference was not significant across sections (F = 2.09, p = 0.16).

Post hoc tests showed that the average headway for drive four (with single speed limit of 70mph) was significantly different from drive one (single speed limit of 50mph) and drive eight (stepped-down speed limit from 60mph to 50mph). In both cases, the average headway for drive four was higher than the other two drives, supporting the case that headway increased as speed limit increased.

3.5 Lane choice

Once within the roadworks, participants were able to choose between travelling in lanes 2, 3 and 4. Lane 1 was closed to traffic by a line of traffic cones; therefore any traffic reported in Lane 1 would represent an incursion into the works. The average proportion of time spent in each lane during the roadworks is presented in Figure 11.

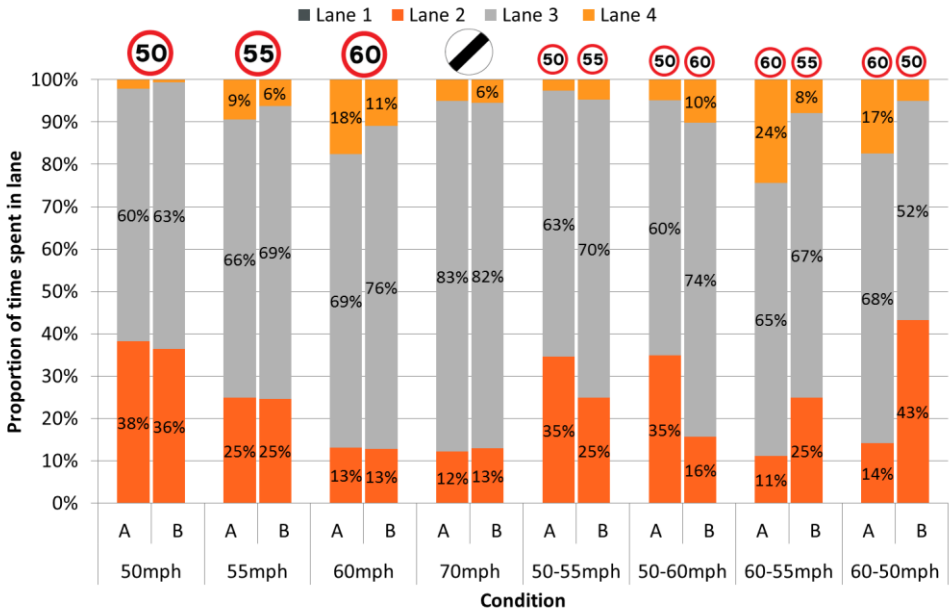

Figure 11: Proportion of time in each lane by condition

For the single speed limit conditions, the proportion of time spent in Lane 2 decreased from 39% to 15% as the speed limit increased from 50mph to 70mph. This pattern was similar for work zones A and B. The proportion of time spent in Lane 3 increased from roughly 59% to 80% as the speed limit increased from 50mph to 70mph. The proportion of time spent in Lane 4 was much smaller than the other lanes; the highest average value (17%) was recorded in the 60mph limit.

For the stepped speed limit conditions, as the speed limit increased from work zone A to B, the proportion of time spent in Lane 2 decreased and Lane 3 increased. As the speed limit decreased from work zone A to B, the proportion of time spent in Lane 3 decreased and Lane 2 increased. This aligns with the findings in the single speed limit conditions and suggests that participants preferred to be in Lane 3 when the speed limit was higher and

Lane 2 when it was lower. Similar to the single speed limits, Lane 4 was used, on average, for a higher proportion of the time when the speed limit was 60mph.

This suggests that higher speed limits may result in better use of all lanes than lower limits, allowing for improved customer lane choice (and so satisfaction).

3.6 Lateral lane position

Lateral lane position measures the position of the participants' vehicle within the lane. The average lateral lane position presented is between 0m and 3.6m; where 0 indicates that, on average, the participant drove mainly on the left side of the lane; 1.8m indicates that the participant drove mainly in the centre of the lane; and 3.6m indicates that the participant drove mainly on the right side of the lane.

Average lateral lane position (in metres) in work zones A and B for each condition is shown in Figure 12 .

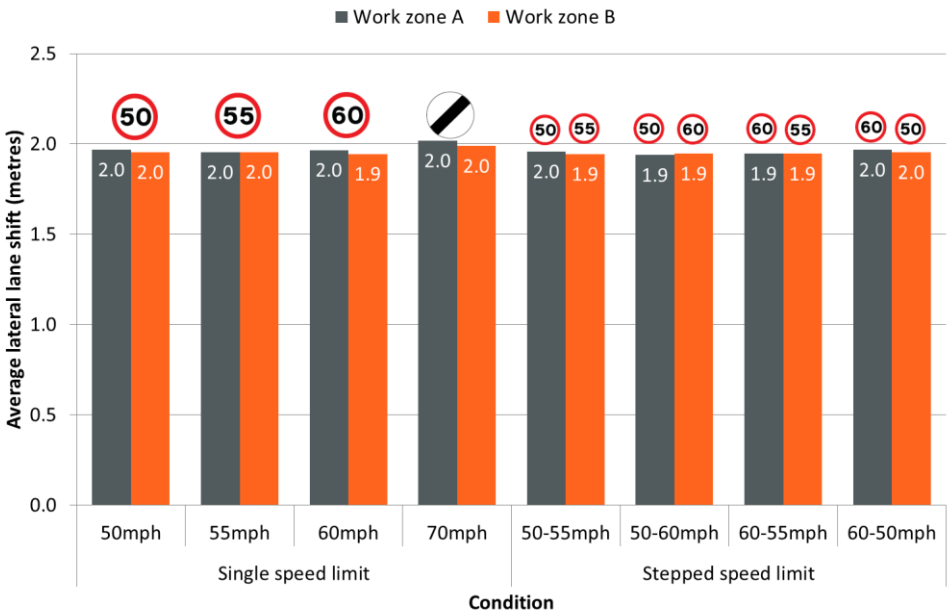

Figure 12: Average lateral lane position (in metres) in work zones A and B by condition

Overall, the average lateral lane position remained fairly consistent across all drives suggesting that drivers tend to drive in the same position within the lane, irrespective of the speed limit.

A two-way repeated measures ANOVA was conducted to test for significant differences in average lateral lane position across the eight conditions and the two work zone sections. The analysis showed that average lateral lane position was not significantly different across drives ($F = 1.7$, $p = 0.1$) or sections ($F = 1.25$, $p = 0.2$).

Average lateral lane position indicates where participants choose to drive relative to the lane lines. However, it does not give any indication as to the amount of movement within

the lane: the variation[12] in the lateral lane position is required for this. Examining this value shows that, on average, participants' amount of movement within lane was similar across all drives. This suggests that the speed limit (and so driver speed choice) did not influence the amount that drivers moved within the lane.

3.7 Collisions

None of the participants were responsible for initiating any collisions during the trial. However, two participants were subjected to minor collisions initiated by the AI controlled traffic when a vehicle unexpectedly changed direction or speed directly in front of them.

In both cases the drivers were monitored by the experimenter immediately after the event and both quickly resumed their usual driving style and soon disregarded the incidents.

3.7.1 Collision 1

One participant collided with a vehicle when the speed limit was 55mph. A series of screenshots which can be seen in Figure 13 depicts the events. The participant (white car) was travelling in Lane 3 when an AI vehicle (white car with red roof) travelling in Lane 2, changed lanes in order to overtake traffic ahead. It did so when the participant was approximately 10-12 metres from it. This event is similar to when a driver might change lane without ensuring that it is safe to do so. The participant avoided the AI vehicle by rapidly moving into Lane 4, but then pulled back into Lane 3 prematurely, before fully passing the vehicle in Lane 3, causing them to clip the front of the AI vehicle.

This collision occurred 10 seconds into work zone A, after the driver had negotiated the taper. In the 30 seconds prior to the collision, the average speed was 49.4mph and as a result, it is unlikely that excessive speed contributed to the collision. Figure 13 shows how the collision unfolded.

[12] Measured using the standard deviation

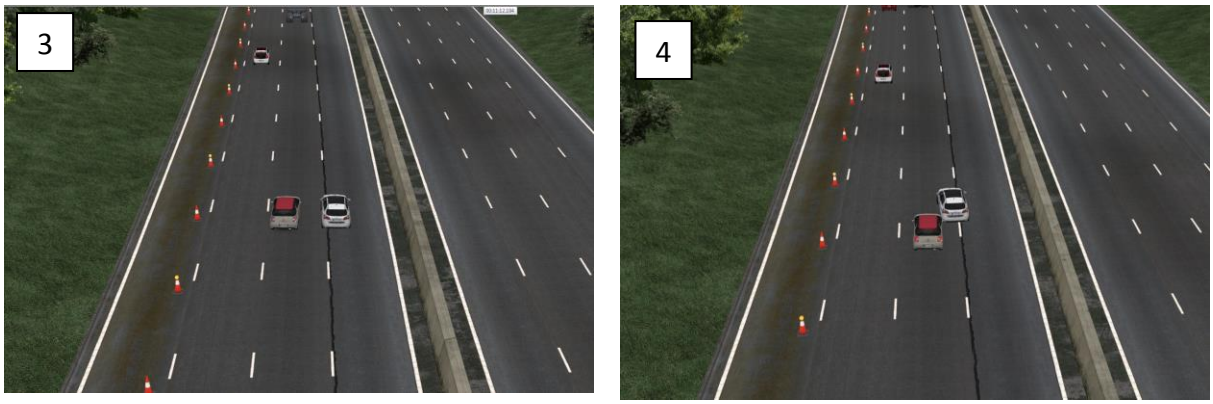

Figure 13: Collision in 55mph speed limit (participant 23)

The degree to which the 55mph speed limit influenced the event is unclear. The driver was not responsible for instigating the event, but they were responsible for failing to navigate it safely. It is possible that the 55mph limit was not a causal factor as the driver may simply have misjudged the location of the AI vehicle and/or the time needed to clear it before moving back into Lane 3. Alternatively, the driver's reactions and situational awareness may have been impaired by their attempts to comply with the 55mph limit.

3.7.2 Collision 2

The next participant to have a collision experienced it soon (13 seconds) after entering the 55mph speed limit in the 50-55mph condition. Prior to this point, the average speed of the participant was 51.7mph, indicating that excessive speed is unlikely to have contributed to the collision. The events leading up to the collision are presented in Figure 14

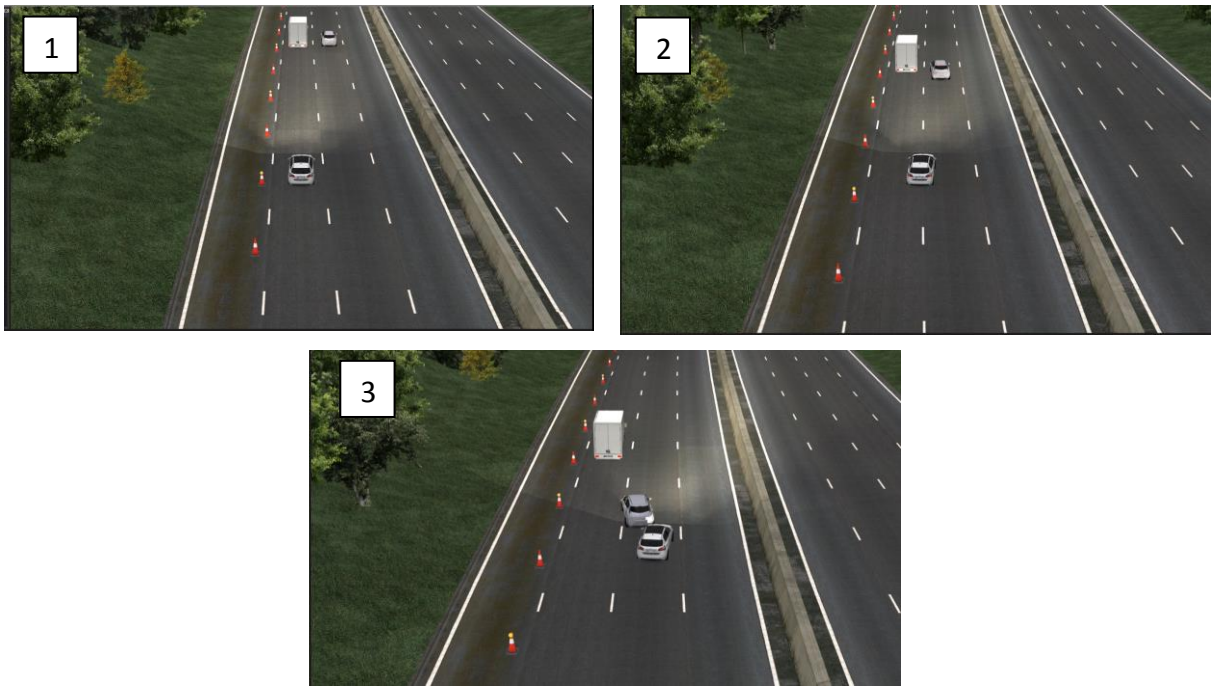

Figure 14: Collision in in 55mph speed limit (participant 9)

In this case, the participant was moving from Lane 2 to Lane 3 into position behind an AI vehicle. This AI vehicle in Lane 3, which had been overtaking an HGV, suddenly decelerated by approximately 10 to 15 mph in an apparent attempt to enter Lane 2 behind the HGV. The participant both slowed and attempted to move further to their right to avoid the vehicle which had decelerated. However, they failed to do so and this caused a collision where the front of the participant's vehicle clipped the rear of the AI vehicle.

As a result, the primary cause of this collision was the sudden deceleration of the AI controlled vehicle. The driver took reasonable action to avoid the collision, however, it is not possible to know the degree to which the 55mph speed limit affected their performance, either positively (the collision might have been worse at a different speed limit) or negatively (they might have avoided it altogether at a different speed limit).

3.8 Driver behaviour at the speed limit change

For all the drives in which the speed limit changed between work zones A and B, the distance after the change in speed limit at which the speed of the participant first reached the new average speed was recorded. The aim of this analysis was to understand how long it took drivers to notice the speed limit change and adjust their behaviour accordingly. The results are presented in Table 5.

Table 5: Distance (in metres) where the driver behaviour changed after encountering speed limit

Condition	Minimum distance	Maximum distance	Average distance
50-55mph	1	2,921	404
50-60mph	1	2,192	526
60-55mph	1	628	68
60-50mph	1	2,740	297

For the step-down speed limit conditions, the average distance at which the new speed limit was reached after encountering the speed limit change was 68m for 60-55mph drive and 297m for the 60-50mph drive. This suggests that for a 5mph drop in speed limit, the average distance taken for drivers to adjust their speed was lower than when the speed limit dropped by 10mph. Note this analysis only records when the driver reached the new speed and not when they initiated their deceleration. Therefore it is possible that within these two drives drivers, on average, started decelerating at similar points but it took longer to achieve the larger speed decrease.

For the step-up speed limit conditions, the average distance at which the new speed limit was reached after encountering the speed limit change was 404m for the 50-55mph drive and 526m for the 50-60mph drive. Participants, on average, took longer to adjust to the step-up in speed limits compared to the step-down and in particular, participants took longer if the increase in speed was greater.

Note that some participants reached the new speed very quickly after the change in speed limit. It is possible to see the new speed limit signs a few hundred metres upstream of the

actual gateway, and thus these individuals may have started accelerating/decelerating before they reached this point.

However, it took nine participants over 1km to adjust their speed (four out of the nine, drove in excess of 2km), suggesting that they did not see the speed limit change at the initial gateways signs and realised somewhere along the route that the speed limit had changed.

3.9 Driver behaviour close to average speed cameras

In order to understand how driver behaviour, in particular speed choice, varies around the average speed cameras (ASCs), speed measurements were taken every 25m from 100m upstream to 100m downstream of each camera. There were four average speed cameras located at various positions in each drive (the exact position of these can be seen in the drawing in Appendix A).

Figure 15 presents the average speed (across all 36 participants) measured upstream and downstream of the camera in the 50mph drive.

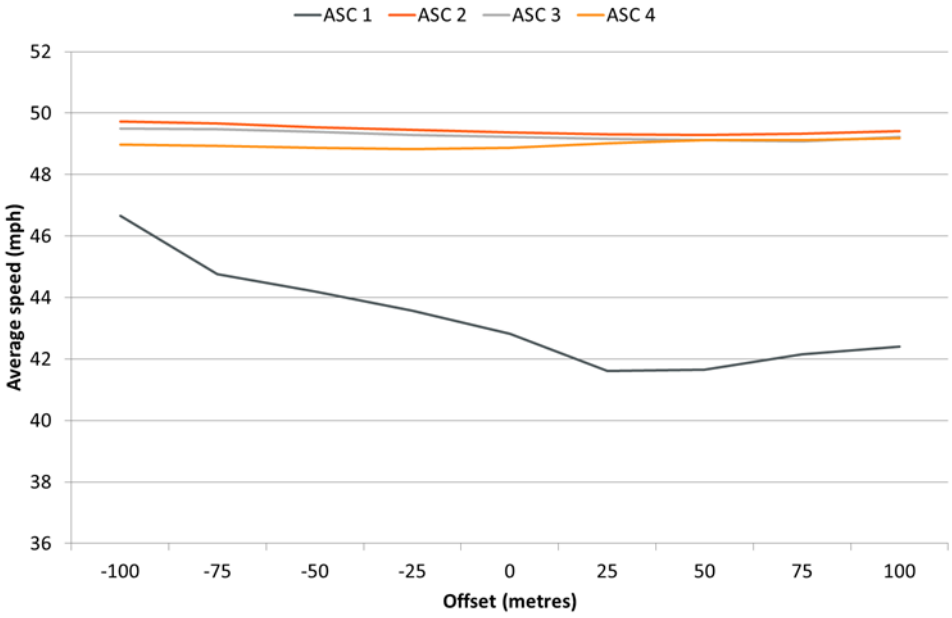

Figure 15: Average speed (mph) for 50mph drive 100m upstream and downstream of the ASC

The offset (in metres) ranges from -100m (i.e. 100m upstream) to 100m (i.e. 100m downstream) of the average speed camera.

There is evidence from the literature to suggest that some drivers slow down prior to and speed up after speed cameras; this behaviour is also known as 'surfing' (Brackstone & McCluskey, 2008). Across ASCs 2, 3 and 4, the average speeds for all participants remained fairly similar across the 200m stretch, suggesting that participants did not slow down on approach to the camera and then speed up again afterwards. This is not unexpected since the literature also suggests that surfing is more prevalent at spot-speed cameras than at average cameras (Brackstone & McCluskey, 2008).

ASC 1 shows a slightly different pattern with a drop in average speed from 100m downstream to 25m upstream, followed by a slight increase after the camera. However, this change in average speed is likely to be due to the position of the camera within the works, which positioned within the advance sign zone close to the taper and just after the first of the speed limit restriction signs. At this point, the participants are likely to be slowing down and changing lane to navigate the taper.

Although not presented here, the same pattern for each of the four ASCs is evident across all the other drives suggesting this surfing was not a prevalent behaviour within the roadworks.

3.10 Summary

- When only a single speed limit was presented, average speed increased slightly in the second half of the roadworks, suggesting that the driver's tendency was to speed up to get through the roadworks faster.
- In general, participants noticed the step change in speed limits and adjusted their speed accordingly. However, for some participants, there was a delay between passing the gateway signs displaying the new speed limit, and the adjustment in speed. This suggests that they may have missed the initial signs and realised somewhere along the route that the speed limit had changed.
- Participants, on average, took longer to adjust to a step-up in speed limit compared to a step-down and in particular, took longer if the increase in speed was greater.
- In all conditions, the proportion of time spent travelling over the enforcement threshold (speed limit + 10% + 2mph) was less than 2%, suggesting that drivers were aiming to be compliant with the speed limit.
- The proportion of time spent driving over the enforcement threshold increased as the speed limit changed from 60mph to 50mph in drive 8; this trend may be linked to the small number of participants who initially missed the change in speed limit.
- Average headway was significantly different across drives, with larger headways recorded at the higher speed limits. This suggests that as a participant's average speed increased, the distance between vehicles was also increased to compensate.
- As the speed limit increased, the proportion of time drivers spent in Lane 2 decreased and Lane 3 increased, suggesting that participants preferred to be in Lane 3 when the speed limit was higher and Lane 2 when it was lower. At 60mph a higher proportion of the drive was spent in Lane 4.
- The average position of drivers within a lane, and the amount that drivers moved within that lane, was similar across all drives for all speed limits.
- Out of 36 participants, only two participants had a collision, each within a 55mph speed limit. However, based on a review of the simulator data, it is unclear whether the 55mph speed limit was a causal factor in either collision.
- There was no evidence of surfing around the average speed cameras.

4 Questionnaire results

This section presents the results of the questionnaire given to participants to complete during the trial. The full questionnaire can be seen in Appendix B.

The results are split into a number of key themes including:

- The participants understanding of the speed limit in each drive (Section 4.1)
- Subjective perceptions of journey time, safety and satisfaction (Section 4.2)
- Understanding of enforcement measures (Section 4.3)
- Preferred speed limits through roadworks (Section 4.4)
- General comments (Section 4.5).

These results are summarised in Section 4.6.

4.1 Understanding of the speed limit

To assess their understanding of the speed limit, participants were asked which speed limit(s) they saw during each drive. Participants' responses were coded as 'correct', 'incorrect', or 'one speed limit correct' where one of the speed limits in the stepped speed limit scenarios was correctly recalled but the other was not. The results are summarised in Figure 16.

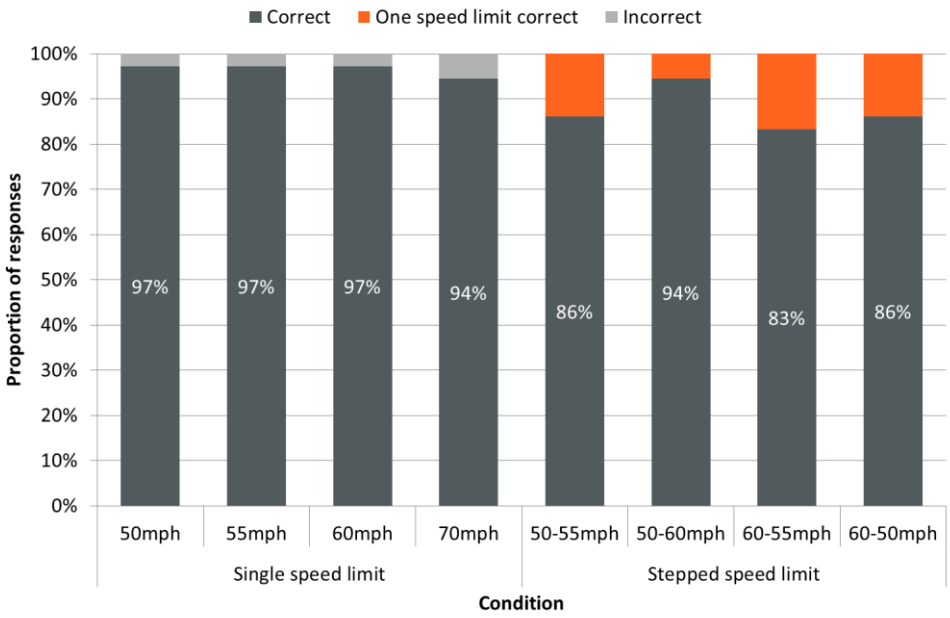

Figure 16: Recall of speed limit(s)

Overall, almost all participants correctly identified the speed limit in the single speed limit conditions. In the stepped speed limit conditions, fewer participants were able to correctly recall the speed limits; the data indicate that recognition of the speed limit was poorest when there was a step down.

The average speed data (presented in Section 3.2) suggests that some participants may have understood the speed limit(s) while completing the drive, but simply could not accurately recall what they had seen at the end of the drive.

4.2 Subjective perceptions

4.2.1 Effect on journey time

Participants were asked to rate how they thought driving through each set of roadworks would affect their journey time (compared to driving the same route with no roadworks). Responses were made on an 11-point scale from 0 (journeys would be much slower) to 10 (journeys would be much faster) with a mid-point of 5 (would have no effect on journey time). Figure 17 displays the mean ratings of effect on journey time.

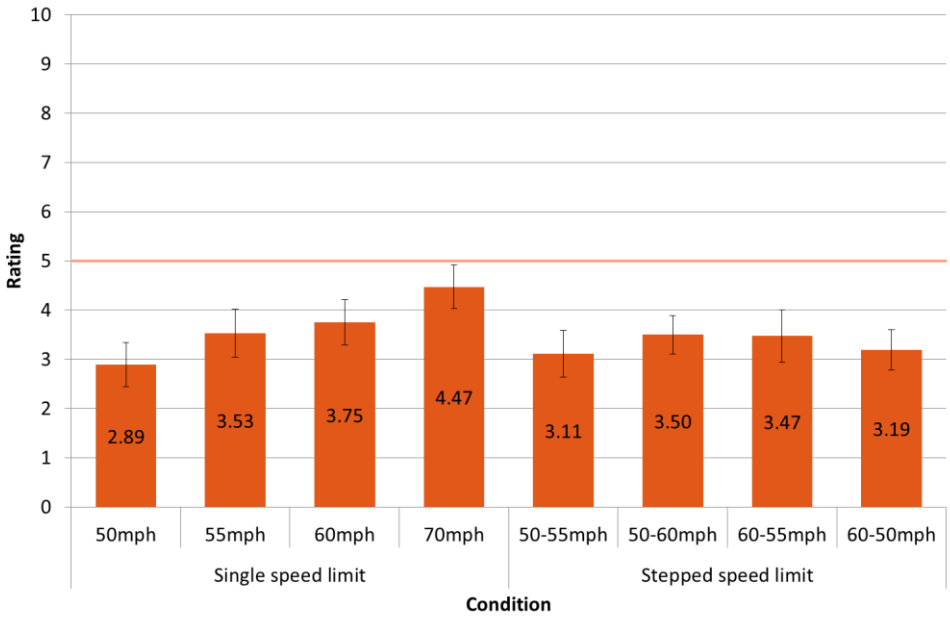

Figure 17: Mean ratings of the effect of driving through the roadworks on journey time (with 95% confidence intervals)

Mean ratings were below 5 in all conditions, indicating that participants thought all of their journeys would be slower compared to driving the same route with no roadworks. The 50mph speed limit was judged to have the greatest effect on journey time, while the 70mph speed limit was judged to have the least effect. Of the stepped speed limit changes, the step up from 50mph to 55mph was considered to slow the journey the most and the step up from 50mph to 60mph was considered to slow the journey the least.

Repeated measures ANOVA revealed that there were statistically significant differences in participants' perception of the effect of the roadworks on journey time based on the speed limit(s) encountered ($F = 10.27$, $p < 0.001$, partial eta squared = 0.71).

Pairwise comparisons show that relative to 50mph, all other speed limit conditions were associated with significant improvements in journey time except the 50-55 step up and 60-50 step down conditions. It is probable that in the 50-55 condition, the step up to 55mph at the end of the works was not sufficient to improve perceptions of journey time. In the 60-50

step down condition, it is possible that participants' recall of having to reduce their speed at the end of the works led them to have a worse impression of journey time than when the same speed limits were presented in the reverse order.

4.2.2 Perceptions of safety

4.2.2.1 Ratings

Participants were asked to rate how safe or unsafe they felt when driving through the roadworks. Responses were made on an 11-point scale from 0 (very unsafe) to 10 (totally safe) with a mid-point of 5 (neither safe nor unsafe). Figure 18 displays the mean ratings of safety for each condition.

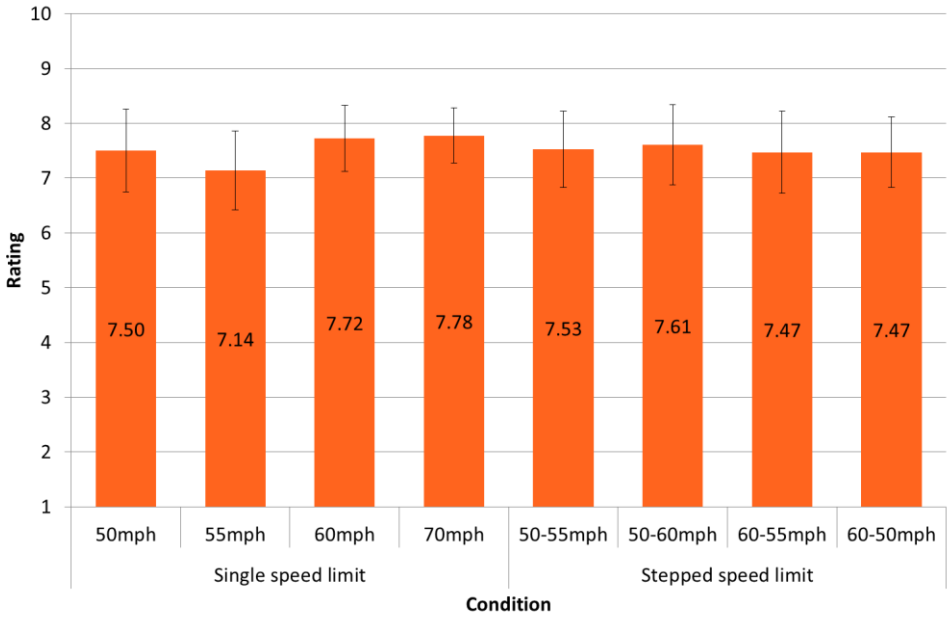

Figure 18: Mean ratings of safety (with 95% confidence intervals)

Mean ratings were between 7 and 8 in all conditions, indicating that participants felt safe in all of the drives. Safety was rated highest in the 70mph condition and lowest in the 55mph condition.

Repeated measures ANOVA revealed that there were no significant differences in participants' ratings of safety based on the speed limit(s) encountered ($F = 0.65$, $p = 0.72$).

4.2.2.2 Explanations

Participants were asked whether there was anything in particular about the roadworks that made them feel safe or unsafe. Analysis of participants' responses revealed the following key themes:

- Speed
- Consistency of the speed limit
- Change in the speed limit

- Signage
- Traffic flow and vehicle behaviour
- Road layout
- Recovery and refuge
- Average speed cameras
- HGVs
- Fatigue and boredom

The number of comments provided for each theme is presented in Appendix C.1.

Reasons for feeling safe

Traffic behaviour, signage and speed were the most frequently cited reasons for feeling safe. Among the scenarios with only a single speed limit, speed was named as a reason for feeling safe most commonly in the 50mph condition: *"Well sign-posted speed limit. Everyone was doing about the same speed"* (50mph condition) and *"50mph speed limit makes you feel more at ease when there's roadworks"* (50mph condition).

Participants frequently reported feeling safe due to the repetition of speed limit signs: *"Speed limit makes you feel safer with repeated signs"* (60-55mph condition). Consistent traffic flow was also cited: *"Driving at 50 seemed to slow everything down and people were keeping to that speed better (less variation)"* (50-55mph condition).

Reasons for feeling unsafe

The most frequent reason for feeling unsafe was the lack of signage in the 70mph condition: *"There were no speed limit signs. It made me feel unsure about what speed to do"* (70mph condition).

Other comments were made about the behaviour of other vehicles and the flow of traffic; this was most common in the 50mph and 55mph conditions and the two 'step down' conditions:

> *"Varying speeds of some of the drivers. Lots of undertaking"* (55mph condition)
>
> *"The change in speed limit. I had to think more about my speed because of the reduction"* (60-50 condition)

A small number of comments were made about feeling unsafe specifically due to HGVs: *"Everything was slower. Lorries were overtaking me when it was 50 but I don't remember it happening when it was 60"* (50-60 condition).

4.2.3 Journey satisfaction

4.2.3.1 Ratings

Participants were asked to rate how satisfied or dissatisfied with their journey they felt when driving through the roadworks. Responses were made on an 11-point scale from 0

(very dissatisfied) to 10 (very satisfied) with a mid-point of 5 (neither dissatisfied nor satisfied). Figure 19 displays the mean ratings of satisfaction for each condition.

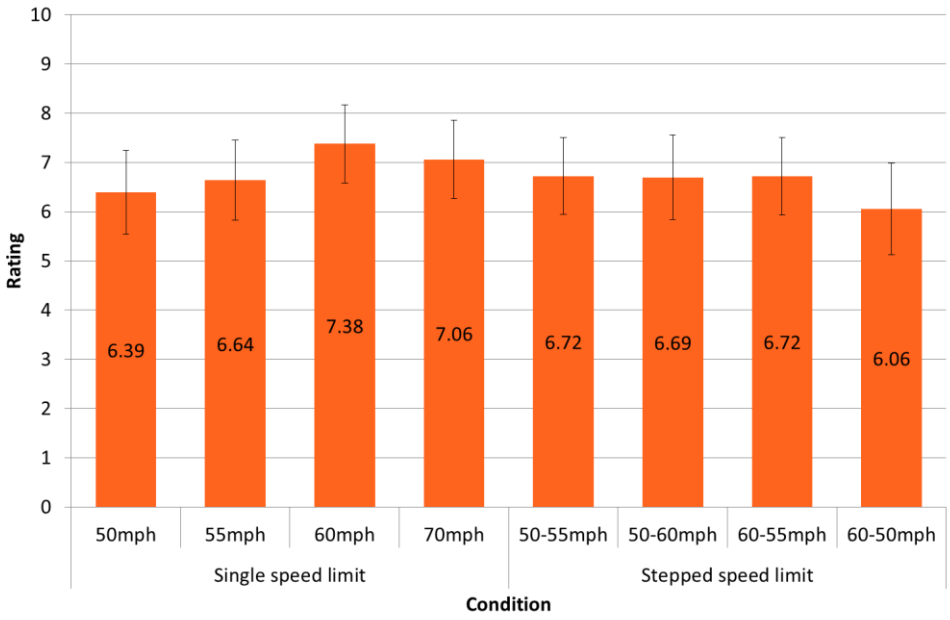

Figure 19: Mean ratings of journey satisfaction (with 95% confidence intervals)

Mean ratings were between 6 and 8 in all conditions, indicating that overall participants were somewhat satisfied with their journeys in all of the drives. Satisfaction was rated highest in the 60mph condition and lowest in the 60 to 50mph condition.

A repeated measures ANOVA determined that there was a statistically significant difference in participants' ratings of satisfaction based on the speed limit(s) encountered (F = 2.84, p = 0.02, partial eta square = 0.41).

All pairwise comparisons were non-significant (at the 5% level). However, two were nearly significant (i.e. had a p-value less than 0.1): relative to 60mph, the 50mph and 60-50mph conditions had lower levels of satisfaction.

4.2.3.2 Explanations

Participants were asked whether there was anything about the roadworks that made them feel especially satisfied or dissatisfied. Analysis of participants' responses revealed the following key themes, which closely mirror the reasons for feelings safe or unsafe:

- Speed
- Consistency of the speed limit
- Change in the speed limit
- Signage
- Traffic flow and vehicle behaviour
- Road layout
- Recovery and refuge

- Average speed cameras
- HGVs
- Fatigue and boredom

The number of comments relating to each theme is presented in Appendix C.2.

Reasons for feeling satisfied

The speed limit, signage and traffic behaviour were the most frequently cited reasons for feeling satisfied. The lack of disruption caused by the speed limit was mentioned in both the 60mph and 70mph drives: *"Going normal speed, it's not holding us up as much"* (60mph condition).

In the single speed limit conditions, participants liked the consistency of the speed limit: *"Consistency of flow of traffic and speed limit"* (60mph condition). However, others thought the change in speed limit was satisfying: *"The gradual increase from 50 to 60 to 70 was quite good"* (50-60 condition).

Reasons for feeling dissatisfied

One of the most common reasons for feeling dissatisfied was the speed limit in the 55mph condition:

> *"55 is an awkward speed. I have to work it out when looking at the speedometer, so you're looking at the speedometer for a fraction longer than you should"* (55mph condition)
>
> *"It's quite difficult to keep to 55, harder than 50 or 60. Mainly because of the position of the needle on the speedometer"* (55mph condition)
>
> *"55 is weird, it threw me off a bit. You don't expect to see it on a sign"* (60-55mph condition)

Several people also mentioned the lack of signage in the 70mph condition: "*Lots of speed cameras but no speed limit"* (70mph condition).

The stepped speed limit conditions also generated several comments; more participants cited this as a reason for feeling dissatisfied in the 60-50 condition than in the other conditions:

> *"The speed limit dropped from 60 to 50 for no apparent reason"* (60-50mph condition)
>
> *"50 to 55 is pointless. The variance in your speed is not enough to make a difference"* (50-55mph condition)
>
> *"The speed kept changing. I was trying to work out what the speed was"* (60-55mph condition)

Across conditions, comments were made about the absence of road workers: *"No-one was working so I'd be annoyed"* (60-50mph condition).

4.2.4 *Ability to drive in preferred lane*

After each drive, participants were asked whether they were able to drive in their preferred lane when within the roadworks. Participants' responses were coded into three categories: 'yes', 'no' and 'sometimes'. Responses are summarised in Figure 20.

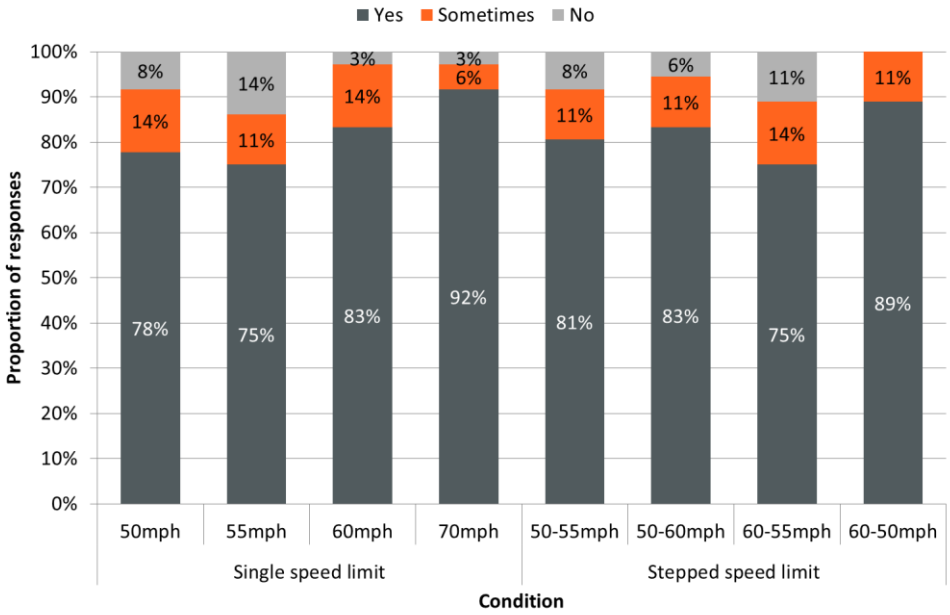

Figure 20: Participants' ability to drive in their preferred lane when within the roadworks

Participants were slightly more likely to say that were unable to drive in their preferred lane in the slower conditions (e.g. 50mph and 55mph) than in the faster conditions (e.g. 70mph).

An analysis of participants' descriptions of what stopped them from driving in their preferred lane revealed that some were prevented by HGVs. The comments indicate that lane choice was affected by HGVs moving from lane one to lane two:

> *"A lorry pulled out and pushed me into lane 3."* (55mph condition)
>
> *"I prefer to be in the inside lane. I stayed in the middle lane because of vans (I like to see ahead) and because I wasn't holding up traffic by doing so."* (50-55mph condition)

4.3 Understanding of enforcement measures

4.3.1 *Opinions on detection and penalisation*

Participants were asked whether drivers should be detected and penalised in the following circumstances:

- Exceeding the speed limit through roadworks on motorways
- Exceeding the National Speed Limit (70mph) on motorways with no roadworks

Participants' responses are summarised in Figure 21.

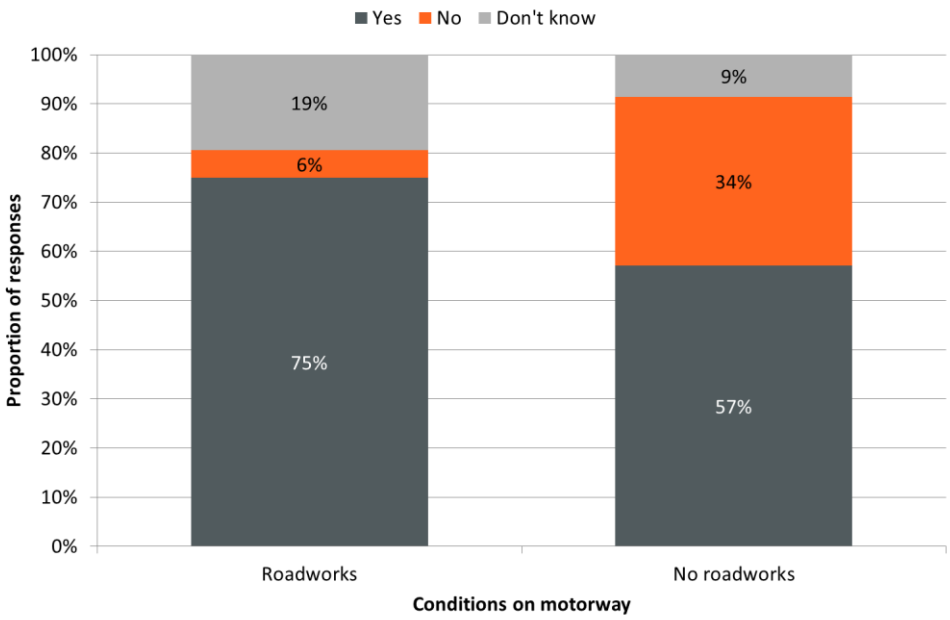

Figure 21: Participants' opinions on whether speeding drivers should be detected and penalised when driving on motorways

In both circumstances, the majority of participants thought that drivers should be detected and penalised. A third of participants felt that drivers should not be penalised for exceeding the National Speed Limit on motorways with no roadworks.

4.3.2 Enforcement thresholds

Participants were asked to indicate the lowest speed at which drivers *would be* and *should be* detected and penalised for exceeding the speed limit through roadworks on motorways. In other words, participants were asked about their perceptions of, and preferences for, speed enforcement. Responses were required for each of the four speed limits experienced in the trial. The same two questions were asked about drivers who exceed the National Speed Limit on motorways with no roadworks.

Ten participants responded by placing a tick alongside one of the speed limits rather than writing a speed, indicating that the question was misunderstood. A small number of participants also wrote speeds that were lower than the posted speed limit; these participants presumably understood the question to be asking at which speed drivers would and should be penalised for driving too slowly. These responses were excluded from the analysis.

Figure 22 shows participants' speed enforcement perceptions and preferences at each speed limit against the actual threshold (based on the speed limit + 10% + 2mph guidelines).

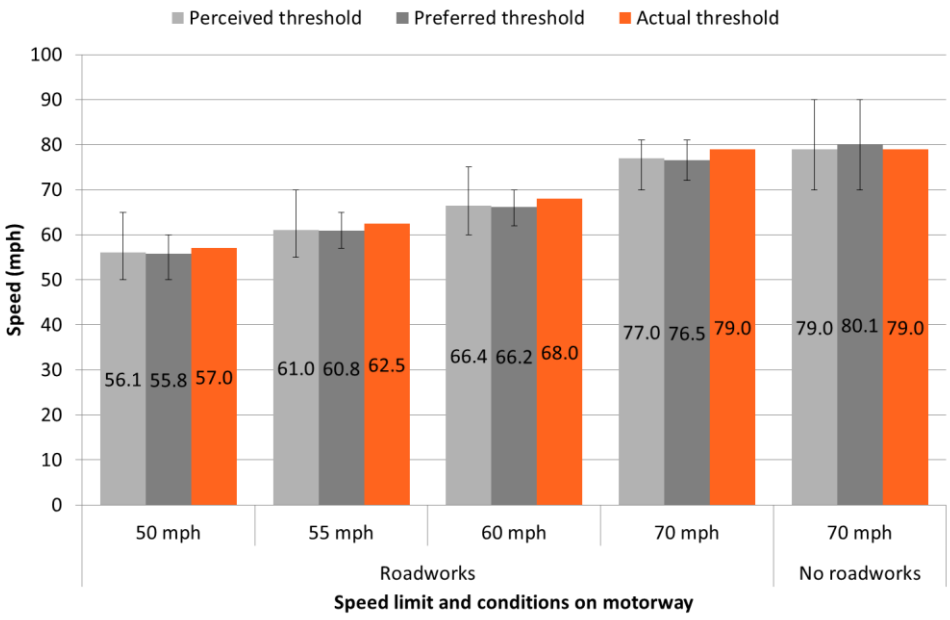

Figure 22: Speed enforcement perceptions and preferences (with minimum and maximum error bars)

Overall, participants' perceived and preferred speed enforcement thresholds were similar to but marginally lower than the actual threshold. The exception to this was when there were no roadworks; on average, participants favoured a higher speed than the actual threshold.

The minimum and maximum values indicate that at the lower speeds (i.e. 50mph, 55mph and 60mph), there was greater variation in participants' perceived threshold speeds than in their preferred threshold speeds.

4.4 Preferred speed limit

At the end of the trial, participants were asked what speed limit(s) they would prefer to see in roadworks and to explain why. Participants' responses are summarised in Figure 23.

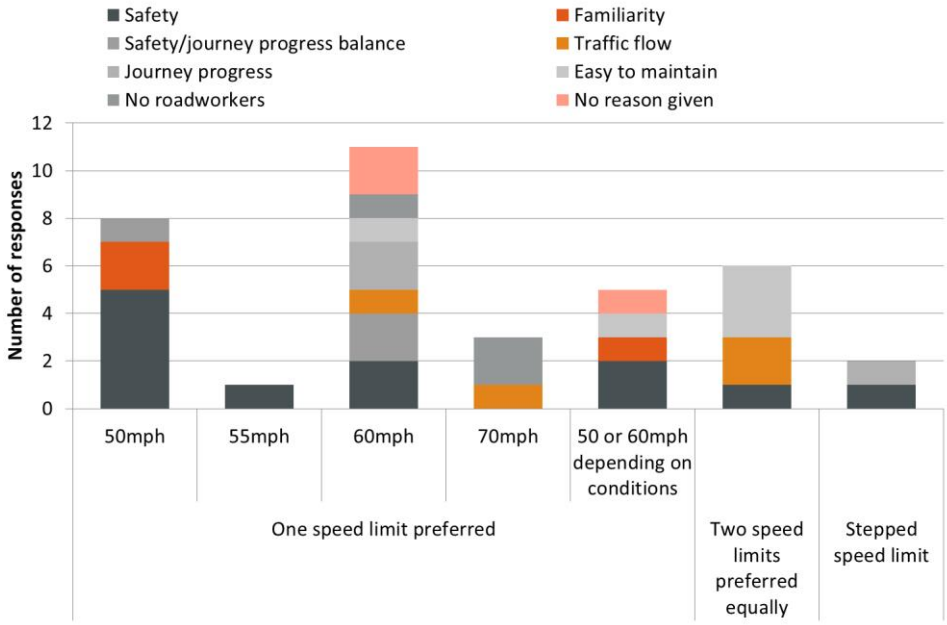

Figure 23: Preferred speed limit(s) in roadworks and reasons

The vast majority of participants (23) stated a preference for a single speed limit; only two participants said they would prefer to see a change in speed limit within the roadworks (i.e. a stepped speed limit). Five participants wanted to see different speed limits for different road conditions, and six stated an equal preference for two speed limits. The detailed responses are described further below.

4.4.1 Clear preference for one speed limit

Among participants who had a clear preference, almost half favoured 60mph as the speed limit. The most common reasons for this were safety, the impact of the speed limit on journey progress, and a balance between these two factors: *"60mph. Slow enough for drivers to react to unexpected situation. Fast enough to not cause frustration to drivers".*

The second most favoured speed limit was 50mph, with safety cited as a key reason: *"50 as I think it is a safer speed to react in case a situation arises".* Familiarity was also given as a reason for preferring 50mph: *"Standard on roads at the moment (e.g. M3 J2-4a)."*

The national speed limit was favoured by two participants due to the absence of road workers: *"Where there is visual evidence for the need to limit speed (e.g. workers, narrow lanes) then I feel 50 is reasonable. Where there is no such sign (i.e. as in the trial) then 70. I feel frustrated that the coned off lane seemed to be perfectly usable and therefore I was being delayed for no reason."* One participant preferred it due to improved traffic flow: *"The traffic moved better."*

Only one participant preferred 55mph, on the basis that it is safer: "*Based on my experience of this trial I felt 55mph was probably safest with 60 definitely feeling a bit fast."*

4.4.2 Preferred speed limit dependent on conditions

Five participants wanted to see the speed limit vary between 50mph and 60mph depending on the conditions.

Most of these participants said that the speed limit should be 60mph in light traffic and 50mph in heavier traffic: *"50mph during rush hour - slower for safety. But after rush hour, up the speed limit to 60mph when the traffic is lighter."*

One participant said they favoured 50mph due to familiarity but that 60mph might be appropriate in very light traffic or at night time: *"Familiarity makes 50mph seem about right. Traffic pulling across lanes at that speed was unlikely to cause problems. Possibly 60mph in very light traffic or night time driving?"*

4.4.3 Two speed limits preferred

Six participants preferred two speed limits equally.

Two participants favoured either 50mph or 55mph: *"Consistent, not too fast, giving you more time to manoeuvre without too much speed. Traffic seems to flow better at these speeds."*

Two participants preferred 50mph or 60mph: *"Either 50 or 60. Harder to accurately drive at 55 if there's no halfway marks on the speedometer so end up rounding down to be safe."*

One person preferred 55mph or 60mph: *"55 or 60mph. I find 50 too slow to maintain for a long stretch of motorway. Also cars nowadays have more powerful engines."*

One participant favoured 60mph to 70mph: *"Between 60 and 70mph I feel that the traffic at that speed tends to be more spaced out and flows more freely with less bunching, and I feel you can react more quickly to incidents."*

4.4.4 Stepped speed limit preferred

Two participants favoured a change in the speed limit within the roadworks.

One participant felt the speed limit should first be 60mph and then 55mph: *"Speed limit should be first 60mph to allow vehicles to slow down to the speed limit and then to 55mph to ensure the safety of drivers in their vehicles and of road workers (if any). If the speed limit is 50mph it doesn't give enough time for speeding vehicles to adhere to the new speed limit."*

The other participant thought that the speed limit should be 50mph until vehicles had merged then 60mph in the works: *"50 when merging, 60 other times. Merging is daunting so 60 is too fast. Some people don't slow for the merge signs and whizz up the inside."*

4.5 General comments

Participants were given the opportunity to provide any general comments or suggestions about their experience. This generated a wide range of responses, not all of which were directly related to the study. However, some key themes could be drawn from the comments provided.

The appropriateness of speed restrictions in roadworks while no road workers were present was discussed:

> *"Unless road workers are on the motorway I don't see why traffic should slow down"*

> *"I was under the impression that speed limits in road works were for the protection of the workforce rather than the drivers who are in the majority of situations still driving on a 3 lane motorway. This doesn't mean that speed limits should not be present because they do protect the workforce but perhaps they should be time limited, say between 6am and 10pm if there is no overnight working."*

> *"People should not be penalised for exceeding roadworks specific speeds if it is clear that there are no roadworks going on."*

As reflected earlier, some participants were not in favour of 55mph as a speed limit:

> *"55mph is an annoying speed limit to stick to. Speedo goes up in 2mph. Preferred 50mph through roadworks. 70mph is too fast through roadworks."*

> *"Didn't like the 55mph speed limit."*

Changing the speed limit in the roadworks was perceived as desirable by one participant; while another thought it presented a risk:

> *"Increasing the speed limit through roadworks is a nice idea if some areas are less dangerous and it helps bring you back up to speed towards the end of the roadworks to avoid everyone putting their foot down once they reach the national speed limit sign."*

> *"Varying speed limits are distracting and takes focus off the road and onto the speedometer."*

One participant commented on their experience of HGVs at lower speeds:

> *"Lower speeds meant lorries could go in all lanes, which was daunting."*

4.6 Summary

- Compared to the single speed limit conditions, fewer participants were able to correctly recall all the speed limits seen during the drive with the stepped speed conditions. The responses suggest that recognition of the speed limit was poorest when there was a step down.
- Relative to 50mph, all the conditions trialled improved perceptions of journey time except the 50-55mph and 60-50mph stepped speed limits.
- There was no significant difference in participant's ratings of safety across the eight conditions; however, perceived safety at 55mph was lower than in the other conditions.
- The repetition of the speed limit signs was seen as a positive feature; in the NSL (70mph) condition, the absence of these signs was the most frequently reported reason for feeling unsafe.
- Ratings of journey satisfaction were highest in the 60mph condition and were significantly lower in the 60-50mph and 50mph conditions.
- Steps up in speed were perceived more positively than steps down, particularly the 50-60mph condition.
- The majority of participants (75%) thought drivers who speed through roadworks should be detected and penalised. On average, people thought the enforcement threshold for each speed limit was slightly lower than the speed limit + 10% + 2mph guidelines.
- When asked what speed limit(s) they would prefer to see in roadworks, the majority of participants (23 out of 36, or 64%) preferred a single speed limit over a stepped speed limit. The most popular speed limit was 60mph (30%) followed by 50mph (22%). Stepped speed limits or dynamic speed limits were also suggested as potential solutions.
- Some participants were dissatisfied with 55mph as a speed limit, with eight people commenting that the speed limit was strange and/or difficult to maintain due to the position of the needle on the speedometer. Four people stated that they spent more time looking at their speedo because of this; however this finding is qualitative and cannot be used to draw conclusions on the impact of a 55mph speed limit on visual distraction.
- A small number of comments were made specifically about the overtaking behaviour of lorries at lower speeds. One participant suggested that this was less prevalent at 60mph.
- Issues relating to the absence of road workers were highlighted by participants on a number of occasions; this suggests that some drivers may not understand the need for speed restrictions when there are no road workers present in the closure.

5 Conclusions

A representative sample of thirty six drivers participated in the simulator trial. Each participant experienced eight drives, completing a short set of questions between each one. Each drive was carried out in a simulated Smart Motorway ALR environment within the 'Operational Regime Testing' phase of development; hence, Lane 1 was closed to traffic, average speed cameras were in place and speed limits were displayed on fixed-plate signs. Traffic was designed to behave in a realistic manner to ensure that the behaviours observed could be generalised to real roads.

The results from the simulator study show that, on average, drivers chose to drive at an average speed below the speed limit in all conditions. Lateral lane positioning and lane shift (the amount a vehicle moves around within the lane) were comparable between all scenarios. This suggests that drivers were able to maintain their preferred speed and lane position, even when travelling at speeds above 50mph.

Relative to the other speed limits, the 60mph speed limit was received well by participants and scored the highest rating of all drives on journey satisfaction. This score was significantly higher than the satisfaction rating given for the current 50mph speed limit. Reasons for feeling satisfied included the consistency of the traffic flow, consistency of the speed limit and the feeling that they were not being held up as much.

Compared to 50mph, some participants reported feeling safer in the 60mph limit due to the fact that HGVs were not overtaking as much. The driver behaviour data showed that on average, participants travelled at approximately 57-58mph in this speed limit and spent a higher proportion of time in Lane 4 than in the other conditions.

There is some evidence to suggest that a speed limit of 55mph may impact on driver behaviour, although further work is required to understand the reasons for this. Average headway for the 55mph scenario was comparable to the other single speed limits; however there was slightly greater variation in headway in the 55mph limit. This may be associated with increased workload and/or increased visual distraction (e.g. due to a greater requirement to look at the speedometer); however firm conclusions cannot be made without further research which directly measures the impact of a 55mph limit on these types of phenomena.

Reductions in speed variability between work zone A and work zone B were observed in all drives, suggesting that as participants settled into the drive, the task of maintaining their speed may have become easier. At 55mph the reduction in speed variability between work zone A and work zone B was lowest compared to other conditions; this might support the assertion that cognitive load could be higher when driving in 55mph limits, but further work is required to fully understand the causal mechanisms behind these findings.

Two collisions occurred during the 55mph scenarios; it is unclear whether these were directly caused by the speed limit.

When asked about their experience, some participants reported safety concerns with the 55mph speed limit. In particular, eight people commented that the speed limit was 'strange' and/or that it was difficult to maintain speed due to the position of the needle on the speedometer. Four people stated that they spent more time looking at their speedo

because of this; however caution should be given to drawing conclusions about visual distraction from qualitative findings such as this. Participants were asked to rate (on a scale of 0 to 10) how safe or unsafe they felt in each drive, and also how satisfied or dissatisfied and they were. On average, safety was rated lowest in the 55mph condition of all the eight drives and satisfaction was amongst the worst three, although neither safety ratings nor satisfaction ratings yielded statistically significant differences compared to the 50mph speed limit condition.

In general, in the drives in which the speed limit changed part way through the roadworks, participants did notice the change in speed limit and adjust their behaviour accordingly. However, they could not always recall both speed limits successfully afterwards. In addition, it seemed that for some participants there was a delay between passing the gateway signs displaying the new speed limit and the adjustment in speed. A small number of participants took in excess of 2km to adjust their speed, suggesting that they did not see the initial signs and realised somewhere along the route that the speed limit had changed. This sometimes resulted in a short duration of time at which the participant was travelling in excess of the enforcement limit (speed limit + 10% + 2mph), especially in the 60-50mph condition which required a step down in speed. However, given how average speed measurements are taken, this would not have resulted in a prosecution for speeding.

Safety and satisfaction ratings for the step speed limit drives were similar to the single speed limit drives, except for the 60-50mph condition which was rated substantially lower on satisfaction than the continuous 60mph limit. Reasons for concern cited the fact that the speed dropped for no clear reason and suggested that varying speed limits were distracting, taking the focus off the road and onto the speedometer. Relative to 50mph, all speed limit conditions were associated with significant improvements in journey time except the 50-55mph step up and 60-50mph step down conditions, suggesting that drivers did not perceive any journey time benefits to these conditions.

Generally a step up in speed was perceived more positively than a step down, particularly the 50-60mph. It is possible that this condition allowed drivers to feel like they were making more progress compared to the opposite 60-50mph condition (in which the overall travel time should have been the same).

When asked what speed limit(s) they would prefer to see in roadworks, the majority of participants preferred a single speed limit over a stepped speed limit, with the most popular speed limit being 60mph. Participants considered that this speed offered a good balance between safety (*"slow enough for drivers to react to an unexpected situation"*) and journey progress (*"fast enough to not cause frustration to drivers"*).

A speed limit of 50mph was also popular for safety reasons and the fact that is was 'familiar' to participants. A small number of people suggested dynamic speed limits where the speed limit changes depending on the traffic conditions or where the speed limit is lifted if no works are taking place.

In summary, there is no evidence to suggest that increasing speed limits to 60mph within roadworks with standard lane widths would result in increased safety risk to drivers. Further work is recommended to fully understand the impact of a 55mph speed limit; the findings of this current study identified a slight increase in headway variability when drivers were

travelling in the 55mph speed limit condition compared to the other single speed limit conditions. Reasons for this finding are currently unknown; one hypothesis, for example, might be that a 55mph speed limit increases drivers' cognitive load (perhaps due to the novelty of the speed limit or increased visual demand when looking at the speedometer). Increased cognitive load may in turn impact driving performance and safety, and so these issues warrant further investigation.

Driver satisfaction was reported to be significantly better for 60mph than the current 50mph limit. Both 50mph and 60mph speed limits were popular choices when participants were asked what speed limit they would prefer to see in roadworks. Generally, step-up speed limits were perceived more favourably than step-down speed limits.

5.1 Next steps

The aim of this simulator trial was to understand the impact of alternative speed limits on driver behaviour and satisfaction. The study revealed no evidence to suggest that increasing the speed limit to 60mph within roadworks with standard lane widths would result in increased safety risk to drivers. Further work is recommended to fully understand the impact of a 55mph speed limit however. For this reason, a follow-up simulator study is recommended to allow further investigation into the effects of a 55mph speed limit on safety.

In particular, future work should focus on understanding driver cognitive load and visual distraction when driving through roadworks with a 55mph speed limit. This could be achieved in a follow-up simulator trial through the use of eye-tracking devices to provide a detailed understanding of the number and duration of drivers' eye glances away from the road and at the speedometer when driving in a 55mph limit. These data can be captured relative to other speed limits in order to assess whether a 55mph limit negatively impacts safety. In addition, cognitive workload can be measured subjectively to understand whether or not the 55mph speed limit impacts on the complexity of the driving task.

These investigations, coupled with further analyses of driving performance metrics captured in the simulator, will provide a more detailed evidence base as to the impact of a 55mph speed limit on driver behaviour and safety. Qualitative methods are also recommended in order to supplement understanding and interpretation of these quantitative data; this could be in the form of semi-structured interviews, designed to probe driver perceptions, experiences and motivations for behaviours observed in the trial.

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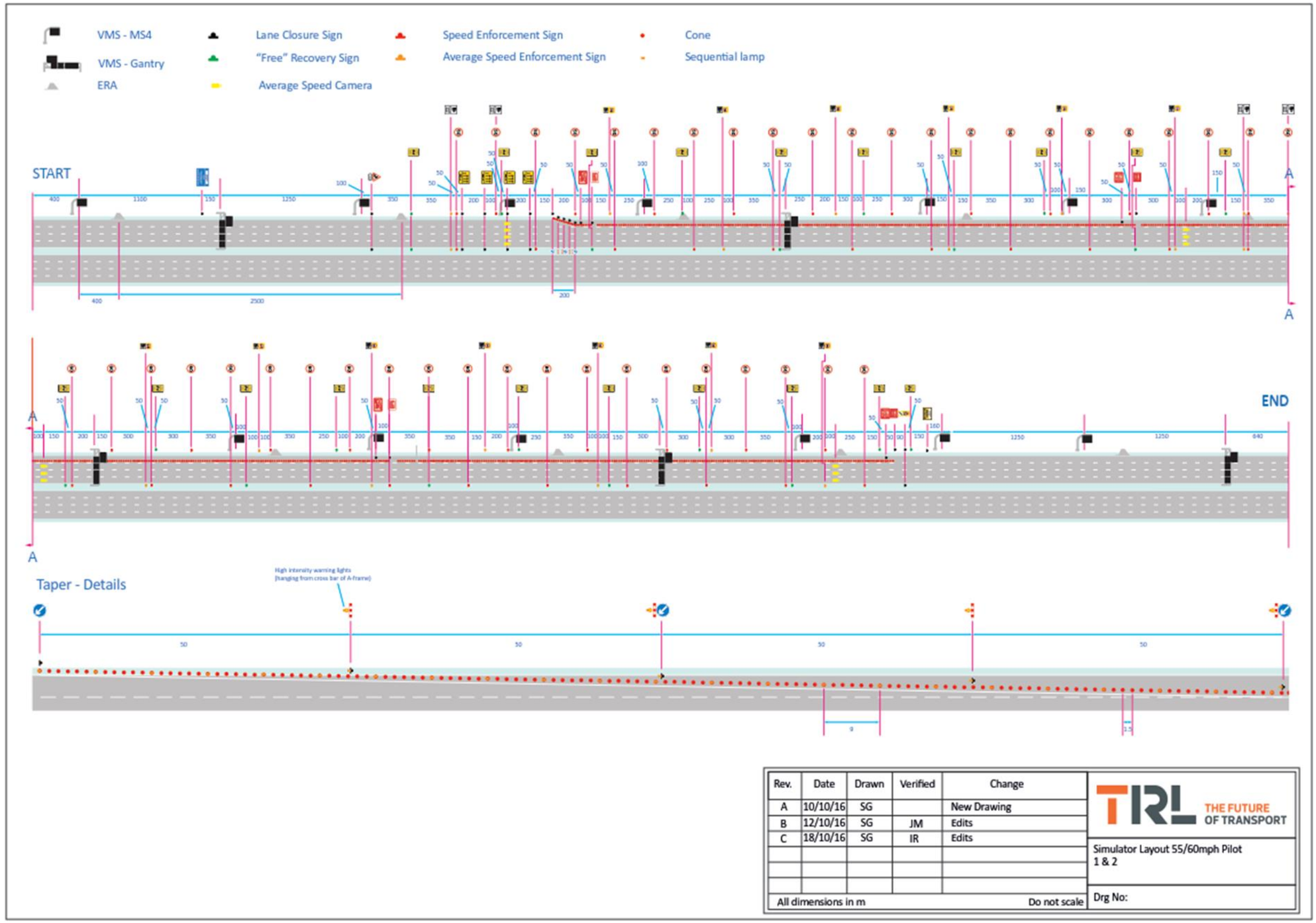
Appendix A Traffic management plan



Rev.	Date	Drawn	Verified	Change
A	10/10/16	SG		New Drawing
B	12/10/16	SG	JM	Edits
C	18/10/16	SG	IR	Edits
All dimensions in m				Do not scale

TRL THE FUTURE OF TRANSPORT

Simulator Layout 55/60mph Pilot 1 & 2

Drg No:

Appendix B Questionnaire

Trial Questionnaire

To be completed by Researcher		
Participant Number: _____	Trial time:_____	Date: _____/_____/_____

SECTION A. Background information		
A1. What was your age at your last birthday?		
A2. Are you male or female? (please tick)	Male	Female
A4. For how many years have you held a driver's licence?		
A5. Approximately how many miles do you drive per year?		

A6. Please estimate how often, on average, you drive on motorways, based on the last 12 months?

Please tick a box.

More than 3 times a week	Once or twice a week	A few times a month	A few times a year	Never

SECTION B. Your experience of driving through the scenario

Please ask the participants these questions after each drive. The questions are designed to ask them about their experiences driving through the roadworks.

Drive 1	Date:		Time:	

B1. How **safe** or unsafe did you feel when driving through the roadworks?

Very unsafe				Neither safe nor unsafe						Totally safe
0	1	2	3	4	5	6	7	8	9	10

B2. Was there anything in particular about the roadworks that made you feel **safe** or unsafe? Please describe below.

B3. How **satisfied** or dissatisfied with your journey did you feel when driving through the roadworks?

Very dissatisfied				Neither dissatisfied nor satisfied						Very satisfied
0	1	2	3	4	5	6	7	8	9	10

B4. Was there anything about the roadworks that made you feel especially satisfied or dissatisfied?

B5. How do you think driving through these roadworks would affect your journey time (compared to driving the same route with no roadworks)?

Journeys would be much **slower**				Would have no effect on journey time						Journeys would be much **faster**
0	1	2	3	4	5	6	7	8	9	10

B6. If your vehicle developed a fault and you needed to stop within the roadworks, how and where would you have brought your vehicle to a halt?
B7. When you were within the roadworks were you able to drive in your preferred lane? Was there anything about the drive that stopped you from doing so?
B8. What speed limit(s) do you remember seeing during the drive?
B9. Did you see any messages on the illuminated overhead signs and gantries? If so, what were they?

Drive 2	Date:		Time:	

B1. How **safe** did you feel when driving through the roadworks?

Very unsafe				Neither safe nor unsafe						Totally safe
0	1	2	3	4	5	6	7	8	9	10

B2. Was there anything in particular about the roadworks that made you feel **safe** or unsafe? Please describe below.

B3. How **satisfied** or dissatisfied with your journey did you feel when driving through the roadworks?

Very dissatisfied				Neither dissatisfied nor satisfied						Very satisfied
0	1	2	3	4	5	6	7	8	9	10

B4. Was there anything about the roadworks that made you feel especially satisfied or dissatisfied?

B5. How do you think driving through these roadworks would affect your journey time (compared to driving the same route with no roadworks)?

Journeys would be much **slower**				Would have no effect on journey time						Journeys would be much **faster**
0	1	2	3	4	5	6	7	8	9	10

B6. If your vehicle developed a fault and you needed to stop within the roadworks, how and where would you have brought your vehicle to a halt?
B7. When you were within the roadworks were you able to drive in your preferred lane? Was there anything about the drive that stopped you from doing so?
B8. What speed limit(s) do you remember seeing during the drive?
B9. Did you see any messages on the illuminated overhead signs and gantries? If so, what were they?

Drive 3	Date:		Time:	

B1. How **safe** did you feel when driving through the roadworks?

Very unsafe				Neither safe nor unsafe						Totally safe
0	1	2	3	4	5	6	7	8	9	10

B2. Was there anything in particular about the roadworks that made you feel **safe** or unsafe? Please describe below.

B3. How **satisfied** or dissatisfied with your journey did you feel when driving through the roadworks?

Very dissatisfied				Neither dissatisfied nor satisfied						Very satisfied
0	1	2	3	4	5	6	7	8	9	10

B4. Was there anything about the roadworks that made you feel especially satisfied or dissatisfied?

B5. How do you think driving through these roadworks would affect your journey time (compared to driving the same route with no roadworks)?

Journeys would be much **slower**				Would have no effect on journey time						Journeys would be much **faster**
0	1	2	3	4	5	6	7	8	9	10

B6. If your vehicle developed a fault and you needed to stop within the roadworks, how and where would you have brought your vehicle to a halt?
B7. When you were within the roadworks were you able to drive in your preferred lane? Was there anything about the drive that stopped you from doing so?
B8. What speed limit(s) do you remember seeing during the drive?
B9. Did you see any messages on the illuminated overhead signs and gantries? If so, what were they?

Drive 4	Date:		Time:	

B1. How **safe** did you feel when driving through the roadworks?

Very unsafe				Neither safe nor unsafe						Totally safe
0	1	2	3	4	5	6	7	8	9	10

B2. Was there anything in particular about the roadworks that made you feel **safe** or unsafe? Please describe below.

B3. How **satisfied** or dissatisfied with your journey did you feel when driving through the roadworks?

Very dissatisfied				Neither dissatisfied nor satisfied						Very satisfied
0	1	2	3	4	5	6	7	8	9	10

B4. Was there anything about the roadworks that made you feel especially satisfied or dissatisfied?

B5. How do you think driving through these roadworks would affect your journey time (compared to driving the same route with no roadworks)?

Journeys would be much **slower**				Would have no effect on journey time						Journeys would be much **faster**
0	1	2	3	4	5	6	7	8	9	10

B6. If your vehicle developed a fault and you needed to stop within the roadworks, how and where would you have brought your vehicle to a halt?
B7. When you were within the roadworks were you able to drive in your preferred lane? Was there anything about the drive that stopped you from doing so?
B8. What speed limit(s) do you remember seeing during the drive?
B9. Did you see any messages on the illuminated overhead signs and gantries? If so, what were they?

Drive 5	Date:		Time:	

B1. How **safe** did you feel when driving through the roadworks?

Very unsafe				Neither safe nor unsafe						Totally safe
0	1	2	3	4	5	6	7	8	9	10

B2. Was there anything in particular about the roadworks that made you feel **safe** or unsafe? Please describe below.

B3. How **satisfied** or dissatisfied with your journey did you feel when driving through the roadworks?

Very dissatisfied				Neither dissatisfied nor satisfied						Very satisfied
0	1	2	3	4	5	6	7	8	9	10

B4. Was there anything about the roadworks that made you feel especially satisfied or dissatisfied?

B5. How do you think driving through these roadworks would affect your journey time (compared to driving the same route with no roadworks)?

Journeys would be much **slower**				Would have no effect on journey time						Journeys would be much **faster**
0	1	2	3	4	5	6	7	8	9	10

B6. If your vehicle developed a fault and you needed to stop within the roadworks, how and where would you have brought your vehicle to a halt?
B7. When you were within the roadworks were you able to drive in your preferred lane? Was there anything about the drive that stopped you from doing so?
B8. What speed limit(s) do you remember seeing during the drive?
B9. Did you see any messages on the illuminated overhead signs and gantries? If so, what were they?

Drive 6	Date:		Time:	

B1. How **safe** did you feel when driving through the roadworks?

Very unsafe				Neither safe nor unsafe						Totally safe
0	1	2	3	4	5	6	7	8	9	10

B2. Was there anything in particular about the roadworks that made you feel **safe** or unsafe? Please describe below.

B3. How **satisfied** or dissatisfied with your journey did you feel when driving through the roadworks?

Very dissatisfied				Neither dissatisfied nor satisfied						Very satisfied
0	1	2	3	4	5	6	7	8	9	10

B4. Was there anything about the roadworks that made you feel especially satisfied or dissatisfied?

B5. How do you think driving through these roadworks would affect your journey time (compared to driving the same route with no roadworks)?

Journeys would be much **slower**				Would have no effect on journey time						Journeys would be much **faster**
0	1	2	3	4	5	6	7	8	9	10

B6. If your vehicle developed a fault and you needed to stop within the roadworks, how and where would you have brought your vehicle to a halt?
B7. When you were within the roadworks were you able to drive in your preferred lane? Was there anything about the drive that stopped you from doing so?
B8. What speed limit(s) do you remember seeing during the drive?
B9. Did you see any messages on the illuminated overhead signs and gantries? If so, what were they?

Drive 7	Date:		Time:	

B1. How **safe** did you feel when driving through the roadworks?

Very unsafe				Neither safe nor unsafe						Totally safe
0	1	2	3	4	5	6	7	8	9	10

B2. Was there anything in particular about the roadworks that made you feel **safe** or unsafe? Please describe below.

B3. How **satisfied** or dissatisfied with your journey did you feel when driving through the roadworks?

Very dissatisfied				Neither dissatisfied nor satisfied						Very satisfied
0	1	2	3	4	5	6	7	8	9	10

B4. Was there anything about the roadworks that made you feel especially satisfied or dissatisfied?

B5. How do you think driving through these roadworks would affect your journey time (compared to driving the same route with no roadworks)?

Journeys would be much **slower**				Would have no effect on journey time						Journeys would be much **faster**
0	1	2	3	4	5	6	7	8	9	10

B6. If your vehicle developed a fault and you needed to stop within the roadworks, how and where would you have brought your vehicle to a halt?
B7. When you were within the roadworks were you able to drive in your preferred lane? Was there anything about the drive that stopped you from doing so?
B8. What speed limit(s) do you remember seeing during the drive?
B9. Did you see any messages on the illuminated overhead signs and gantries? If so, what were they?

Drive 8	Date:		Time:	

B1. How **safe** did you feel when driving through the roadworks?

Very unsafe				Neither safe nor unsafe						Totally safe
0	1	2	3	4	5	6	7	8	9	10

B2. Was there anything in particular about the roadworks that made you feel **safe** or unsafe? Please describe below.

B3. How **satisfied** or dissatisfied with your journey did you feel when driving through the roadworks?

Very dissatisfied				Neither dissatisfied nor satisfied						Very satisfied
0	1	2	3	4	5	6	7	8	9	10

B4. Was there anything about the roadworks that made you feel especially satisfied or dissatisfied?

B5. How do you think driving through these roadworks would affect your journey time (compared to driving the same route with no roadworks)?

Journeys would be much **slower**				Would have no effect on journey time						Journeys would be much **faster**
0	1	2	3	4	5	6	7	8	9	10

B6. If your vehicle developed a fault and you needed to stop within the roadworks, how and where would you have brought your vehicle to a halt?
B7. When you were within the roadworks were you able to drive in your preferred lane? Was there anything about the drive that stopped you from doing so?
B8. What speed limit(s) do you remember seeing during the drive?
B9. Did you see any messages on the illuminated overhead signs and gantries? If so, what were they?

SECTION C. Your experience of the trial

Please complete this section at the end of all of the scenario drives.

The questions below will ask you about your experiences driving through the **roadworks**. By roadworks we mean the section between the first sign you saw showing there were works ahead and the "national speed limit applies" sign that was present at the end of the coned section.

C1. What speed limit(s) would you prefer to see in roadworks? Please explain the reasons for your answer?

C2. Do you think that drivers who exceed the speed limit **through roadworks on motorways** should be detected and penalised?

Please answer by ticking a box.

Yes		No		Don't know	

C2a. What do you think is the lowest speed at which drivers **would be** detected and penalised through roadworks on motorways with a speed limit of…	
50mph	
55mph	
60mph	
70mph	

C2b. What do you think is the lowest speed at which drivers ***should* be** detected and penalised through roadworks on motorways with a speed limit of…	
50mph	
55mph	
60mph	
70mph	

C3. Do you think that drivers who **exceed the National Speed Limit (70mph) on motorways with no roadworks** should be detected and penalised? Please answer by ticking a box.					
Yes		No		Don't know	
C3a. What do you think is the lowest speed at which drivers **would be** detected and penalised on motorways with the National Speed Limit?					
C3b. What do you think is the lowest speed at which drivers **should be** detected and penalised on motorways with the National Speed Limit?					

SECTION D. General comments

D1. Please use the space below to provide any general comments or suggestions you have regarding your experiences today.

This is the end of the questionnaire.
Many thanks for your participation in this trial

Appendix C Responses to safety and satisfaction questions

C.1 Comments on safety

Table 6: Reasons for feeling safe

Theme	50	55	60	70	50-55	50-60	60-55	60-50
Speed	4	1	2	3	2	4	2	3
Speed limit consistency	1	0	3	1	0	0	0	0
Signage	2	4	4	2	5	4	5	1
Average speed cameras	1	1	0	0	0	1	0	0
Road layout	4	1	1	1	2	2	2	3
Traffic behaviour	3	2	4	3	6	5	3	1
Recovery & refuge	0	1	2	0	0	0	0	1

Table 7: Reasons for feeling unsafe

Theme	50	55	60	70	50-55	50-60	60-55	60-50
Speed	2	1	3	1	2	4	0	0
Change in speed limit	0	0	0	0	2	0	4	4
Signage	0	0	0	11	0	0	1	1
Average speed cameras	1	1	0	0	0	0	1	0
Road layout	0	1	0	2	1	1	0	3
Traffic behaviour	9	9	5	2	2	1	6	8
Recovery and refuge	2	4	5	0	0	1	1	0
HGVs	3	0	0	0	2	2	0	1
Fatigue or boredom	0	0	1	0	0	1	1	0

C.2 Comments on satisfaction

Table 8: Reasons for feeling satisfied

Theme	50	55	60	70	50-55	50-60	60-55	60-50
Speed limit	2	0	5	6	2	4	2	4
Consistency of speed limit	1	0	4	0	0	0	0	0
Change in speed limit	0	0	0	0	0	3	0	0
Signage	3	5	5	0	1	2	3	2
Average speed cameras	1	0	0	0	0	0	0	0
Road layout	0	1	0	1	0	1	1	2
Traffic behaviour	3	1	2	3	5	2	2	0
Recovery and refuge	0	0	0	0	0	1	1	1

Table 9: Reasons for feeling dissatisfied

Theme	50	55	60	70	50-55	50-60	60-55	60-50
Speed limit	6	8	0	0	3	0	5	2
Consistency of speed limit	1	0	0	0	0	0	0	0
Change in speed limit	0	0	0	0	2	0	3	7
Signage	0	0	0	8	1	1	0	0
Average speed cameras	0	0	0	3	0	0	0	1
Road layout	0	2	0	1	2	2	1	0
Traffic behaviour	1	3	3	3	3	5	4	0
Recovery and refuge	0	1	2	2	0	0	1	0
HGVs	1	0	0	0	0	0	1	0
Lack of activity in works	2	2	2	2	2	1	0	2

Monitoring and evaluation of the 55/60mph pilots

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