Smart Motorway All Lane Running Overarching Safety Report 2019

Highways England

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Combined evaluation results from nine SMALR

This report represents the combined findings for nine Smart Motorway All Lane Running (SMALR) schemes across England. These have been monitored and evaluated by Atkins on an individual basis as part of the SMALR Monitoring and Evaluation Projects.

The safety performance metrics assessed are:

SM-ALR safety performance metrics

- Personal injury collisions (PIC) and collision rate
- Killed and seriously injured (KSI) collisions and collision rate
- Personal injury casualties and casualty rate
- KSI casualties and casualty rate
- Fatal and weighted injury (FWI) casualties and casualty rate

Larger sample size enables more conclusions to be drawn

The purpose of this overarching evaluation is to present a wider picture. Combining data from all the schemes provides a larger sample size, increasing the evidence from which we have drawn our conclusions. This overarching evaluation also enables the safety performance of the individual schemes to be compared.

Collisions and casualties

Statistically significant improvements in collision and casualty rates

Overall, the results show strong safety performance of All Lane Running (ALR).

There has been a statistically significant improvement in PIC rate, with the absolute reduction of 22% exceeding the national trend by 12%. Similarly, there has been a statistically significant improvement in casualty rate, with the absolute reduction of 28% exceeding the national trend by 10%.

FWI rate improved above national motorway trend

FWI rate is the most informative performance metric. Overall, there has been an absolute improvement of 0.10 FWI per hundred million vehicle miles (hmvm). The reduction is 0.09 per hmvm better than the national motorway trend.

KSI rates worsened in line with national trends

The KSI collision rate across the nine schemes has increased from 1.03 to 1.18 collisions per hmvm, an increase of 0.15 per hmvm which is in line with the national background trend in the same period.

Overall safety has improved

In summary, the results show that the overall performance of the ALR schemes evaluated has improved. Against a background of increasing flows, the safety objective has been met which is no increase in number or rate of FWI casualties.

Additional collision analysis

Shunt and single vehicle run off PICs reduced

The personal injury collisions (PIC) rates for shunts and incidents involving single vehicles have reduced. There has been a negligible reduction in side swipe collision rate.

Human error remains predominant factor in collisions

Rates of nine of the top ten contributory factors in the After periods have reduced, suggesting that road users were less prone to errors when travelling on ALR schemes, although human error remained the predominant contributory factor in PICs.

Live lane breakdowns occur less often than predicted

As we had anticipated, the rate of PIC as a result of live lane breakdowns (LLB) increased. However, the number of breakdowns was lower than forecast, on all nine schemes.

Average compliance with Red X was 94%

One EA stop every four hours; EAs not occupied for long periods

Compliance

Average Red X compliance was above 92% in all nine schemes evaluated, with an overall compliance of 94.3%.

On average, one stop was observed per Emergency Area (EA) every four hours. Of the 452 unique EA stops observed, 71% were non-emergency and 29% were genuine. The duration of non-emergency stops averaged to 2 minutes 35 seconds and that of genuine stops averaged to 14 minutes 10 seconds. We conclude that EAs are not typically occupied for long periods.

1. Introduction

1.1. Project background

The first Smart Motorway All Lane Running (SMALR) scheme was opened in 2014 and since then further schemes have been implemented on some of the busiest parts of the motorway network. The current SM design standard is documented in IAN161/15: Smart Motorways[1].

SMALR schemes across England have been monitored and evaluated by Atkins on an individual basis as part of the SMALR Monitoring and Evaluation Projects. It is crucial that the performance and any associated impacts of the schemes are accurately assessed in order to:

- review the safety performance
- inform Highways England of any changes in the safety risk assessment
- quantify and provide evidence of the benefits of the SMALR concept
- provide evidence to help improve the design requirements and the concept of operation

1.2. Purpose of the report

The purpose of this overarching evaluation is to present a wider picture of SMALR by collating the findings obtained from nine evaluated SMALR schemes. Combining data from all the schemes provides a larger sample size, increasing the number of conclusions that can be drawn where the sample for individual schemes is prohibitively small. This overarching evaluation enables the safety performance of the individual schemes to be compared.

1.3. Report structure

There are a further six sections in this report as follows:

- Section 2: Evaluation framework – detailing the schemes, time periods and data used
- Section 3: Collision and casualty rates – shows the results of the collision and casualty analysis
- Section 4: Additional collision analysis – covering collision types, factors that may influence safety and the generic hazard log
- Section 5: Compliance – covering Red X and Emergency Area use
- Section 6: Conclusions

[1] Highways England. Interim Advice Note 161/15: Smart Motorways. Available from: http://www.standardsforhighways.co.uk/ha/standards/ians/pdfs/IAN161_15.pdf [Accessed 15 April 2019].

2. Evaluation framework

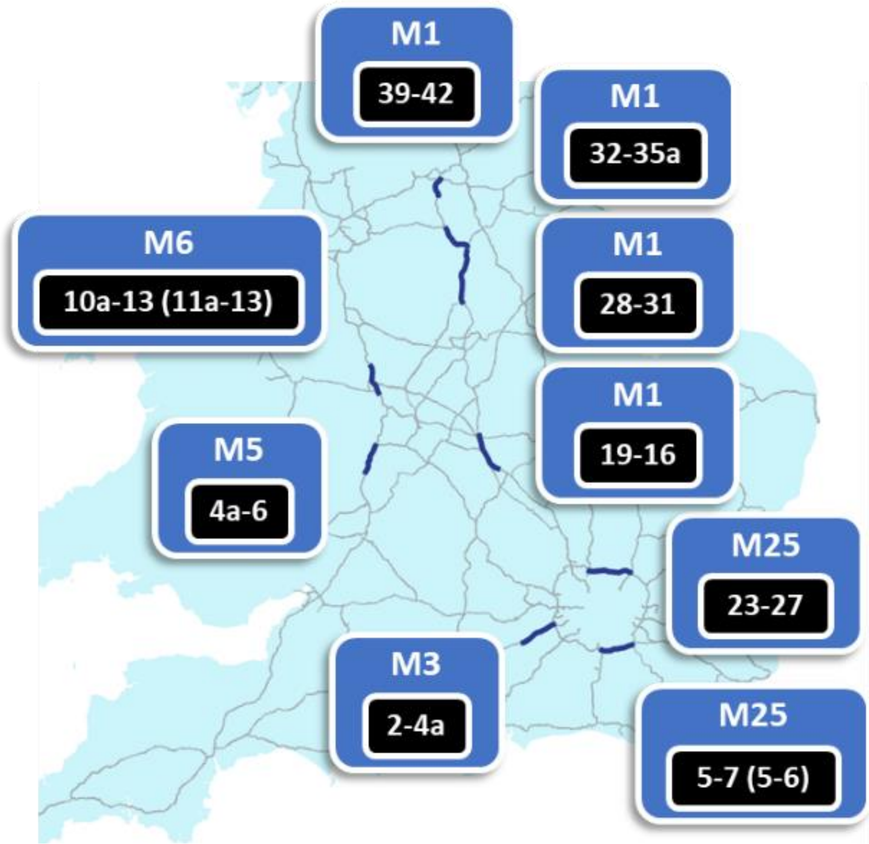
2.1. Schemes and evaluation periods

Evaluations were carried out by comparing the post-implementation (After) data against the pre-implementation (Before) data. For simplicity and clarity, the following terms are used throughout this report when referring to results:

- Before (absolute) – Results calculated using the actual data associated with the Before period
- Before (counterfactual) – Before results derived from the actual After data, assuming the national motorway trend has been followed
- After – Results calculated using the actual data associated with the After period

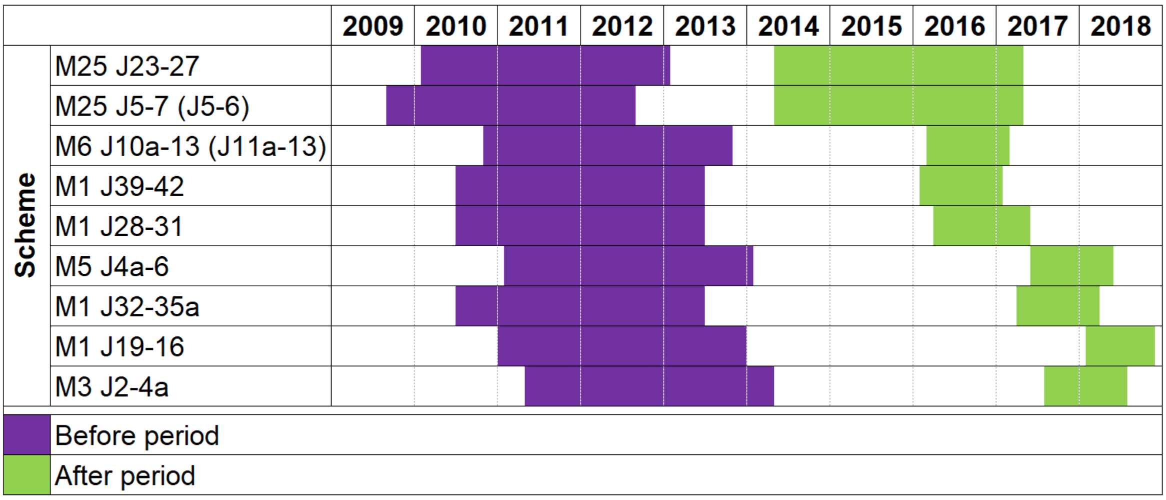
With the view to forming like-for-like comparisons, the Before and the After periods were carefully selected. The periods were chosen to be as close as possible to minimise the risk of any other factors that could skew the results. In addition, it was ensured that the traffic conditions have remained as consistent as possible, and that no major works or developments were in place in the vicinity of the schemes of interest. The geographical locations of these schemes are illustrated in Figure 2-1. Figure 2-2 shows the schemes covered by this overarching evaluation and their respective evaluation periods. A total of nine SMALR schemes are covered in this report. Note that the two M25 ALR schemes have been evaluated for three-year After periods and the results provided in separate reports; M25 J5-7[2] and M25 J23-27[3].

Figure 2-1 Geographical locations of the SMALR schemes evaluated



[2] https://www.gov.uk/government/publications/m25-junction-5-to-7-third-year-evaluation-report
[3] https://www.gov.uk/government/publications/m25-junction-23-to-27-third-year-evaluation-report

Figure 2-2 'Gantt chart' showing SMALR schemes evaluated and their respective evaluation periods



2.2. Time slices

The time slices shown in Table 2-1 and Table 2-2 have been used in cases where an analysis was day type and/or time slice dependent during the weekday.

Table 2-1 Time slices used in the evaluations of the two M25 schemes

		M25 J23-27		M25 J5-7 (J5-6)	
		Start	End	Start	End
Weekday (Monday to Thursday)	AM	05:30	10:30	05:30	10:30
	IP	10:30	15:00	10:30	15:00
	PM	15:00	20:00	15:00	20:00
	Overnight	20:00	05:30	20:00	05:30
Weekday (Friday)	AM	05:00	09:00	05:30	09:00
	IP	09:00	13:00	09:00	13:00
	PM	13:00	20:00	13:00	20:00
	Overnight	20:00	05:00	20:00	05:30

Table 2-2 Time slices used in the evaluations of the remaining schemes

		Start	End
Weekday	AM	06:30	09:30
	IP	09:30	15:30
	PM	15:30	18:30
	Overnight	18:30	06:30

2.3. Data sources

STATS19 provides records of all injury collisions and has been used to identify changes in collision rate and severity. It is collected by the police at the scene of a collision before being aggregated and checked by the local authority and made available for use in the evaluations. Operational STATS19 was used because it includes free-text collision descriptions, which provided extra context to the evaluations.

Disclaimer: *"The accident data referred to in this report has not necessarily been derived from the national validated accident statistics produced by the Department for Transport. As such, the data may subsequently be found to be incomplete or contain inaccuracies. The requirement for up to date information and site-specific data was a consideration in the decision to use operational STATS19 data and, as it is sourced from Local Processing Units through Highways England's Asset Support Contractors, it is sufficiently robust for use in this context."*

Command & Control and Control Works are both Highway England's incident management systems; the former was replaced by the latter on 3rd September 2016. Command & Control and Control Works will be referred to as C&C and CW, respectively; or when combined, C&C/CW hereafter. C&C/CW are intended for operational purposes, whereby all incidents are logged regardless of whether any injuries are involved. In the case of road traffic collisions, although codes are used to categorise collisions into injury and non-injury, the injury collisions are not further categorised into severity levels. However, considering that C&C/CW typically has a lead time of less than a month, C&C/CW is a good proxy to provide an indication of safety performance.

2.4. Statistical analysis and background trend analysis

When evaluating the impact of an intervention, it is important to ensure that the results are not skewed by background trends in the data being assessed. There has been a national trend of reducing personal collision rate and, during the period of analysis of the ALR schemes, a slight increase in killed and seriously injured collision rate.

The best way to take into account the national trend is to assume that, if the scheme had not been built, the number of collisions on the roads in the study area would have changed at the same rate as they did nationally during the same time period. This provides what is known as a counterfactual 'without scheme' scenario and can be compared on a like-for-like basis with the observed After data which is the 'with scheme' scenario[4]. The difference between the numbers of collisions in these two scenarios can then be attributed to the scheme rather than the wider national trends.

It should be noted that while improvements in collision rate on ALR schemes during the period will have contributed to the national trend of reducing collision rate, the impact will be slight because SM schemes installed in the period only make up a small proportion of the national motorway network.

Analysis of accident statistics, will often show variations in numbers and rates from year to year. This could be for any number of reasons, not least random fluctuation, due to the unpredictable nature of accidents and a host of other variables. 'Chi-squared goodness of fit' tests were used to test for statistical significance between the Before (counterfactual) and After STATS19 results using Department for Transport statistics on motorway collisions and casualties[5]. The test uses 'confidence levels' to explain the level of confidence that a result is due to the intervention being evaluated. A confidence level of 95% is commonly adopted, meaning that if the chi-squared test is passed, there is a 95% certainty that a change happened as a result of the intervention. If not, there was 'effectively no change' as a result of the intervention. In the context of this project, our use of this terminology should be taken to mean:

- A result that is statistically significant would suggest with 95% certainty that the change was a direct impact of ALR.
- A result that is not statistically significant suggests that the trends we have observed are likely to be due to chance rather than our intervention.

[4] The counterfactual factor is calculated using the national collision data for motorway class roads in the middle year of the After period (2016) and for the middle year in the Before period (2012).
[5] Department for Transport. Reported road casualties in Great Britain: 2016 annual report. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/648081/rrcgb2016-01.pdf [Accessed 15 April 2019].

It should be noted that statistical analysis was only performed when the requirements for number of collisions were met, because very small sample make the analysis impossible.

An effect size was calculated when a change in rate was statistically significant. The effect size is a measure of the magnitude of deviation between the observed frequency values and the expected frequency values. It can vary from 0 to 1, where 0.10, 0.30 and 0.50 correspond to small, medium and large magnitudes, respectively. It follows that while a change indicating worsening performance might be statistically significant, the level of concern that should be raised would be relatively less in the case of a small effect size (slight degree of worsening) than that of a large effect size (considerable degree of worsening).

Due to the relatively rare occurrence of collisions on the motorway network, it was found that the small sample size meant it would sometimes be inappropriate for statistical analysis to be carried out on ALR performance measures such as the Killed and Seriously Injured (KSI) collision rates on a scheme by scheme basis. Therefore, the overarching evaluation is intended to take the results from all evaluated schemes together to produce a larger sample size.

3. Collision and casualty rates

3.1. Introduction

The safety objective of SMALR is for the safety of ALR not to worsen when compared to traditional motorways. To evaluate the safety performance of the nine ALR schemes covered in this report, standard performance measures have been used. The results of these evaluations are presented in Section 3.2 and Section 3.3. Section 3.4 presents the results of an investigation into the 'CRASH' effect, and Section 3.5 contains a summary.

The safety performance metrics assessed are:

- Personal injury collisions and collision rate
- Killed and seriously injured (KSI) collisions and collision rate
- Personal injury casualties and casualty rate
- KSI casualties and casualty rate
- Fatal and weighted injury (FWI[6]) casualties and casualty rate

IAN 161 specifies that an all lane running scheme will satisfy the minimum road user safety objective if it is demonstrated for a period of three years after becoming fully operational that:

- The average FWI per year is at or below the number in the 'Before' period.
- The rate of FWI per hundred million vehicle miles per annum is no more than the number than the rate in the 'Before' period.

This was the safety objective for all nine schemes assessed in this project and is therefore the key performance metric.

High level results are presented graphically throughout to facilitate visual comparisons between the performance of the schemes evaluated. Most of the graphs (apart from for 'CRASH effect' analysis in Section 3.4) show the rates for Before (absolute), Before (counterfactual), and After. Detailed numerical values are co-located in the Appendices to aid further discussion should the performance of any scheme require more in-depth investigation.

3.2. Collisions

3.2.1. Personal injury collisions and collision rates

The personal injury collision rates are summarised graphically in Figure 3-1 while the detailed numerical values can be found in Table A-1 in Appendix A.

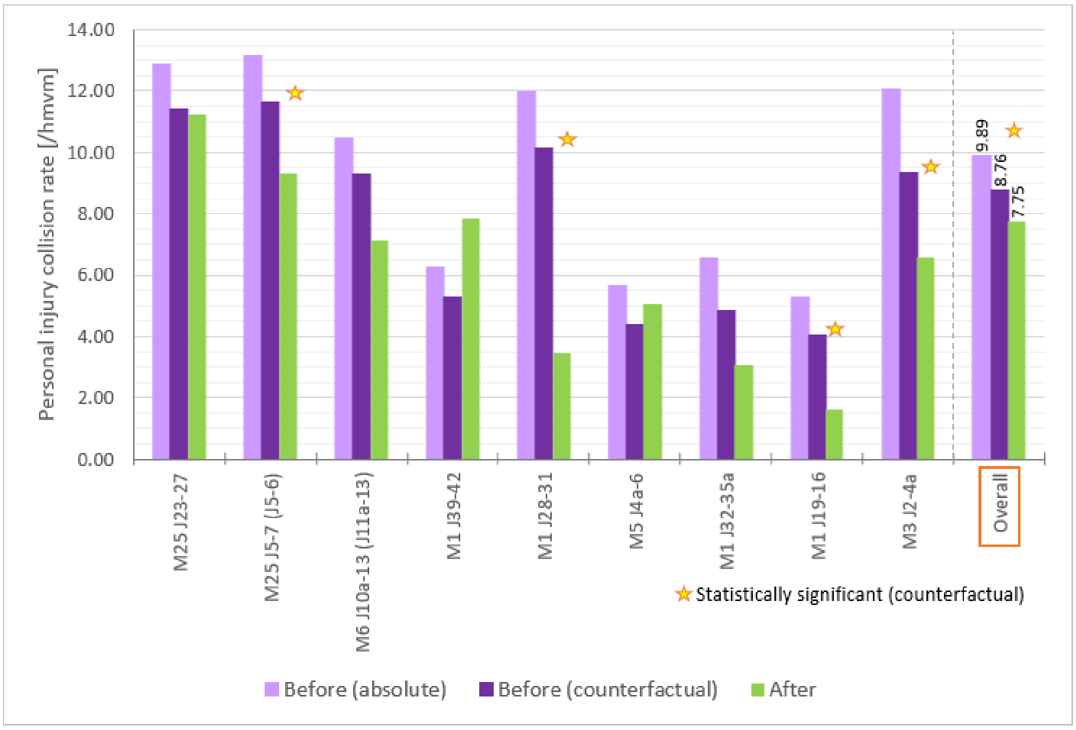
Overall, there has been an absolute reduction of 21.6% in the personal injury collision rate, from 9.89 to 7.75 per hmvm. When taking into account the national motorway trend of an 11.4% reduction in personal injury collision rate, there has been a statistically significant reduction of 1.01 collisions per hmvm, which is an 11.5% improvement. Reductions greater than the national background trend were seen in seven of the nine schemes evaluated, of which the improvement on four of the schemes was statistically significant. The greatest improvement was seen on the M1 J28-31 scheme. It should be noted that this scheme was subjected to a permanent 60mph speed limit during peak hours for air quality purposes and this may have had a positive impact on the number and severity of collisions.

The M1 J39-42 and M5 J4a-6 schemes were the only two schemes of the nine evaluated that showed worsening performance in terms of the personal injury collision rate; however, the changes were not statistically significant when taking into account the national motorway trend, meaning the change was not necessarily as a result of ALR. The lack of significance is due to the small difference between the annual

[6] Fatal and Weighted Injury (FWI) is based on the number of fatal, serious and slight casualties as weighted proportions, to adjust for severity. FWI is defined as (number of fatalities) + 0.1 x (number of serious casualties) + 0.01 x (number of slight casualties)

average number of personal injury collisions in the Before and the After periods relative to other schemes. The M1 J39-42 was the only scheme to see an increase in side-swipe collisions (Section 4.2.1).

Figure 3-1 Personal injury collision rates



3.2.2. KSI collisions and collision rates

The KSI collision rates and numerical values for each scheme are detailed in Table A-2 in Appendix A.

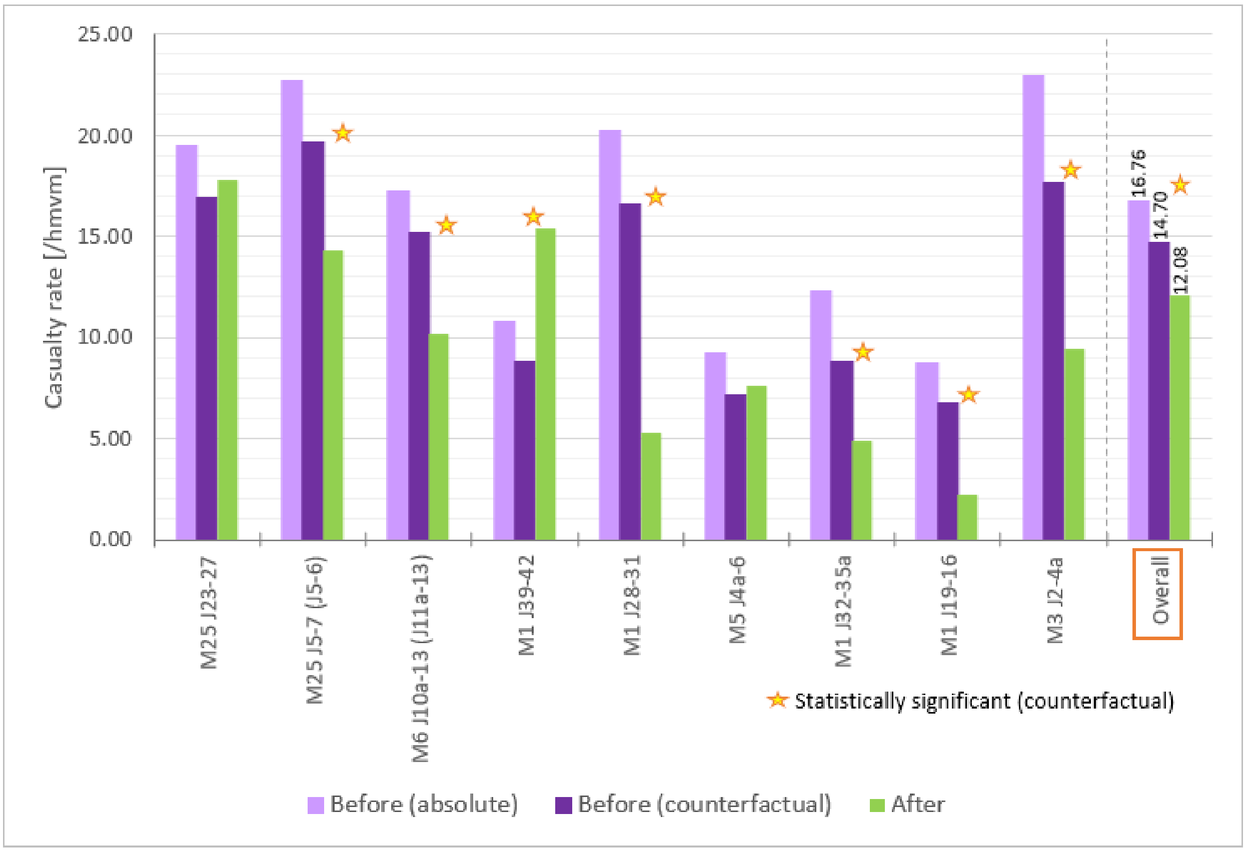
The KSI collision rate across the nine schemes has increased from 1.03 to 1.18 collisions per hmvm, an increase of 0.15 per hmvm which is in line with the national background trend in the same period. This change is not statistically significant. Of the nine schemes evaluated, four showed improvement, while five showed worsening. However, these changes were either not statistically significant when accounting for the national motorway trend or the sample sizes were too small for statistical analyses to be carried out. The five schemes which worsened each had five or fewer KSI collisions per year in the Before period. Given the very small sample size of KSI collisions and the fact that the overall change is in line with the national average, none of the changes in KSI rate are attributable to the schemes.

3.3. Casualties

3.3.1. Casualties and casualty rates

The casualty rates are presented graphically in Figure 3-2. The detailed numerical values are included in Table B-1 in Appendix B.

Figure 3-2 Casualty rates



Overall, there has been an absolute reduction of 27.9% in the casualty rate, from 16.76 to 12.08 per hmvm. When taking into account the national motorway trend of a 12.3% reduction in casualty rate, there has been a statistically significant reduction of 2.62 casualties per hmvm, which is a 17.8% improvement. This change was statistically significant.

Of the nine schemes, improvement was seen in six and worsening was seen in three. The greatest improvement was seen on M1 J28-31 while worsening was seen on the M1 J39-42 scheme. On the M1 J39-42 scheme, although the number of casualties per annum in the After period was comparable to the other schemes evaluated, the number of casualties in the Before period was the lowest among all the schemes. Considering the relatively small baseline compared to the other schemes and that the annual vehicle distance travelled has remained similar, it is not surprising that any changes in the number of casualties would produce a larger percentage change. It should also be noted that while the worsening in the casualty rate on this scheme was statistically significant, the associated effect size of 0.22 was between small and medium, meaning that the impact of this on overall safety performance was relatively small.

3.3.2. KSI casualties and KSI casualty rates

The KSI casualty rates and numerical values for each scheme are detailed in Table B-2 in Appendix B.

The KSI casualty rate across the nine schemes has increased from 1.19 to 1.35 per hmvm, an increase of 0.16 per hmvm which is in line with the national background trend in the same period. The change is not statistically significant. Of the nine schemes evaluated, three showed improvement, while six showed worsening. However, these changes were either not statistically significant when accounting for the national motorway trend in KSI casualty rate or the sample sizes were too small for statistical analyses to be carried out. The five schemes which worsened each had 16 or fewer KSI casualties per year in the Before period. This means that none of the changes in KSI rate are attributable to the schemes, which is understandable given the very small sample of KSI casualties and the fact that the overall change is in line with the national average.

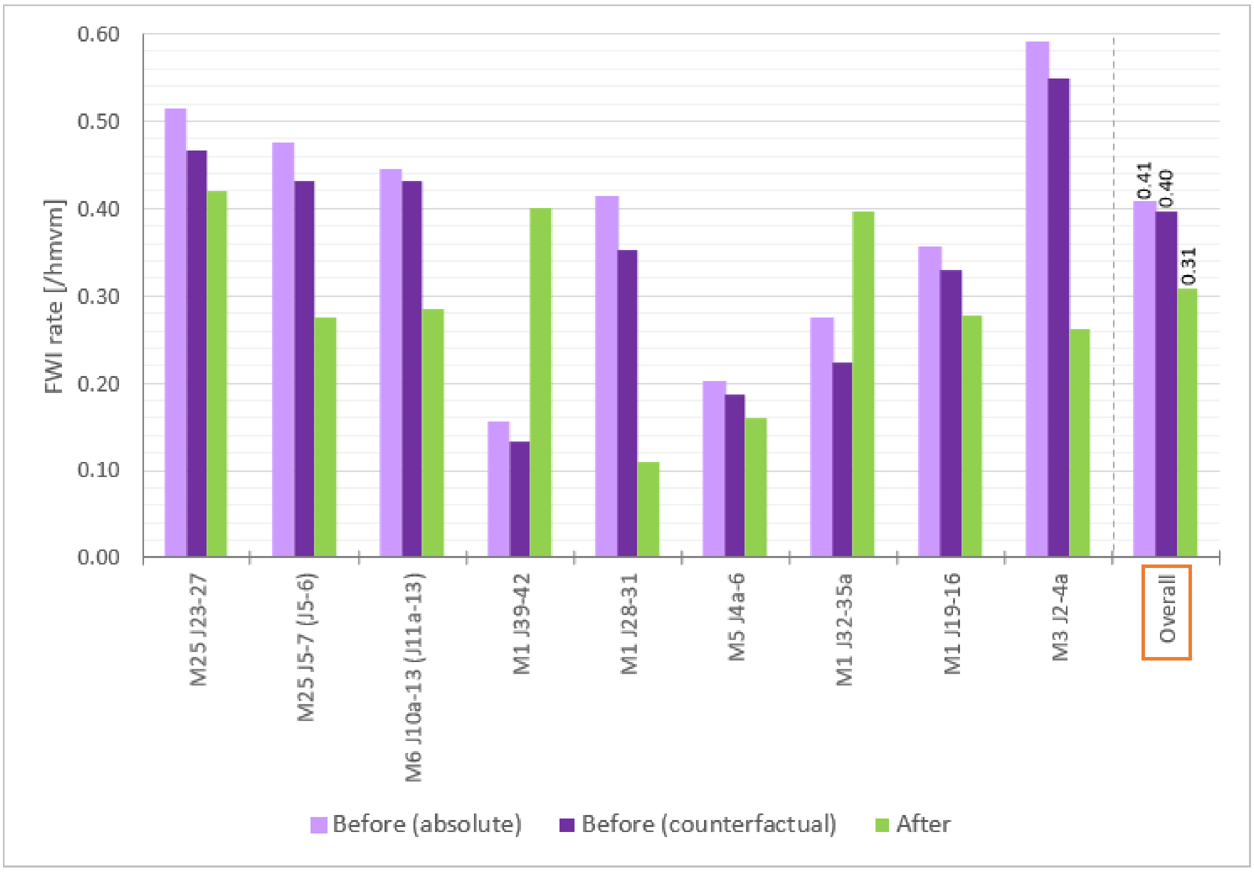
It is worth noting that the M1 J39-42 scheme had the smallest number of KSI casualties in the Before period. Considering that the annual vehicle distance travelled has remained similar, any changes in the After period against such a small baseline would therefore result in a large percentage change compared to other schemes that had a relatively larger baseline. Variability could also be responsible for large percentage changes if the sample size is small in general. For example, on the M6 J10a-13 (J11a-13) scheme, there were seven KSI casualties in the three-year Before period, and six in the After period; and on the M5 J4a-6 scheme, there were five KSI casualties in the three-year Before period, and four in the After period.

3.3.3. FWI and FWI rates

The FWI rates are presented graphically in Figure 3-3. The detailed FWIs are included in Table B-3 in Appendix B.

The FWI rate across the nine schemes has reduced from 0.41 to 0.31 per hmvm, an improvement of 0.10 per hmvm which is 0.09 per hmvm better than the national background trend. Of the nine schemes evaluated, seven showed an improvement in the FWI rate. The statistical significance of these results however could not be ascertained as it was deemed inappropriate to conduct Chi-Square ‘goodness of fit’ tests on a weighted metric because the test does not allow for transformation of data. In other words, the test does not accommodate for the respective weighting of the three severity levels of fatal, serious and slight. However, given the context of the statistically significant improvement in the personal injury collision rate, this result is also positive.

Figure 3-3 FWI rates



The two schemes that showed worsening in the FWI rate were the M1 J39-42 and M1 J32-35a schemes. The relatively low FWI rate in the Before period on the M1 J39-42 scheme was because there were no fatalities and only 4 serious casualties recorded during the three-year period. As such, when seven serious casualties was recorded in the one-year After period, the percentage change was large. On the M1 J32-35a scheme, there were one fatal casualty, eight serious casualties and 130 slight casualties in the Before period. In the After period, there were one fatal casualty, four serious casualties and 14 slight casualties on this scheme. The average annual vehicle distance travelled in both the Before and the After periods was similar. Although there were 5 fatal casualties in the After period, compared to 20 in the Before period, the number of slight casualties has reduced by roughly a third in the After period. However, considering that the

FWI is heavily weighted towards the number of fatal casualties, the reduction in the number of slight casualties per annum was not sufficient to outweigh the increase in the number of fatal casualties per annum.

3.4. The 'CRASH effect'

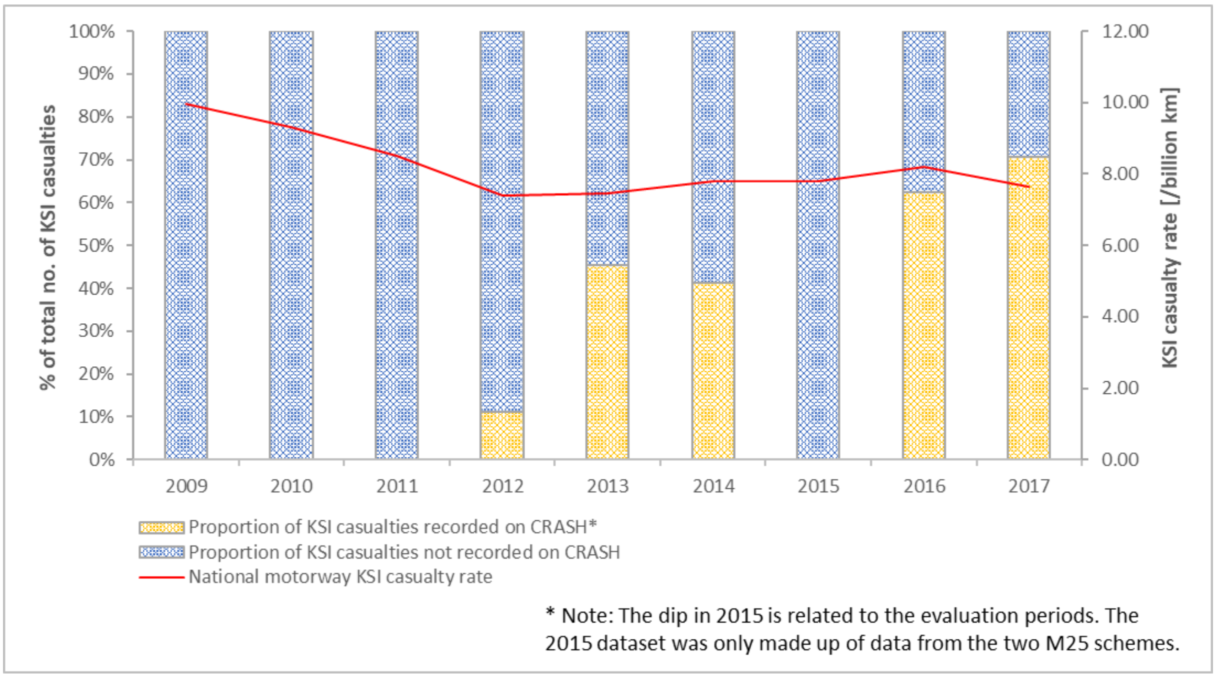
In recent years, a new system, Collision Recording And SHaring (CRASH) system has been implemented in some police areas. This has slightly changed the processes involved in the classification of casualty severity, which is correlated with the collision severity. It was hypothesised that the casualty severity level could be more accurately recorded by replacing manual classification by the police officers at the scene with automatic classification based on the injury types recorded. Early indications suggest that the migration to CRASH has increased the number of serious injuries recorded by 5 to 15%[7]. This is known as the 'CRASH effect'. The 'CRASH effect' could have skewed the results where CRASH was implemented between the start and end of the evaluation period, causing a false image to be portrayed.

Seven of the nine SMALR schemes evaluated were subject to the 'CRASH effect', some to a greater extent than the others. A summary of the extent to which each of the nine schemes evaluated was affected is included in Table B-4 in Appendix B. The associated impacts are difficult to quantify because:

- CRASH was not implemented universally across all police areas;
- Some police areas, such as South Yorkshire had a trial implementation period; and
- Some of the SMALR schemes evaluated span multiple police areas.

Figure 3-4 shows the proportions of KSI casualties in the overarching dataset recorded and not recorded on CRASH as well as the national motorway trend in KSI casualty rate.

Figure 3-4 Proportions of KSI casualties in the overarching dataset recorded on CRASH



Prior to 2012, there has been a clear decreasing trend in the national KSI casualty rate. However, this reduction appears to have stalled in 2012 and has increased by a slight amount in the following years. Figure 3-4 shows that there has been a general trend in increasing proportion of KSI casualties recorded on the CRASH system since 2012. It is worth noting that the transition in 2012 seen in the national trend coincides with the first year that some of the data in the overarching dataset was recorded on the CRASH system. The

[7] Highways England. Reported Road Casualties on the Strategic Network 2016. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/725587/SRN_Casualty_Report_2016_v3_0._July_2018.pdf [Accessed 15 April 2019].

dip in 2015 is related to the evaluation periods. The 2015 dataset was only made up of data from the two M25 schemes. The increase in the KSI casualty rate seen in the overarching dataset reflects the trend in the national KSI casualty rate; however, it cannot be conjectured as to whether the national motorway casualty figures have been affected by a similar degree to that of the overarching dataset. Only a small proportion of motorways on Highways England's network have been converted to ALR, and the length of SMALR schemes in each police force area differs.

To provide an indication of the 'CRASH effect' on the overarching dataset, a correction factor was applied. A summary of the overall number of serious casualties recorded and not recorded on the CRASH system can be found in Table B-5 in Appendix B.

Correction factors of 5% and 15% were used. The casualty data that was recorded on the CRASH system was extracted and 5% or 15% of those that were recorded as seriously injured were re-classified as slightly injured. The results are presented in Figure 3-5. It should be noted that counterfactual analyses could not be carried out. In other words, this analysis does not account for the national background trends. This is because the national background trends would have been subject to the 'CRASH effect' as well and it would take an extensive amount of effort to perform a CRASH adjustment on all national motorway personal injury collisions.

Figure 3-5 Percentage changes in KSI casualty rate adjusted for the 'CRASH effect'

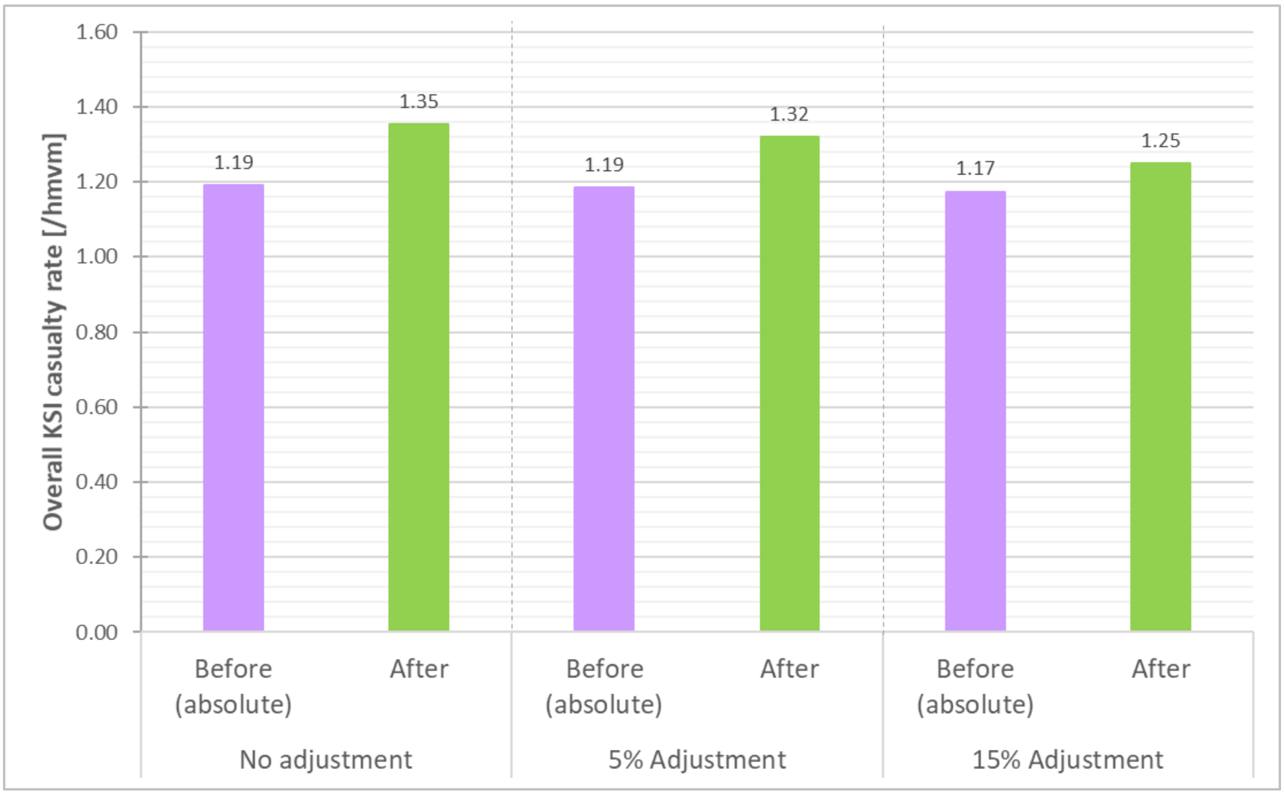
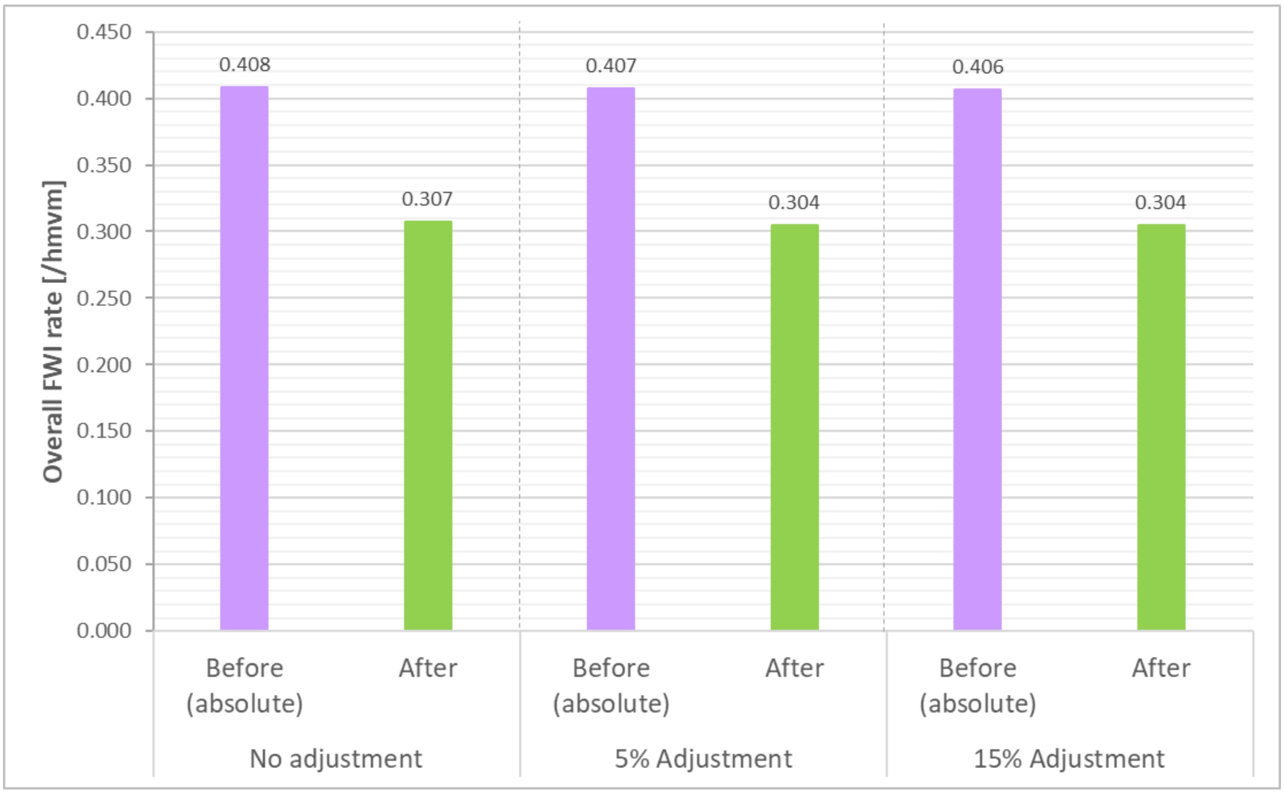


Figure 3-5 shows that without any adjustments, there has been a 0.16 per hmvm absolute worsening in the KSI casualty rate across the nine schemes. With the 5% and 15% corrections to adjust for the 'CRASH effect', the results indicate that the absolute worsening without CRASH might have been between 0.08 and 0.13 per hmvm.

The FWI rates have also been re-calculated using the adjusted casualty severities and the results are shown in Figure 3-8.

Overall, without any corrections, there has been a 0.100 per hmvm absolute improvement in the FWI rate across the board. With the 5% and 15% corrections to adjust for the 'CRASH effect', the results indicate that the absolute improvement without CRASH might have been between 0.103 and 0.108 per hmvm. The impact of the CRASH on FWI is smaller because the metric is weighted towards fatalities, which are not affected by the CRASH changes.

Figure 3-6 Percentage changes in FWI rate adjusted for the 'CRASH effect'



3.5. Summary

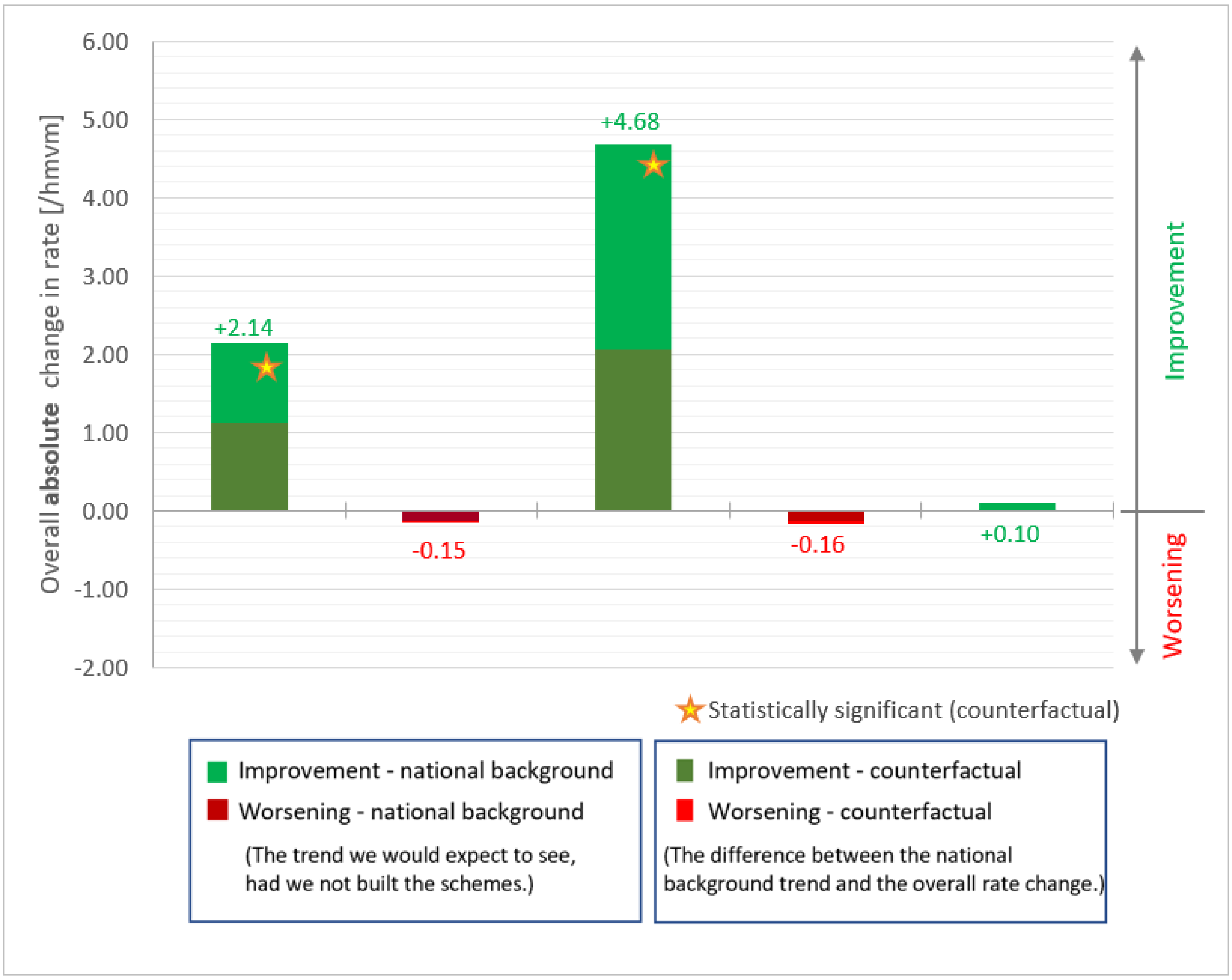
3.5.1. Evaluation against ALR performance measures

Overall, the results show strong safety performance of ALR.

There has been a 2.14 per hmvm improvement in personal injury collision rate. This has improved from 9.89 to 7.75 per hmvm, representing a 22% improvement in absolute terms which is 12% better than the national motorway background trend. The casualty rate has also improved by 4.68 per hmvm, from 16.76 to 12.08 per hmvm, which is a 28% overall improvement and 18% above the national background trend. Both of these changes are statistically significant. There has been a 0.15 per hmvm worsening in the KSI collision rate and 0.16 per hmvm in the KSI casualty rate; these changes were not statistically significant.

Therefore, in summary, the results show that the overall performance of the ALR schemes evaluated has improved. Against a background of increasing flows, the safety objective has been met which is no increase in number or rate of fatal and weighed injury (FWI) casualties These results are summarised graphically in Figure 3-7.

Figure 3-7 Overall changes in rates by ALR performance measures



3.5.2. The 'CRASH effect'

To gauge the magnitude of the 'CRASH effect', correction factors of 5% and 15% have been applied. The results suggest that without the 'CRASH effect', the KSI casualty rate might be worsened by between 0.08 and 0.13 per hmvm compared to 0.16 with no adjustment. The FWI rate might have improved by between 0.103 and 0.108 per hmvm, compared to 0.100 with no adjustment.

Counterfactual analyses have not been carried out as the national background figures were also subject to the 'CRASH effect' and the proportion of casualties recorded on the CRASH system for the rest of the motorway network was not known.

4. Additional collision analysis

4.1. Introduction

To probe further into areas of particular interest (collision types, factors that may influence safety and the SMALR generic hazard log), additional analyses of the STATS19 data have been performed; the results are presented in Section 4.2 to Section 4.4.

Collision types are of interest because it might be expected that certain types of collision might be less likely on ALR schemes, for example shunt collisions. Factors that may influence safety include live lane breakdowns, and the use of variable speed limits. The SMALR generic hazard log (GHL)was created to support the safety risk assessment[8] for all lane running. The risk assessment predicted the change in risk of each hazard, to estimate the overall change in risk. It is therefore interesting to use collision data to understand the change in collision rate associated with hazards from the GHL, where possible.

Where an analysis was dependent on times and weekdays / weekend, the time slices shown in Section 2.2 have been used to filter and interrogate the data; however, the rates have been calculated using the average daily vehicle distance travelled for simplicity. It would have been preferable to use actual vehicle distance travelled in each time slice but this was not possible for cost reasons. The same method was used for both the Before and the After data, so it was deemed acceptable for comparisons to be made. The statistics on motorway collisions and casualties published by the Department for Transport are not time slice nor time specific, so the background trend in these additional areas of interest could not be assessed. As such, any changes in the background have not been accounted for in the changes in rate presented in Section 4.2 to Section 4.4 below.

4.2. Collision types and causes

4.2.1. Collision types

With the conversion from traditional motorway to ALR, the distribution between the types of collisions could potentially change. It is therefore of interest to study the changes in rate in these types of injury collisions. Since many collision types could result from a multi-vehicle injury collision, only the primary collision between the first two vehicles was considered. To facilitate the filtering of data, the types of injury collisions of interest are defined as follows:

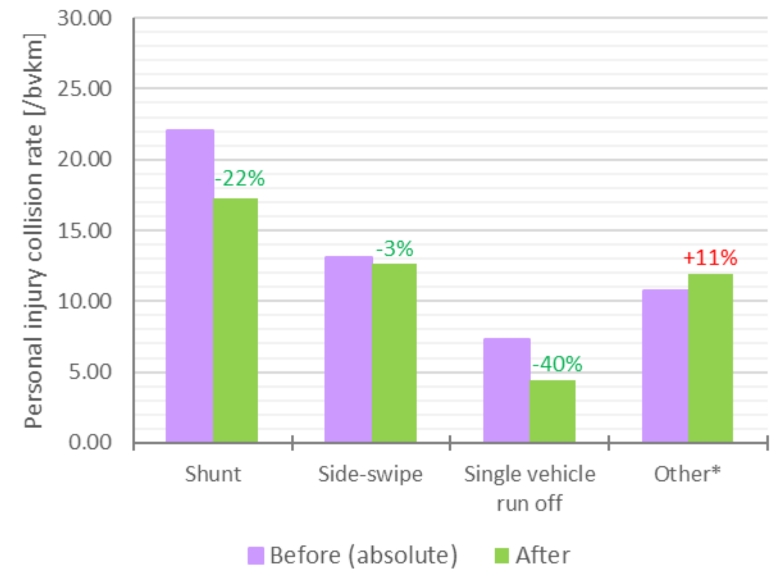
- **Shunt** – Two or more vehicles were involved, in which vehicle 1 had a point of impact at the front/back, and vehicle 2 had a point of impact at the back/front.
- **Side-swipe** – Two or more vehicles were involved, in which vehicle 1 had a point of impact on the nearside/offside, and vehicle 2 had a point of impact on the offside/nearside.
- **Single vehicle run off** – Only one vehicle was involved. No pedestrian was involved, and no carriageway hazards were present.

The collision type classification was reliant upon the vehicle information recorded in STATS19 data recorded. However, some of this data was not recorded on four of the schemes. The missing data accounted for a range from 5% of the number of collisions in the After period on the M25 J23-27 scheme, and up to 100% of the number of collisions in the After period on the M1 J19-16 scheme. The exact numbers of missing records and the collision types results are shown in Table C-1 in Appendix C.

Figure 4-1 shows the overall results from the five schemes with no missing data. Overall, the rates of shunt, side-swipe and single vehicle run off collisions have reduced by 22%, 3% and 40%, respectively, while the rate of other collision types has increased by 11%. Other collision types include collisions such as head-on collisions and single vehicle collisions that did not result in the vehicle leaving the carriageway.

Figure 4-1 Personal injury collision rates by collision types

[8] http://assets.highwaysengland.co.uk/specialist-information/knowledge-compendium/All+Lane+Running+GD04+assessment++report.pdf

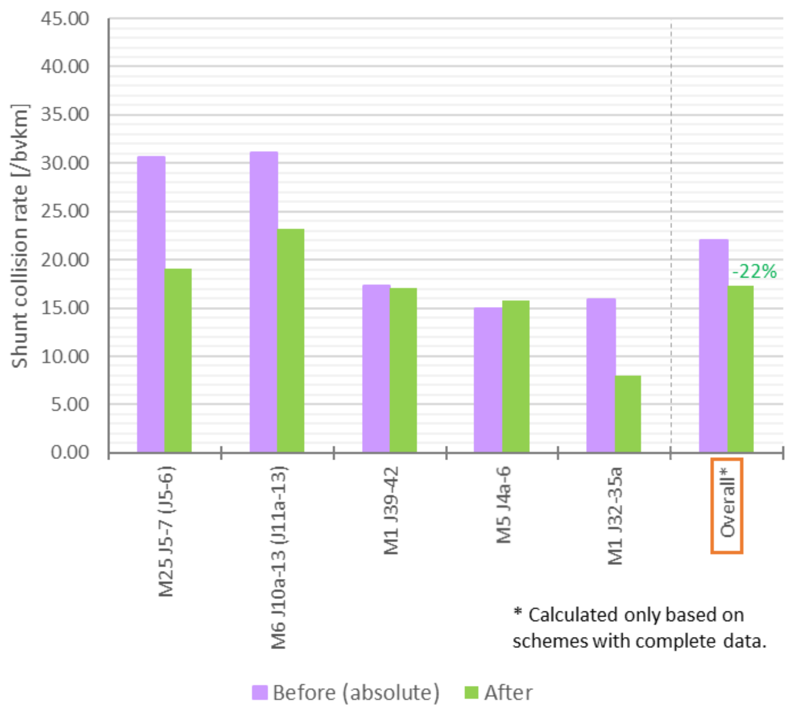


* Other collision types include collisions such as head-on collisions and single vehicle collisions that did not result in the vehicle leaving the carriageway.

4.2.1.1. Shunt collision rates

Shunt collisions are commonly caused by stop-start traffic conditions; these collisions should be reduced by the reduction in congestion and also by queue protection signs and signals. Figure 4-2 shows that the changes in shunt collision rate on the five schemes compared have all reduced with the exception of the M5 J4a-6 scheme.

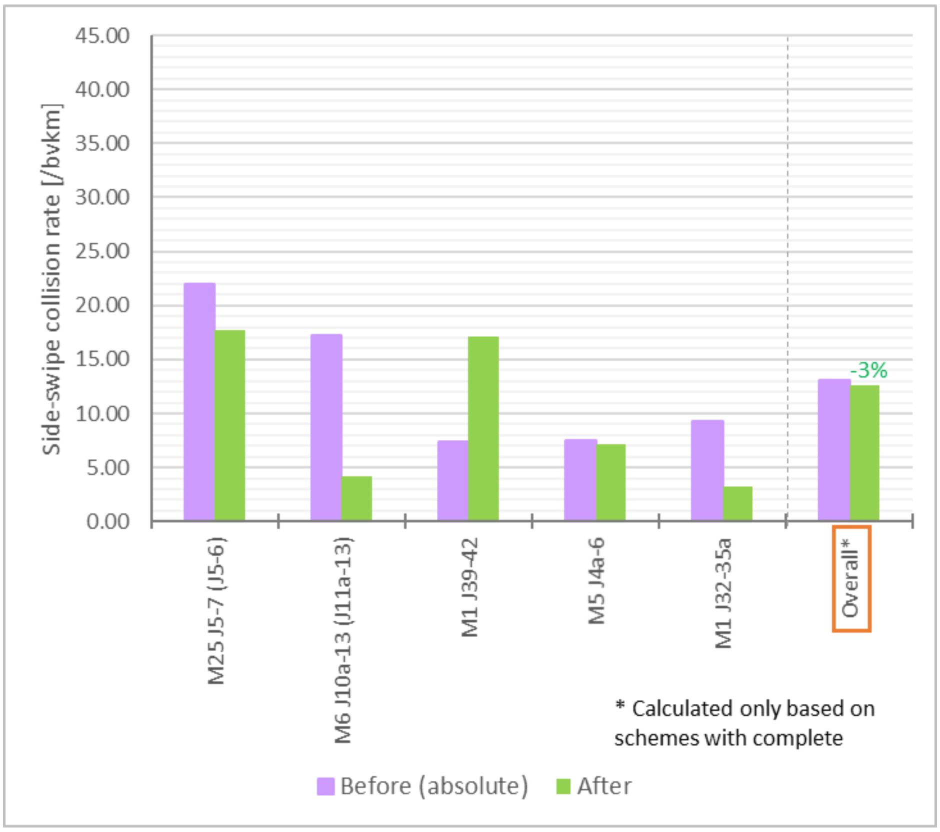
Figure 4-2 Shunt collision rates



4.2.1.2. Side-swipe collision rates

With smaller speed differentials between lanes in ALR, the likelihood of side-swipe collisions might reduce as the incentives for drivers to change lanes and weave within traffic would reduce. Compared to the shunt collision rate, the side-swipe collision rate has improved by a much smaller amount at 3%; this might be because the increase from three to four lanes automatically makes lane changing more common, which increases the risk of unsafe lane changing. This should be considered negligible because accounting for background trend would make the change even smaller, or positive. The M1 J39-42 scheme, which saw an increase, had only nine collisions in the Before period. The other four schemes showed an improvement, see Figure 4-3.

Figure 4-3 Side-swipe collision rates



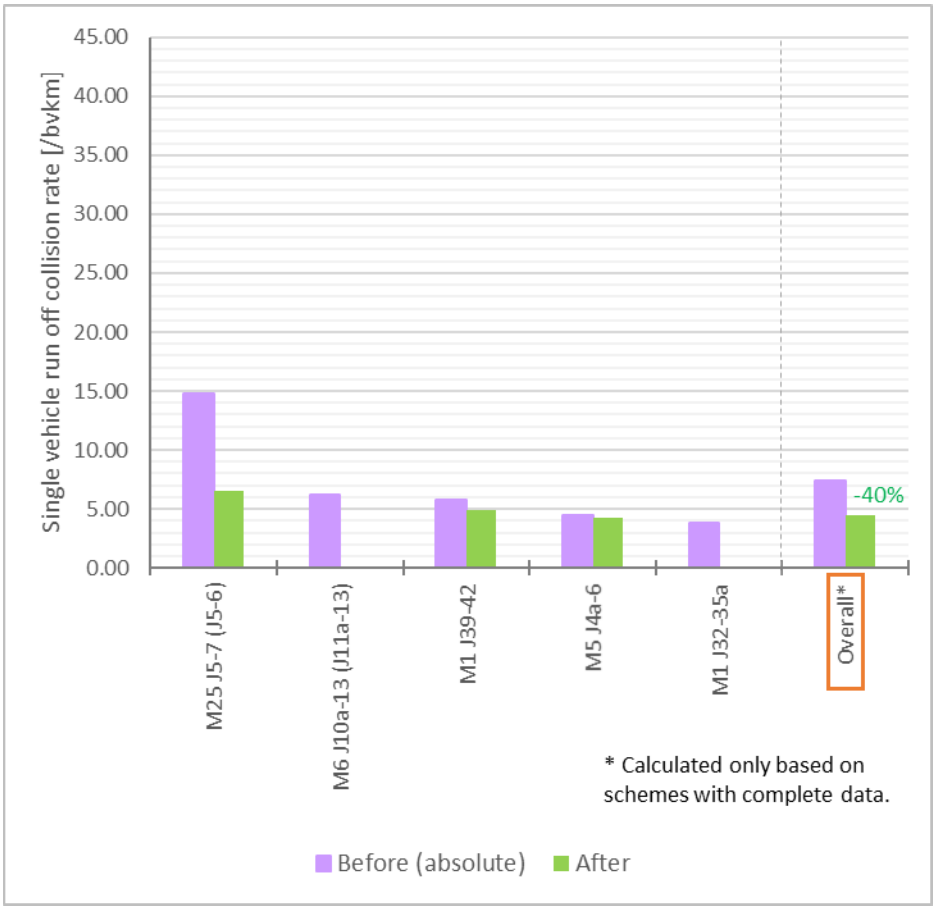
4.2.1.3. Single vehicle run off collision rates

Several factors are involved for single vehicle run-off collisions:

- It is possible that the increased signs and signals could help keep drivers alert during their journey,
- Alternatively, the amount of information provided by these signs and signals could potentially increase the chance of driver fatigue.
- The rumble strip is much closer to the edge of the carriageway on ALR schemes due to the lack of hard shoulder, so drivers have less time to react to avoid a collision once they stray onto it.

Single vehicle run-off collisions happen less often than shunt or side swipe incidents; four of the five schemes had three collisions or fewer in the Before period. Figure 4-4 shows that improvement was seen across the five schemes compared, with an overall reduction of 40%. This suggests that ALR has led to a reduction in this type of collision.

Figure 4-4 Single vehicle run off collision rates



4.2.2. Contributory factors

Contributory factors recorded in the STATS19 data for both the Before and the After periods have been studied. A breakdown of the contributory factors recorded by sub-categories for each of the periods is included in Table C-2 in Appendix C. It should be noted that some of the personal injury collisions did not have contributory factors recorded. There were 1,337 personal injury collisions across the nine SMALR schemes in the Before period, and 538 personal injury collisions in the After period. Overall, personal injury collisions without contributory factors accounted for 4% of the total number of personal injury collisions in the Before period and 7% in the After period.

The top ten contributory factors recorded in the 1,337 personal injury collisions in the Before periods are listed in Table 4-1. The respective figures in the After periods are also included, although they cannot be directly compared.

The majority of the contributory factors in Table 4-1 are commonly ranked high for most roads on the strategic road network. As such, these top contributory factors are not specific to motorways regardless of it being traditional motorway or ALR.

Nine of the top ten contributory factors were common in the Before and the After periods. Seven of these were under the sub-categories of 'Injudicious action' and 'Driver / Rider error or reaction', which are independent of and not relevant to the change in road environment brought about by the conversion from traditional motorway to ALR.

The rankings of the majority of the top five contributory factors in the After period have not changed when compared to the Before period. The only exception was 'Careless, reckless or in a hurry', which has risen from the 10th in the Before period to the 3rd in the After period. The rankings of rest of the top ten contributory factors in the After period have not moved by more than three places.

The only non-human error-related contributory factors in the top ten was ‘Slippery road (due to weather)’.

Table 4-1 Top ten contributory factors

Rank	Description	Number of times recorded		Rate [/bvkm]			Change in rank
		Before	After	Before	After		
1	Failed to look properly	466	223	20.28	18.37	↓	0
2	Failed to judge other person's path or speed	382	160	16.63	13.18	↓	0
3	Following too close	350	62	15.23	5.11	↓	-3
4	Sudden braking	290	67	12.62	5.52	↓	0
5	Loss of control	259	66	11.27	5.44	↓	0
6	Travelling too fast for conditions	160	29	6.96	2.39	↓	-5
7	Slippery road (due to weather)	127	43	5.53	3.54	↓	-1
8	Swerved	120	32	5.22	2.64	↓	-2
9	Poor turn or manoeuvre	119	61	5.18	5.03	↓	+2
10	Careless, reckless or in a hurry	109	73	4.74	6.01	↑	+7

Overall, the results show that regardless of the conversion to ALR, human errors remained the predominant factor contributed to injury collisions. It should however be highlighted that the rates of nine of the top ten contributory factors in the After periods have reduced, which suggests that road users were less prone to errors when travelling on ALR schemes.

4.3. Investigation of factors potentially affecting safety

4.3.1. Impact of live lane breakdowns

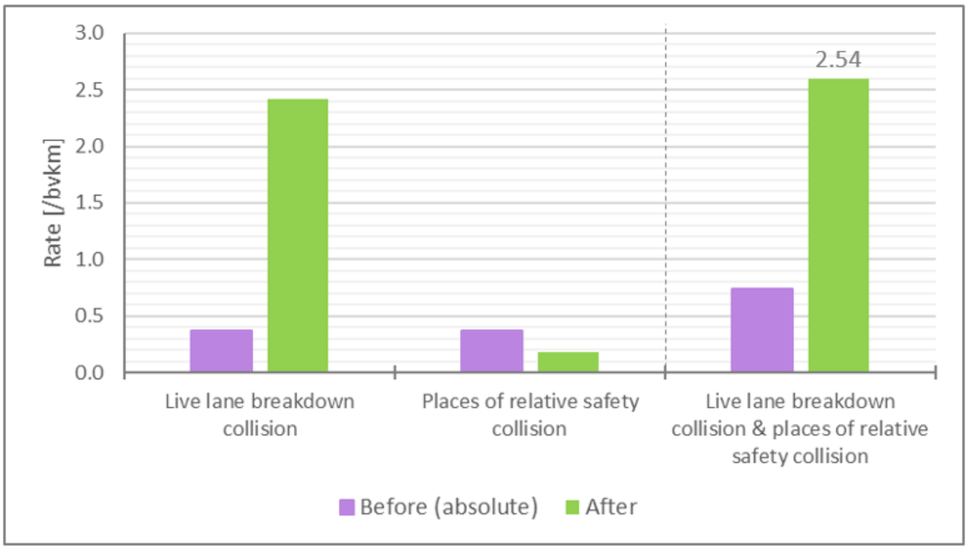
The Generic Hazard Log predicts an increase in the risk score for live lane breakdowns (LLBs); this is because the hard shoulders in traditional motorways are replaced with EAs in ALR, and some vehicles will not reach the EA in the event of a breakdown. It is also expected that collisions as a result of stops in ‘places of relative safety’ (PRS) would reduce, due to the removal of most of the hard shoulders and creation of EAs set back from the carriageway. The change in rates of personal injury collisions due to breakdowns in live lanes and places of relative safety, across all nine schemes, are shown in Figure 4-5. The detailed figures are included in Table C-4 to Table C-3 in Appendix C.

In the Before period, there were eight personal injury collisions (PICs) due to breakdowns in live lanes, and eight in PRS; the eight in PRS will have been all, or mostly, on the hard shoulder.

In the After period, there were 27 LLB PICs, so the rate has increased, as predicted; they occurred, on average, just over twice a year on each scheme. LLB PICs made up 5% of the total, and LLB KSI collisions made up 17% of all KSI collisions in the After period.

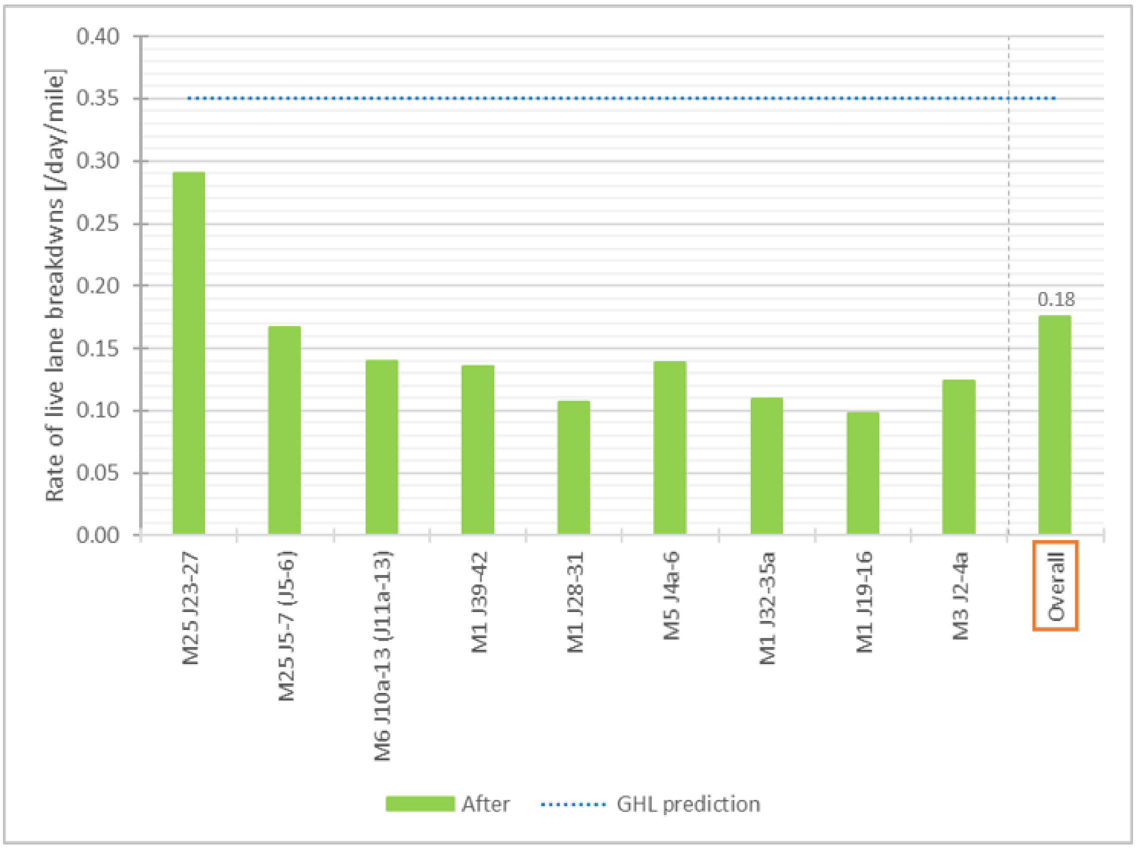
The rate of PRS collisions has reduced, also as expected; the combined effect is an increase in the rate of collisions due to breakdowns in live lanes and PRS.

Figure 4-5 Collision rates due to breakdowns in live lanes and places of relative safety



The Generic Hazard Log also predicted that the rate of LLBs would be less than 0.35 per day per mile. C&C/CW records were used to test this assumption; the results for the individual schemes and the overall rate are shown graphically in Figure 4-6.

Figure 4-6 Rate of live lane breakdowns against Generic Hazard Log prediction



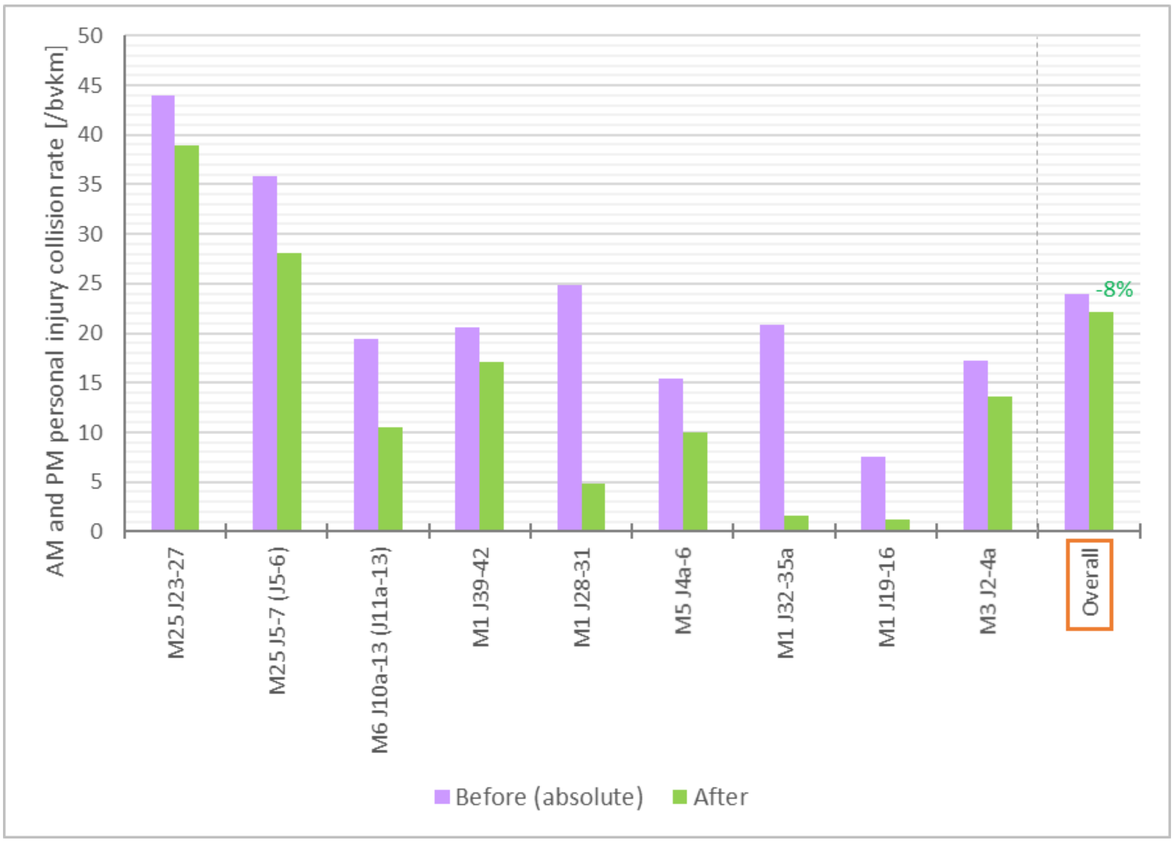
Based on the C&C/CW logs, there were 18,675 stops classed as “Breakdown – live lane” in the After periods across the nine schemes evaluated. The total length (both directions) of the nine schemes is 213.3 miles. The overall number of LLBs per day per mile is therefore 0.18, which compares positively with the SMALR

Generic Hazard Log prediction. It should be noted that a small proportion (1%) of the breakdowns recorded in CW did not have any classification for whether they were live lane or not and are therefore not included in the number of LLBs, however the impact of this is negligible. The Generic Hazard Log assumption is based on a flow of 65,000 per day. In comparison, the average daily flow across the nine schemes evaluated was 61,012. Whilst the actual flow was lower than the assumed flow, proportionally the rate of LLBs was still far lower than the predicted rate.

4.3.2. Impact of variable speed limits

The conversion from traditional motorway to ALR stemmed from the need to alleviate congestion on the motorways during periods of high demand. SM algorithms are likely to have been triggered mainly during the weekday AM and PM peaks in the After periods, and less likely outside these times. It follows that a study of the changes in collision rate during the weekday AM and PM peaks would help infer if the motorways were safer when signals were set by the SM algorithms. The personal injury collision rates during the weekday AM and PM peaks are shown graphically in Figure 4-7. The detailed figures for all weekday time slices are included in Table C-6 in Appendix C.

Figure 4-7 Weekday AM and PM personal injury collision rates



Overall, there has been an 8% improvement in the personal injury collision rate during the weekday AM and PM peaks. During the weekday AM and PM peaks, the personal injury collision rates have reduced on all schemes. Large improvements were seen on the M1 J28-31, M1 J32-35a, and M1 J19-16 schemes.

It should be noted that while the overall improvement during weekday peak periods is 8%, the overall improvement in PIC rate was 22%, meaning that the collision rate improved more outside of the weekday peaks.

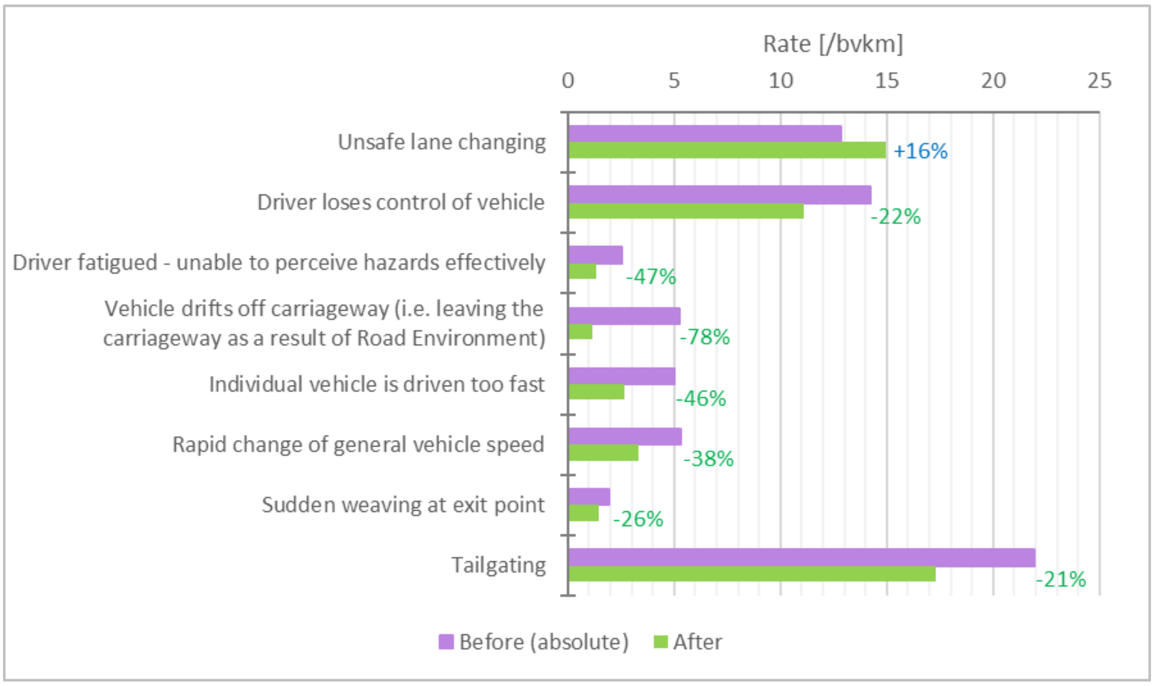
4.4. Investigation of impacts on hazards from generic hazard log

The objective of hazard analysis in SMALR is to increase the understanding of the Generic Hazard Log. In both the Generic Hazard Log and the scheme specific Hazard Log, 90% of the risks were associated with 19 main hazards. Of these main hazards, 17 are common in both logs. Therefore, a combined total of 21 main hazards have been identified.

To improve our understanding of the changes in risk by converting from traditional motorway to ALR, the rates of hazards associated with the personal injury collisions in the Before and the After periods have been studied. The list of assumptions made in the hazard analysis is included in Appendix C.8. The complete results can be found in Table C-8 in Appendix C. In the classification of LLBs, breakdowns that happened in the AM and PM peaks were considered peak events, and those that happened in other time slices were considered off-peak events. The changes in the collision rates relating to the most common hazards, i.e. those with a count of greater than 40 in the Before period, are summarised graphically in Figure 4-8.

Of the most common hazards shown in the graph, seven show improvements of greater than 20%. For all seven, it could be expected that the introduction of ALR might lead to an improvement due to improved compliance, reduced congestion and better information about queues and other hazards. The only hazard to show an increase in associated collision rate is ‘unsafe lane changing’; this might be because the increase from 3 to 4 lanes automatically makes lane changing more common, which increases the risk of unsafe lane changing. Interestingly, side swipe collisions showed only a negligible improvement as discussed in Section 4.2.1.2.

Figure 4-8 Changes in rate for hazards most commonly associated with personal injury collisions



It is interesting to compare the collisions relating to hazards from the Generic Hazard Log (GHL), with the predictions from the GHL[9]. This is shown in the form of Manhattan graphs in Figure 4-9 and Figure 4-10. The two graphs do not show the same things. The GHL graph in Figure 4-9 shows the predicted risk scores for all hazards and the overarching results graph in Figure 4-10 shows the rates of PICs related to the top 21 hazards, stacked. However, both graphs show a reduction in risk / collisions between Before and After.

[9] Extracted from Generic Hazard Log v 0.23.xlsm

Figure 4-9 Manhattan chart based on Generic Hazard Log predictions

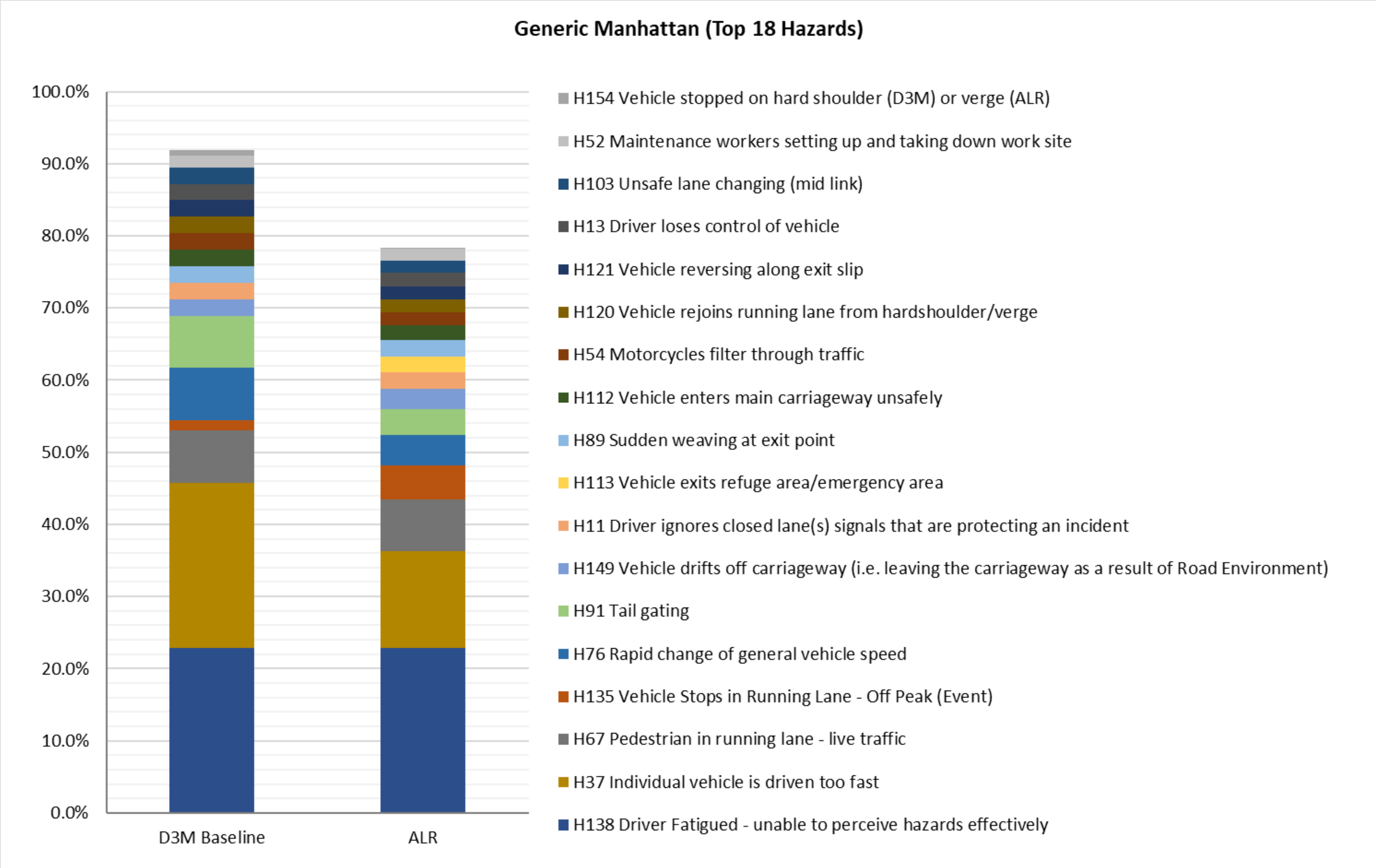
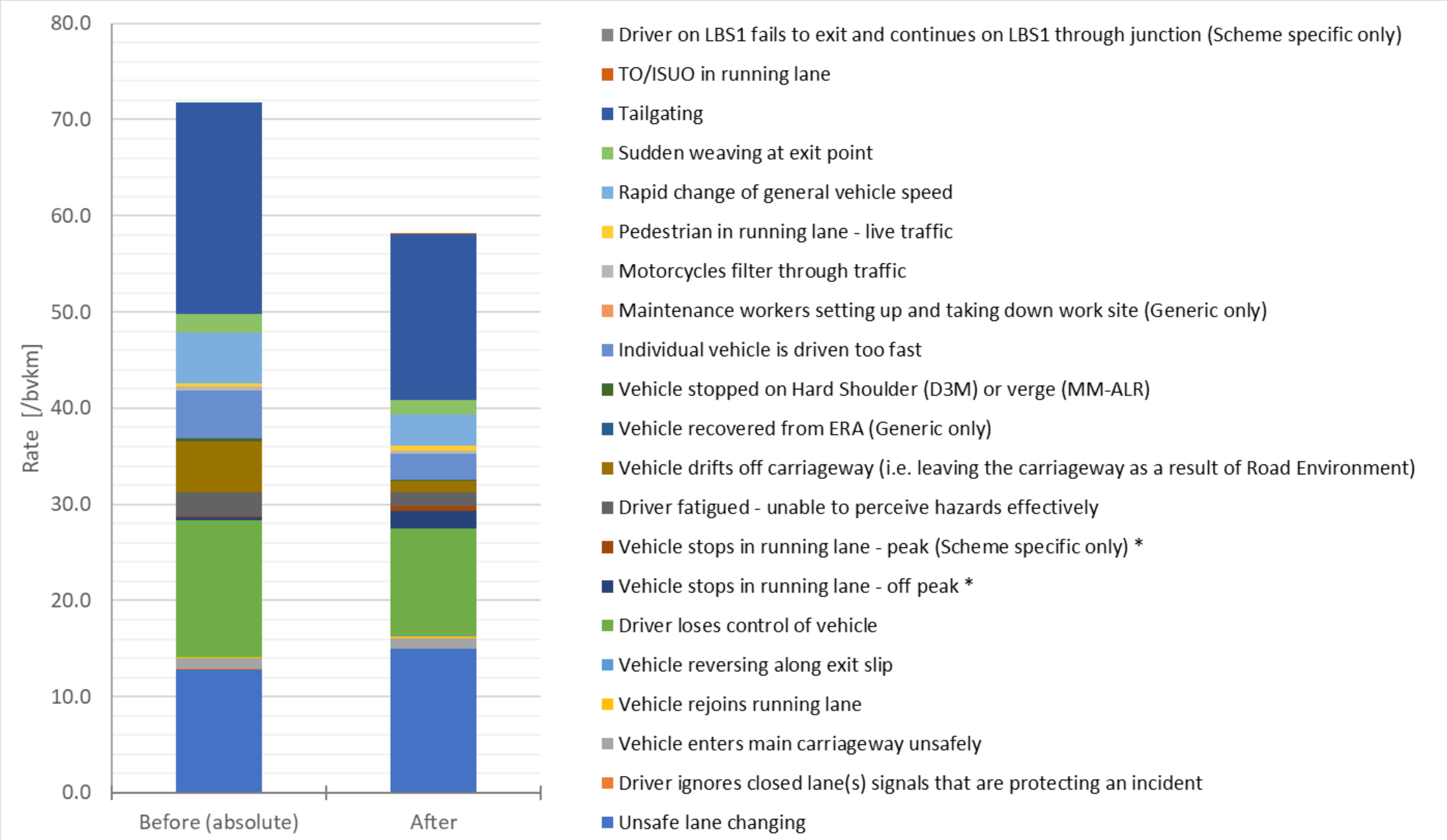


Figure 4-10 Manhattan charts based on the overarching STATS19 dataset



4.5. Summary

4.5.1. Collision types and causes

The rates for shunt and single vehicle run off collisions have reduced, which could be a result of reduced congestion, increased signs and signals to warn drivers of hazards and keep them alert. There has been a negligible reduction in the side swipe collision rate.

Overall, the results show that regardless of the conversion to ALR, human errors remained the predominant factor contributed to injury collisions. Among the top ten contributory factors, nine were common in both the Before and the After periods. It should however be highlighted that the rates of nine of the top ten contributory factors in the After periods have reduced, which suggests that road users were less prone to errors when travelling on ALR schemes.

4.5.2. Investigation of factors potentially affecting safety

The rate of LLB collisions increased, as predicted in the Generic Hazard Log; they occurred, on average, just over twice a year on each scheme in the After period. LLB PICs made up 5% of the total, and LLB KSI collisions made up 17% of all KSI collisions in the After period. The rate of collisions in places of relative safety has reduced, also as expected; the combined effect is an increase in the rate of collisions.

Variable speed limits are applied for queue protection and congestion management and are proven to improve safety. The collision rate in the weekday peak periods (when speed limits are most likely to have been displayed) improved in all nine schemes evaluated, even those which experienced a worsening collision rate overall.

4.5.3. Investigation of impacts on hazards from generic hazard log

By combining the data from all nine schemes, it has been possible to identify reductions in collision rate associated with a number of hazards, where it was not possible for individual schemes. This will allow those GHL assumptions to be reviewed and potentially revised.

5. Compliance

5.1. Compliance with Red X signals

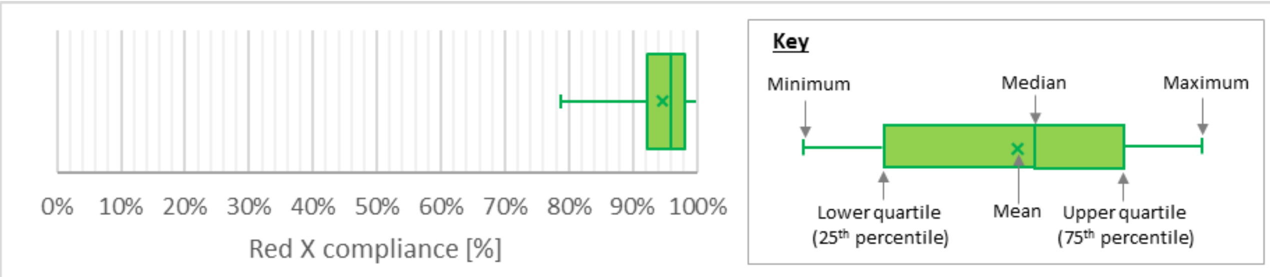
The red X signal is used to dynamically manage traffic in individual lanes in the event where a lane closure is required. Drivers ignoring red X signs could potentially lead to serious consequences, such as colliding with a broken-down vehicle. Table 5-1 below shows the percentages of red X compliance of the nine SMALR schemes evaluated. Average Red X compliance ranged from 92.7% to 97.1%, with the average across all schemes 94.3%.

Table 5-1 Average percentage of red X compliance by scheme

	Scheme									Overall
	M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
% of red X compliance	94.2%	94.1%	95.9%	94.8%	94.1%	93.2%	92.7%	96.7%	97.1%	**94.3%**

Figure 5-1 shows a 'box and whiskers' representation of the Red X compliance for individual Red X events, across all nine schemes. This shows the minimum, maximum, 25th and 75th percentile, and average values across 813 events. It is worth noting that compliance was greater than 92%, for 75% of all events.

Figure 5-1 Red X compliance across the nine schemes evaluated



5.2. Emergency area usage

CCTV monitoring was carried out on a representative sample of emergency areas (EAs). Across the nine schemes covered in this report, a total of 1,698.4 hours of CCTV monitoring have been carried out to monitor the usage of 88 EAs in the After periods. An overall summary of the EA activities is shown in Table 5-2. Only stops made by a lead vehicle have been considered; further related vehicle activities such as Highways England Traffic Officer services or recovery vehicles have been discounted. Detailed figures for the individual schemes can be found in Table D-1 in Appendix D.

In total, 452 unique EA stops have been observed over 1,698 hours. This translates to 0.27 stops per hour per EA, which is equivalent to one stop per EA every four hours. Of the 452 unique EA stops, 71% were assessed as non-emergency and 29% were genuine. The average durations of non-emergency and genuine stops were 2 minutes 35 seconds and 14 minutes 10 seconds, respectively. It should be noted that some EA stops were already in progress when monitoring started, so it is likely that these durations were longer in reality. Given the relative duration of non-emergency and genuine stops, it is probable that the average duration of genuine stops would increase more than that of the non-emergency stops.

Table 5-2 A overall summary of EA activities

		Number of EA stops	% of all EA stops	Average duration [hh:mm:ss]
EA activity	Non-emergency	319	71%	00:02:35
	Genuine reason	133	29%	00:14:10

An overall breakdown of the types of lead vehicles which stopped in EAs and whether they were genuine emergencies is shown in Table 5-3.

Table 5-3 A summary of the EA stops by vehicle types

		Number of EA stops	% of all EA stops	Non-emergency	Genuine
Vehicle type	Car	231	51%	70%	30%
	Van	80	18%	73%	28%
	Car / van with trailer	4	1%	50%	50%
	HGV / LGV	136	30%	71%	29%
	Coach	1	0%	0%	100%
	Motorbike	0	0%	0%	0%
	Total	**452**	**100%**	**71%**	**29%**

Overall, across the nine schemes monitored, 51% of the EA stops were made by car drivers, 30% were made by HGV/LGV drivers and 18% were made by van drivers. HGVs / LGVs account for only 15% of the national motorway vehicle mileage[10], suggesting that they are more likely to stop than cars; this is not unexpected. Cars, vans and HGVs/LGVs all made a similar proportion of non-emergency stops, around 70%.

5.3. Summary

5.3.1. Compliance with Red X signals

Average Red X compliance was above 92% in all nine schemes evaluated, with an overall compliance of 94.3%. The highest compliance was seen on the M1 J19-16 and M3 J2-4a schemes.

5.3.2. Emergency area usage

On average, one stop was observed per EA every four hours. Of the 452 unique EA stops observed, 71% were non-emergency and 29% were genuine. The duration of non-emergency stops averaged to 2 minutes 35 seconds and that of genuine stops averaged to 14 minutes 10 seconds. Overall, 51% of the EA stops were made by car drivers, 30% were made by HGV/LGV drivers and 18% were made by van drivers. The proportions of non-emergency stops made by these user groups were similar at approximately 70%.

[10] DfT Road Traffic Estimates: Great Britain 2018

6. Conclusions

An overarching review of the results of nine ALR schemes has been presented in this report. The purpose was to gather together evidence from the evaluation of the schemes to present a wider picture of ALR safety performance. The key findings are presented below, followed by recommendations.

Collision and casualty rates

Overall, the results show strong safety performance of ALR. There has been a statistically significant improvement in personal injury collision rate and casualty rate, outperforming the national trend by 12% and 18%, respectively. Across the 9 schemes evaluated there has been an absolute reduction of 28% in the casualty rate.

FWI rate is the key performance metric to be assessed and while a statistical analysis could not be performed on this due to the weighted nature of FWI, overall, there has been an absolute reduction of 0.10 per hmvm in the FWI rate. This is equivalent to a reduction of 1 serious injury, or 10 slights, per hundred million vehicle miles, because of the FWI equation (see Section 3.1). The reduction is 0.09 per hmvm better than the national motorway trend.

There has been a 0.15 per hmvm worsening in the KSI collision rate and 0.16 per hmvm in the KSI casualty rate. The changes were not statistically significant, meaning there was effectively no change; they were not a result of ALR. In addition, the magnitude of these changes was relatively small compared to those of the other ALR performance measures. Therefore, in summary, the results clearly show that the ALR concept has improved safety overall.

To gauge the magnitude of the ‘CRASH effect’, correction factors of 5% and 15% were applied to the casualty data. The results suggest that without the ‘CRASH effect’, the KSI casualty rate might have worsened by a lesser degree and the FWI rate might have improved more, compared to the rates we have seen with no adjustment.

In summary, the results show that the overall performance of the ALR schemes evaluated has improved. Against a background of increasing flows, the safety objective has been met which is no increase in number or rate of fatal and weighed injury (FWI) casualties.

Additional collision analysis

The rates for shunt and single vehicle run off collisions have reduced, which could be a result of reduced congestion, increased signs and signals to warn drivers of hazards and keep them alert. There has been a negligible reduction in side swipe collision rate.

Among the top ten contributory factors, nine were common in both the Before and the After periods. Overall, the results show that regardless of the conversion to ALR, human errors remained the predominant factor contributed to injury collisions. It should however be highlighted that the rates of nine of the top ten contributory factors in the After periods have reduced, which suggests that road users were less prone to errors when travelling on ALR schemes.

The rate of live lane breakdown (LLB) collisions increased, as predicted in the Generic Hazard Log (GHL); they occurred, on average, just over twice a year per scheme in the After period. LLB PICs made up 5% of the total, and LLB KSI collisions made up 17% of all KSI collisions in the After period. The rate of collisions in places of relative safety has reduced, also as expected; the combined effect is an increase in the rate of collisions due to breakdowns in live lanes and places of relative safety.

Variable speed limits are applied for queue protection and congestion management and are proven to improve safety. The collision rate in the weekday peak periods (when speed limits are most likely to have been displayed) improved in all nine schemes evaluated, even those which experienced a worsening collision rate overall.

By combining the data from all nine schemes, it has been possible to identify reductions in collision rate associated with a number of hazards, where it was not always possible for individual schemes. This will allow those GHL assumptions to be reviewed and potentially revised.

Compliance

Average Red X compliance was above 92% in all nine schemes evaluated, with an overall compliance of 94.3%.

On average, one stop was observed per EA every four hours. Of the 452 unique EA stops observed, 71% were non-emergency and 29% were genuine. The duration of non-emergency stops averaged 2 minutes 35 seconds and that of genuine stops averaged 14 minutes 10 seconds. It can be concluded that EAs are not typically occupied for long periods.

Appendices

Appendix A. Collisions

A.1. Personal injury collision and personal injury collision rates

Table A-1 Personal injury collisions and personal injury collision rates

		Scheme									Overall
		M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Duration [year]	3	3	3	3	3	3	3	3	3	**-**
	Number of personal injury collisions	291	171	94	47	282	70	74	95	213	**1,337**
	Vehicle distance travelled [hmvm]	22.6	13.0	9.0	7.5	23.6	12.4	11.3	18.1	17.7	**135.2**
	Rate (absolute) [/hmvm]	12.87	13.15	10.47	6.24	11.97	5.63	6.55	5.25	12.05	**9.89**
	Rate (counterfactual) [/hmvm]	11.41	11.66	9.27	5.28	10.14	4.35	4.84	4.06	9.32	**8.76**
After	Duration [year]	3	3	1	1	1	1	1	0.8	1	**-**
	Number of personal injury collisions	255	134	21	20	27	22	12	8	39	**538**
	Vehicle distance travelled [hmvm]	22.7	14.4	2.9	2.5	7.8	4.3	3.9	4.9	5.9	**69.4**
	Rate [/hmvm]	11.23	9.33	7.13	7.87	3.46	5.08	3.09	1.62	6.58	**7.75**
Change in rate	Absolute										**-2.14**
	Counterfactual										**-1.01**
Effect size											**0.13**

(light blue)	Not statistically significant – no change
(light orange)	Statistically significant
(grey)	Statistical significance could not be determined – sample size too small

A.2. Personal injury (KSI) collision and personal injury (KSI) collision rates

Table A-2 Personal injury (KSI) collisions and personal injury (KSI) collision rates

		Scheme									Overall
		M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Duration [year]	3	3	3	3	3	3	3	3	3	**-**
	Number of personal injury (KSI) collisions	31	15	4	4	22	5	7	21	30	**139**
	Vehicle distance travelled [hmvm]	22.6	13.0	9.0	7.5	23.6	12.4	11.3	18.1	17.7	**135.2**
	Rate (absolute) [/hmvm]	1.37	1.15	0.45	0.53	0.93	0.40	0.62	1.16	1.70	**1.03**
	Rate (counterfactual) [/hmvm]	1.29	1.09	0.50	0.53	0.93	0.41	0.56	1.18	1.73	**1.16**
After	Duration [year]	3	3	1	1	1	1	1	0.8	1	**-**
	Number of personal injury (KSI) collisions	26	19	6	5	5	3	5	4	9	**82**
	Vehicle distance travelled [hmvm]	22.7	14.4	2.9	2.5	7.8	4.3	3.9	4.9	5.9	**69.4**
	Rate [/hmvm]	1.15	1.32	2.04	1.97	0.64	0.69	1.29	0.81	1.52	**1.18**
Percentage change in rate	Absolute										**0.15**
	Counterfactual										**0.02**
Effect size											**N/A.**

(light blue)	Not statistically significant – no change
(light orange)	Statistically significant
(light grey)	Statistical significance could not be determined – sample size too small

Appendix B. Casualties

B.1. All casualties and all casualty rates

Table B-1 All casualties and all casualty rates

		Scheme									Overall
		M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Duration [year]	3	3	3	3	3	3	3	3	3	**-**
	Number of casualties	441	295	155	81	477	115	139	158	405	**2,266**
	Vehicle distance travelled [hmvm]	22.6	13.0	9.0	7.5	23.6	12.4	11.3	18.1	17.7	**135.2**
	Rate (absolute) [/hmvm]	19.51	22.68	17.26	10.76	20.25	9.24	12.30	8.73	22.91	**16.76**
	Rate (counterfactual) [/hmvm]	16.87	19.62	15.14	8.79	16.55	7.12	8.82	6.72	17.64	**14.70**
After	Duration [year]	3	3	1	1	1	1	1	0.8	1	**-**
	Number of casualties	404	206	30	39	41	33	19	11	56	**839**
	Vehicle distance travelled [hmvm]	22.7	14.4	2.9	2.5	7.8	4.3	3.9	4.9	5.9	**69.4**
	Rate [/hmvm]	17.80	14.34	10.18	15.34	5.26	7.62	4.89	2.22	9.45	**12.08**
Change in rate	Absolute										**-4.68**
	Counterfactual										**-2.62**
Effect size											**0.15**

(blue)	Not statistically significant – no change
(orange)	Statistically significant
(grey)	Statistical significance could not be determined – sample size too small

B.2. KSI casualties and KSI casualty rates

Table B-2 KSI casualties and KSI casualty rates

		Scheme									Overall
		M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Duration [year]	3	3	3	3	3	3	3	3	3	**-**
	Number of KSI casualties	40	16	7	4	25	5	9	24	31	**161**
	Vehicle distance travelled [hmvm]	22.6	13.0	9.0	7.5	23.6	12.4	11.3	18.1	17.7	**135.2**
	Rate (absolute) [/hmvm]	1.77	1.23	0.78	0.53	1.06	0.40	0.80	1.33	1.75	**1.19**
	Rate (counterfactual) [/hmvm]	1.62	1.21	0.94	0.56	1.12	0.46	0.79	1.51	1.99	**1.32**
After	Duration [year]	3	3	1	1	1	1	1	0.8	1	**-**
	Number of KSI injury casualties	31	21	6	7	5	4	5	4	11	**94**
	Vehicle distance travelled [hmvm]	22.7	14.4	2.9	2.5	7.8	4.3	3.9	4.9	5.9	**69.4**
	Rate [/hmvm]	1.37	1.46	2.04	2.75	0.64	0.92	1.29	0.81	1.86	**1.35**
Change in rate	Absolute										**0.16**
	Counterfactual										**0.03**
Effect size											**N/A.**

(light blue)	Not statistically significant – no change
(light orange)	Statistically significant
(grey)	Statistical significance could not be determined – sample size too small

B.3. FWI and FWI rates

Table B-3 FWI and FWI rates

		Scheme									Overall
		M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Duration [year]	3	3	3	3	3	3	3	3	3	**-**
	Number of fatal casualties	4	2	2	0	3	1	1	3	4	**20**
	Number of serious casualties	36	14	5	4	22	4	8	21	27	**141**
	Number of slight casualties	401	279	148	77	452	110	130	134	374	**2,105**
	FWI	11.61	6.19	3.98	1.17	9.72	2.50	3.10	6.44	10.44	**55.15**
	Vehicle distance travelled [hmvm]	22.6	13.0	9.0	7.5	23.6	12.4	11.3	18.1	17.7	**135.2**
	Rate (absolute) [/hmvm]	0.51	0.48	0.44	0.16	0.41	0.20	0.27	0.36	0.59	**0.41**
	Rate (counterfactual) [/hmvm]	0.47	0.43	0.43	0.13	0.35	0.19	0.22	0.33	0.55	**0.40**
After	Duration [year]	3	3	1	1	1	1	1	0.8	1	**-**
	Number of fatal casualties	3	0	0	0	0	0	1	1	0	**5**
	Number of serious casualties	28	21	6	7	5	4	4	3	11	**89**
	Number of slight casualties	373	185	24	32	36	29	14	7	45	**745**
	FWI	9.53	3.95	0.84	1.02	0.86	0.69	1.54	1.37	1.55	**21.35**
	Vehicle distance travelled [hmvm]	22.7	14.4	2.9	2.5	7.8	4.3	3.9	4.9	5.9	**69.4**
	Rate [/hmvm]	0.42	0.27	0.29	0.40	0.11	0.16	0.40	0.28	0.26	**0.31**
Change in rate	Absolute										**-0.10**
	Counterfactual										**-0.09**

B.4. The 'CRASH effect'

Table B-4 A summary of the number of personal injury collisions subject to the 'CRASH effect'

		Scheme								
		M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a
Before	Total number of personal injury collisions	291	171	94	47	282	70	74	95	213
	Number of personal injury collisions recorded on CRASH	0	0	0	0	1	0	2	0	112
	Affected by the implementation of CRASH	*N*	*N*	*N*	*N*	*Y*	*N*	*Y*	*N*	*Y*
	% of personal injury collisions recorded on CRASH out of total	0%	0%	0%	0%	0.4%	0%	3%	0%	53%
After	Total number of personal injury collisions	255	134	21	20	27	22	12	8	39
	Number of personal injury collisions recorded on CRASH	82	98	21	0	8	22	12	0	37
	Affected by the implementation of CRASH	*Y*	*Y*	*Y*	*N*	*Y*	*Y*	*Y*	*N*	*Y*
	% of personal injury collisions recorded on CRASH out of total	32%	73%	100%	0%	30%	100%	100%	0%	95%

Table B-5 Number of serious casualties recorded and not recorded on the CRASH system

Number of serious casualties		Scheme									
		M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	**Overall**
Before	Recorded on CRASH	0	0	0	0	0	0	2	0	13	**15**
	Not recorded on CRASH	36	14	5	4	22	4	6	21	14	**126**
	Total	36	14	5	4	22	4	8	21	27	**141**
After	Recorded on CRASH	15	10	6	0	1	4	4	0	8	**48**
	Not recorded on CRASH	13	11	0	7	4	0	0	3	3	**41**
	Total	28	21	6	7	5	4	4	3	11	**89**

Appendix C. Additional collision analyses

C.1. Personal injury collisions and personal injury collision rates by collision types

Table C-1 Personal injury collisions and personal injury collision rates by collision types

			Scheme									Overall*
			M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Duration [year]		3	3	3	3	3	3	3	3	3	**-**
	Number	Shunt	138	64	45	21	25	30	29	38	3	**189**
		Side-swipe	70	46	25	9	19	15	17	17	1	**112**
		Single vehicle run off	26	31	9	7	9	9	7	8	4	**63**
		Other	57	30	15	10	27	16	21	32	0	**92**
		% of personal injury collisions without point of impact recorded	0%	0%	0%	0%	72%	0%	0%	0%	96%	
		% of personal injury collisions without vehicle information recorded	0%	0%	0%	0%	0%	0%	0%	0%	0.5%	
		All personal injury collisions	*291*	*171*	*94*	*47*	*282*	*70*	*74*	*95*	*213*	***456***
	Vehicle distance travelled [bvkm]		3.6	2.1	1.4	1.2	3.8	2.0	1.8	2.9	2.8	**8.6**
	Rate [/bvkm]	Shunt	37.90	30.57	31.14	17.33	6.60	14.98	15.95	13.05	1.05	**22.05**
		Side-swipe	19.23	21.97	17.30	7.43	5.01	7.49	9.35	5.84	0.35	**13.07**
		Single vehicle run off	7.14	14.81	6.23	5.78	2.37	4.50	3.85	2.75	1.41	**7.35**
		Other	15.66	14.33	10.38	8.25	7.12	7.99	11.55	10.99	0.00	**10.73**
After	Duration [year]		3	3	1	1	1	1	1	0.8	1	**-**
	Number	Shunt	109	44	11	7	9	11	5	0	16	**78**
		Side-swipe	80	41	2	7	5	5	2	0	6	**57**

		Single vehicle run off	24	15	0	2	0	3	0	0	6	**20**
		Other	29	34	8	4	5	3	5	0	11	**54**
		% of personal injury collisions without point of impact recorded	0%	0%	0%	0%	30%	0%	0%	100%	0%	
		% of personal injury collisions without vehicle information recorded	5%	0%	0%	0%	0%	0%	0%	0%	0%	
		All personal injury collisions	*255*	*134*	*21*	*20*	*27*	*22*	*12*	*8*	*39*	***209***
	Vehicle distance travelled [bvkm]		3.7	2.3	0.5	0.4	1.3	0.7	0.6	0.8	1.0	**4.5**
	Rate [/bvkm]	Shunt	29.84	19.03	23.19	17.11	7.18	15.79	7.99	0.00	16.79	**17.27**
		Side-swipe	21.90	17.74	4.22	17.11	3.99	7.18	3.20	0.00	6.29	**12.62**
		Single vehicle run off	6.57	6.49	0.00	4.89	0.00	4.31	0.00	0.00	6.29	**4.43**
		Other	7.94	14.71	16.87	9.77	3.99	4.31	7.99	0.00	11.54	**11.95**
% Change in rate	Shunt											**-22%**
	Side-swipe											**-3%**
	Single vehicle run off											**-40%**
	Other											**11%**
Complete data			*N*	*Y*	*Y*	*Y*	*N*	*Y*	*Y*	*N*	*N*	*Y*
* Calculated only based on schemes with complete data.												

C.2. Contributory factors

Table C-2 A summary of the contributory factors recorded

			Scheme									Overall
			M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Number	Personal injury collisions	291	171	94	47	282	70	74	95	213	**1,337**
		% of personal injury collisions without contributory factors	1%	0%	10%	15%	0%	0%	1%	29%	0%	**4%**
	Rate [/bvkm]	Road environment contributed	6.32	21.50	16.17	4.95	8.18	4.00	2.75	2.40	8.09	**6.70**
		Vehicle defects	3.02	1.91	2.70	0.83	0.79	4.00	1.65	1.03	2.81	**1.83**
		Injudicious action	35.71	23.41	126.70	8.25	37.99	14.98	4.95	17.16	26.01	**23.63**
		Driver / Rider error or reaction	116.18	94.11	353.13	35.48	70.70	54.94	52.79	28.84	108.98	**72.34**
		Impairment or distraction	12.09	12.42	32.35	2.48	11.08	6.99	3.30	5.49	12.30	**8.62**
		Behaviour or inexperience	20.05	4.78	53.91	3.30	7.12	4.50	3.85	3.78	8.79	**8.10**
		Vision affected by	10.44	13.38	40.43	2.48	7.91	4.99	4.40	2.75	2.81	**6.44**
		Pedestrian only (casualty or uninjured)	0.82	0.00	2.70	0.00	0.53	0.50	1.10	0.00	0.00	**0.39**
		Special codes	2.47	2.39	2.70	1.65	0.79	0.00	1.65	1.03	1.76	**1.35**
After	Number	Personal injury collisions	255	134	21	20	27	22	12	8	39	**538**
		% of personal injury collisions without contributory factors	9%	6%	0%	5%	4%	0%	0%	88%	3%	**7%**
	Rate [/bvkm]	Road environment contributed	7.39	11.68	24.97	2.44	3.19	8.61	1.60	0.00	1.05	**4.86**
		Vehicle defects	2.46	3.89	0.00	0.00	0.00	0.00	0.00	0.00	4.20	**1.65**
		Injudicious action	16.42	25.96	41.61	9.77	7.97	5.74	1.60	0.00	11.54	**9.31**
		Driver / Rider error or reaction	85.41	134.97	149.80	78.20	12.76	50.23	12.78	3.77	35.67	**51.08**
		Impairment or distraction	10.40	16.44	8.32	7.33	1.59	4.31	4.79	0.00	12.59	**6.18**
		Behaviour or inexperience	21.90	34.61	8.32	2.44	5.58	4.31	0.00	0.00	5.25	**8.90**
		Vision affected by	8.76	13.84	16.64	4.89	3.19	4.31	4.79	0.00	3.15	**5.19**

		Pedestrian only (casualty or uninjured)	0.55	0.87	0.00	4.89	0.80	0.00	1.60	0.00	0.00	**0.49**
		Special codes	3.01	4.76	0.00	7.33	1.59	2.87	0.00	0.00	2.10	**1.73**

C.3. Live lane breakdown and places of relative safety breakdown collisions and collision rates

Table C-3 A summary of LLB and places of relative safety breakdown collisions and collision rates

			Scheme									Overall
			M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Number	Fatal	0	0	0	0	0	0	0	1	0	**1**
		Serious	0	0	0	1	0	0	0	1	0	**2**
		Slight	1	4	0	0	1	2	1	1	3	**13**
		Total	1	4	0	1	1	2	1	3	3	**16**
	Vehicle distance travelled [bvkm]		3.64	2.09	1.45	1.21	3.79	2.00	1.82	2.91	2.84	**21.76**
	Rate [/bvkm]	Fatal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.343	0.000	**0.046**
		Serious	0.000	0.000	0.000	0.825	0.000	0.000	0.000	0.343	0.000	**0.092**
		Slight	0.275	1.911	0.000	0.000	0.264	0.999	0.550	0.343	1.055	**0.597**
		Total	0.275	1.911	0.000	0.825	0.264	0.999	0.550	1.030	1.055	**0.735**
After	Number	Fatal	3	0	0	0	0	0	0	1	0	**4**
		Serious	0	0	2	1	3	1	0	2	2	**11**
		Slight	5	1	1	0	1	3	1	1	1	**14**
		Total	8	1	3	1	4	4	1	4	3	**29**
	Vehicle distance travelled [bvkm]		3.65	2.31	0.47	0.41	1.25	0.70	0.63	0.80	0.95	**11.17**
	Rate [/bvkm]	Fatal	0.821	0.000	0.000	0.000	0.000	0.000	0.000	1.256	0.000	**0.358**
		Serious	0.000	0.000	4.217	2.444	2.392	1.435	0.000	2.511	2.098	**0.984**
		Slight	1.369	0.433	2.108	0.000	0.797	4.306	1.598	1.256	1.049	**1.253**
		Total	2.190	0.433	6.325	2.444	3.190	5.741	1.598	5.023	3.147	**2.595**

C.4. Live lane breakdown collisions and collision rates

Table C-4 A summary of live lane breakdown collisions and collision rates

			Scheme									Overall
			M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Number	Fatal	0	0	0	0	0	0	0	0	0	**0**
		Serious	0	0	0	0	0	0	0	1	0	**1**
		Slight	1	1	0	0	0	1	1	1	2	**7**
		Total	1	1	0	0	0	1	1	2	2	**8**
	Vehicle distance travelled [bvkm]		3.64	2.09	1.45	1.21	3.79	2.00	1.82	2.91	2.84	**21.76**
	Rate [/bvkm]	Fatal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
		Serious	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.343	0.000	**0.046**
		Slight	0.275	0.478	0.000	0.000	0.000	0.499	0.550	0.343	0.703	**0.322**
		Total	0.275	0.478	0.000	0.000	0.000	0.499	0.550	0.687	0.703	**0.368**
After	Number	Fatal	3	0	0	0	0	0	0	1	0	**4**
		Serious	0	0	2	1	3	1	0	1	2	**10**
		Slight	4	1	1	0	1	3	1	1	1	**13**
		Total	7	1	3	1	4	4	1	3	3	**27**
	Vehicle distance travelled [bvkm]		3.65	2.31	0.47	0.41	1.25	0.70	0.63	0.80	0.95	**11.17**
	Rate [/bvkm]	Fatal	0.821	0.000	0.000	0.000	0.000	0.000	0.000	1.256	0.000	**0.358**
		Serious	0.000	0.000	4.217	2.444	2.392	1.435	0.000	1.256	2.098	**0.895**
		Slight	1.095	0.433	2.108	0.000	0.797	4.306	1.598	1.256	1.049	**1.163**
		Total	1.916	0.433	6.325	2.444	3.190	5.741	1.598	3.767	3.147	**2.416**

C.5. Places of relative safety breakdown collisions and collision rates

Table C-5 A summary of places of relative safety breakdown collisions and collision rates

			Scheme									Overall
			M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Number	Fatal	0	0	0	0	0	0	0	1	0	**1**
		Serious	0	0	0	1	0	0	0	0	0	**1**
		Slight	0	3	0	0	1	1	0	0	1	**6**
		Total	0	3	0	1	1	1	0	1	1	**8**
	Vehicle distance travelled [bvkm]		3.64	2.09	1.45	1.21	3.79	2.00	1.82	2.91	2.84	**21.76**
	Rate [/bvkm]	Fatal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.343	0.000	**0.046**
		Serious	0.000	0.000	0.000	0.825	0.000	0.000	0.000	0.000	0.000	**0.046**
		Slight	0.000	1.433	0.000	0.000	0.264	0.499	0.000	0.000	0.352	**0.276**
		Total	0.000	1.433	0.000	0.825	0.264	0.499	0.000	0.343	0.352	**0.368**
After	Number	Fatal	0	0	0	0	0	0	0	0	0	**0**
		Serious	0	0	0	0	0	0	0	1	0	**1**
		Slight	1	0	0	0	0	0	0	0	0	**1**
		Total	1	0	0	0	0	0	0	1	0	**2**
	Vehicle distance travelled [bvkm]		3.65	2.31	0.47	0.41	1.25	0.70	0.63	0.80	0.95	**11.17**
	Rate [/bvkm]	Fatal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
		Serious	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.256	0.000	**0.089**
		Slight	0.274	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.089**
		Total	0.274	0.000	0.000	0.000	0.000	0.000	0.000	1.256	0.000	**0.179**

C.6. Weekday all injury collisions and all injury collision rates by time slices

Table C-6 Weekday all injury collisions and weekday all injury collision rates by time slices

			Scheme									Overall
			M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Duration [year]		3	3	3	3	3	3	3	3	3	**-**
	Number	AM and PM	160	75	28	25	94	31	38	22	49	**522**
		IP	37	26	33	7	75	14	11	24	50	**277**
		Overnight	36	21	9	5	44	10	13	18	45	**201**
		Total	233	122	70	37	213	55	62	64	144	**1,000**
	Vehicle distance travelled [bvkm]		3.64	2.09	1.45	1.21	3.79	2.00	1.82	2.91	2.84	**21.76**
	Rate [/bvkm]	AM and PM	44	36	19	21	25	15	21	8	17	**24**
		IP	10	12	23	6	20	7	6	8	18	**13**
		Overnight	10	10	6	4	12	5	7	6	16	**9**
		Total	64	58	48	31	56	27	34	22	51	**46**
After	Duration [year]		3	3	1	1	1	1	1	0.8	1	**-**
	Number	AM and PM	142	65	5	7	6	7	1	1	13	**247**
		IP	40	20	3	3	8	3	3	1	7	**88**
		Overnight	23	19	8	5	7	6	3	3	6	**80**
		Total	205	104	16	15	21	16	7	5	26	**415**
	Vehicle distance travelled [bvkm]		3.65	2.31	0.47	0.41	1.25	0.70	0.63	0.80	0.95	**11.17**
	Rate [/bvkm]	AM and PM	39	28	11	17	5	10	2	1	14	**22**
		IP	11	9	6	7	6	4	5	1	7	**8**
		Overnight	6	8	17	12	6	9	5	4	6	**7**

		Total	56	45	34	37	17	23	11	6	27	**37**
% Change in rate	AM and PM											**-8%**
	IP											**-38%**
	Overnight											**-22%**

C.7. Weekday personal injury collisions and collision rates by days of the week

Table C-7 Weekday personal injury collisions collision rates by days of the week

			Scheme									Overall
			M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Before	Duration [year]		3	3	3	3	3	3	3	3	3	**-**
	Number	Weekday	233	122	70	37	213	55	62	64	144	**1,000**
		Weekend	58	49	24	10	69	15	12	31	69	**337**
		Total	291	171	94	47	282	70	74	95	213	**1,337**
	Vehicle distance travelled [bvkm]		3.64	2.09	1.45	1.21	3.79	2.00	1.82	2.91	2.84	**21.76**
	Rate [/bvkm]	Weekday	64	58	48	31	56	27	34	22	51	**46**
		Weekend	16	23	17	8	18	7	7	11	24	**15**
		Total	80	82	65	39	74	35	41	33	75	**61**
After	Duration [year]		3	3	1	1	1	1	1	0.8	1	**-**
	Number	Weekday	205	104	16	15	21	16	7	5	26	**415**
		Weekend	50	30	5	5	6	6	5	3	13	**123**
		Total	255	134	21	20	27	22	12	8	39	**538**
	Vehicle distance travelled [bvkm]		3.65	2.31	0.47	0.41	1.25	0.70	0.63	0.80	0.95	**11.17**
	Rate [/bvkm]	Weekday	56	45	34	37	17	23	11	6	27	**37**
		Weekend	14	13	11	12	5	9	8	4	14	**11**
		Total	70	58	44	49	22	32	19	10	41	**48**
% Change in rate	Weekday											**-19%**
	Weekend											**-29%**

C.8. Assumptions used to identify hazards

The assumptions used to identify the likelihood of a hazard using the STATS19 data are presented below.

Unsafe lane changing. It was assumed that this hazard was likely to be present if the collision description included details of vehicle(s) changing lanes leading to a collision. The following contributory factors were used: '[405] failed to look properly', '[406] failed to judge other person's path or speed', '[409] swerved', '[404] failed to signal or misleading signal', '[601] aggressive driving' and '[602] careless, reckless or in a hurry'.

Driver ignores closed lane(s) signals that are protecting an incident. It was assumed that this hazard was likely to be present if closed lanes were detailed in the collision description. The following contributory factors were used: '[104] inadequate or masked signs or road markings', '[105] defective traffic signals' and '[301] disobeyed automatic traffic signal'.

Vehicle enters main carriageway unsafely. It was assumed that this hazard was likely to be present if the collision description specified the collision was resulted from vehicle(s) merging or entering the main carriageway. The following contributory factors were used: '[401] junction overshoot', '[405] failed to look properly', '[601] aggressive driving' and '[602] careless, reckless or in a hurry'.

Vehicle re-joins running lane. It was assumed that this hazard was likely to be present if it was detailed in the collision description. The following contributory factors were used: '[403] poor turn or manoeuvre', '[405] failed to look properly' and '[406] failed to judge other person's path or speed'.

Vehicle reversing along exit slip. It was assumed that this hazard was likely to be present if it was detailed in the collision description.

Driver loses control of vehicle. It was assumed that this hazard was likely to be present if either the collision description included 'loss of control' or 'skidding' or if the contributory factor '[410] loss of control' was recorded.

Vehicle stops in running lane - off peak. It was assumed that this hazard was likely to be present if the collision was attributable to a vehicle breakdown or a vehicle stopping for unknown reason in the live lane. The day type and time slice associated with the collision were used to determine if the likely hazard occurred during off peak.

Vehicle stops in running lane - peak. It was assumed that this hazard was likely to be present if the collision was attributable to a vehicle breakdown or a vehicle stopping for unknown reason in the live lane. The day type and time slice associated with the collision were used to determine if the likely hazard occurred during the peak.

Driver fatigued - unable to perceive hazards effectively. It was assumed that this hazard was likely to be present if contributory factor '[503] fatigue' was recorded and/or stated in the collision description. The hazard did not include '[806] impaired by alcohol' and '[807] impaired by drugs (illicit or medicinal)'.

Vehicle drifts off carriageway (i.e. leaving the carriageway as a result of road environment). It was assumed that this hazard was likely to be present if described in the collision description. Collisions with vehicles drifting off the carriageway as a result of collision with another vehicle(s) or due to weather conditions were not included. The following contributory factors were used: '[101] poor defective road surface', '[102] deposit on road (e.g. oil, mud, chippings)', '[103] slippery road (due to weather)', '[108] road layout (e.g. bend, hill, narrow carriageway', '[110] sunken, raised or slippery inspection cover', '[703] road layout (e.g. bend, winding road, hill crest)' and '[704] buildings, road signs, street furniture'.

Vehicle recovered from ERA. It was assumed that this hazard was likely to be present if it was detailed in the collision description. The following contributory factor was used: '[701] stationary or parked vehicle(s)'.

Vehicle stopped on hard shoulder (D3M) or verge (SM-ALR). It was assumed that this hazard was likely to be present if it was detailed in the collision description. The following contributory factor was used: '[701] stationary or parked vehicle(s)'.

Individual vehicle is driven too fast. It was assumed that this hazard was likely to be present if speeding was recorded in the collision description. The following contributory factors were used: '[306] exceeding speed limit', '[307] traveling too fast for conditions', '[308] following too close', '[601] aggressive driving' and '[602] careless, reckless or in a hurry'.

Maintenance workers setting up and taking down work site. The following contributory factor was used: '[107] temporary road layout (e.g. contraflow)'.

Motorcycles filter through traffic. It was assumed that this hazard was likely to be present if it was detailed in the collision description.

Pedestrian in running lane - live traffic. It was assumed that this hazard was likely to be present if it was detailed in the collision description.

Rapid change of general vehicle speed. It was assumed that this hazard was likely to be present if the collision description recorded evidence of vehicles stopping suddenly on the main carriageway, braking hard, slowed for unknown reason or due to congestion. The following contributory factor was used: '[604] driving too slow for conditions or slow vehicle (e.g. tractor)'.

C.9. Hazard analysis against the main hazards identified

Table C-8 A summary of the hazard analysis results

	Number		Rate [/bvkm]	
	Before	After	Before	After
Vehicle distance travelled [bvkm]	21.76	11.17	-	-
Unsafe lane changing	280	167	12.9	14.9
Driver ignores closed lane(s) signals that are protecting an incident	1	0	0.0	0.0
Vehicle enters main carriageway unsafely	24	13	1.1	1.2
Vehicle rejoins running lane	2	2	0.1	0.2
Vehicle reversing along exit slip	1	1	0.0	0.1
Driver loses control of vehicle	309	124	14.2	11.1
Vehicle stops in running lane - off peak *	7	21	0.3	1.9
Vehicle stops in running lane - peak (Scheme specific only) *	1	6	0	0.5
Driver fatigued - unable to perceive hazards effectively	55	15	2.5	1.3
Vehicle drifts off carriageway (i.e. leaving the carriageway as a result of Road Environment)	114	13	5.2	1.2
Vehicle recovered from ERA (Generic only)	0	0	0.0	0.0
Vehicle stopped on Hard Shoulder (D3M) or verge (SM-ALR)	8	2	0.4	0.2
Individual vehicle is driven too fast	109	30	5.0	2.7
Maintenance workers setting up and taking down work site (Generic only)	0	0	0.0	0.0
Motorcycles filter through traffic	9	3	0.4	0.3
Pedestrian in running lane - live traffic	6	6	0.3	0.5
Rapid change of general vehicle speed	116	37	5.3	3.3
Sudden weaving at exit point	42	16	1.9	1.4
Tailgating	477	193	21.9	17.3
TO/ISUO in running lane	0	1	0.0	0.1
Driver on LBS1 fails to exit and continues on LBS1 through junction (Scheme specific only)	0	0	0.0	0.0
Total	**1561**	**650**	**-**	**-**

Appendix D. Compliance

D.1. Genuine and non-emergency EA stops

Table D-1 Genuine and non-emergency EA stops

		Scheme									Overall
		M25 J23-27	M25 J5-7 (J5-6)	M6 J10a-13 (J11a-13)	M1 J39-42	M1 J28-31	M5 J4a-6	M1 J32-35a	M1 J19-16	M3 J2-4a	
Number of EA stops	Genuine stop	22	14	8	15	14	15	12	24	9	**133**
	Non-emergency stop	97	53	29	19	22	24	30	37	8	**319**
	Total	119	67	37	34	36	39	42	61	17	**452**
% of all EA stops	Genuine stop	18%	21%	22%	44%	39%	38%	29%	39%	53%	**29%**
	Non-emergency stop	82%	79%	78%	56%	61%	62%	71%	61%	47%	**71%**
Stops/hour/EA	Genuine stop	0.09	0.06	0.05	0.10	0.08	0.05	0.08	0.17	0.05	**0.08**
	Non-emergency stop	0.40	0.22	0.19	0.13	0.13	0.09	0.20	0.27	0.04	**0.19**
	Total	0.50	0.28	0.25	0.23	0.21	0.14	0.28	0.44	0.09	**0.27**
One stop/EA/*x* hours	Genuine stop	10.91	17.14	18.88	10.04	12.05	18.48	12.63	5.81	20.00	**12.77**
	Non-emergency stop	2.47	4.53	5.21	7.93	7.67	11.55	5.05	3.77	22.50	**5.32**
	Total	2.02	3.58	4.08	4.43	4.69	7.11	3.61	2.29	10.59	**3.76**