Smart motorways - scheme safety

‘Before’ versus ‘after’ assessment

Contents

Executive summary

In early 2020, we published the Smart Motorway All Lane Running Overarching Safety report 2019, which compared the safety of nine all lane running (ALR) motorway schemes before their construction and after their opening.

The Office of Rail and Road (ORR) 2021 Quality assurance of all lane running motorway data report recommended updating the 2019 report and to also include dynamic hard shoulder (DHS) motorway schemes. In our response to ORR's review, we committed to undertake this analysis.

There are three types of smart motorway: controlled motorways, which have hard shoulders, DHS motorways which use the hard shoulder as a running lane at the busiest times, and the latest type, ALR motorways, where the hard shoulder is permanently converted to a running lane.

On 15 April 2023 the Government announced that plans for new smart motorways would be cancelled in recognition of the lack of public confidence felt by drivers and cost pressures. We and the Government continue to invest £900 million in further safety improvements on existing smart motorways, and to give motorists clear advice when using them.

While no new stretches of road will be converted into smart motorways, the M56 J6-8 and M6 J21a-26, which were both in construction at the time, would be completed given they were already more than three quarters constructed.

This report goes beyond the commitment in response to ORR's 2019 report and assesses a total of 37 smart motorway schemes[1]. This report includes schemes which have at least one year's worth of safety data, including 15 ALR, seven DHS and 15 controlled motorways. This report compares five years' worth of safety data before the schemes' construction started and up to five years after opening and helps understand how each scheme's safety compares between before each scheme was constructed and after. Two-thirds of all smart motorway schemes and only one-third of ALR motorways have five years' worth of after data. Due to differences in the amount of data available per scheme, any direct comparisons between scheme safety should be made with significant caution.

Where appropriate, we have also calculated a counterfactual, meaning a hypothetical after-period estimating what could have happened if the specific locations had not been converted to smart motorways. This gives an indication of whether changes in safety data may be due to a scheme or to other external factors. In this report we have undertaken this counterfactual only in relation to personal injury collision (PIC) rates.

As highlighted in the ORR 2021 Quality assurance of all lane running motorway data report, when schemes are constructed over different time periods, the counterfactual is specific to each scheme. Because collisions fluctuate from year-to-year, the counterfactual can be very sensitive to the precise years chosen. This is particularly

[1] In our response to the ORR 2021 Quality assurance of all lane running motorway data report, we suggested the name of this report would be 'ALR & DHS Overarching Safety Report'. As we increased the scope subsequently to include controlled motorways, we have updated the name of this report to 'Smart motorways scheme safety - 'Before' versus 'after' assessment'.

the case for fatal and weighted injuries (FWI) rates, which place greater emphasis on deaths and serious injuries, and killed and seriously injured (KSI) rates, which place equal emphasis on deaths and serious injuries. Both of these metrics are influenced by the STATS19 adjustment factors which are explained later in this report, whereas PICs are not. For this reason, we have chosen not to calculate a counterfactual for FWI and KSI rates. We will now assess the most appropriate way to apply counterfactual analysis to FWI and KSI rates.

Based on available data so far, most ALR, DHS and controlled motorway schemes (25 out of 37) have seen a reduction in PIC rates after they were constructed both against the before and the counterfactual[2]. Most schemes (32 out of 37) have also seen a reduction in FWI rates. This has also been the case for most schemes (29 out of 37) for the KSI rates.

In this report we have taken a conservative approach to conducting and presenting the analysis. We will work closely with specialist statisticians and the ORR to assess opportunities to continuously improve, where possible, our analysis over the coming years. Such opportunities may include research on statistical significance testing, counterfactual analysis, expanding the safety data over longer periods and aggregating the scheme-level data.

As part of our response to the Smart motorway safety evidence stocktake and action plan published in March 2020 (later in this report called the 2020 Action Plan), we have already completed safety reviews and committed to interventions on the:

- M1 junctions 32 to 35a and M1 junctions 39 to 42 (ALR motorways)
- M1 junctions 10 to 13 and M6 junctions 5 to 8 (DHS motorways)[3].

Using the results of this report, in addition to other evidence sources, we want to better understand why other locations in the after period show increased rates compared to the before period. We have defined these as locations where at least one metric is higher either compared to before (FWI/ KSI) or to the counterfactual (PIC).

As part of our business-as-usual (BAU) activities we are already undertaking safety reviews of the ALR and DHS motorways which have not already been subject to safety reviews following the 2020 Action Plan. We are doing the same for the M60 junctions 8 to 18 controlled motorway scheme.

For the remaining schemes, where the after period shows increased rates compared to the before period, we will undertake desktop safety assessments to understand the latest safety data (if available) and to better understand why these locations in their after period show increased rates compared to the before period. These are the locations included in the table below.

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[2] For one scheme (M1 J24-25) it was not possible to calculate a counterfactual due to limited background data. This scheme saw lower collision rates in the after period compared to before.

[3] The safety review already undertaken combined sections of the M1 J28-31 and J32-35a into a single review of the section M1 J30-35. For schemes M1 J28-J31, M1 J32-J35a and M6 J5-J8 we undertook safety reviews particularly for sections M1 J30-35 and M6 J5-6 as part of the 2020 Action Plan. As this report does not suggest an increase in rates, we consider that it is not required to undertake another safety assessment or safety review.

We plan to complete both the safety reviews and desktop safety assessments in Autumn 2023, at which point we will review the results and determine the next steps, if any, we need to take.

Scheme	Type	Assessment/ Review
M1 J16-19	ALR	Safety review in progress through BAU activities
M5 J4a-6	ALR	Safety review in progress through BAU activities
M23 J8-10	ALR	Desktop safety assessment
M25 J5-7	ALR	Safety review in progress through BAU activities
M6 J11a-13	ALR	Safety review in progress through BAU activities
M1 J23a-J24	Controlled	Desktop safety assessment
M25 J15-J16	Controlled	Desktop safety assessment
M42 J7-J9	Controlled	Desktop safety assessment
M20 J5-J7	Controlled	Desktop safety assessment
M25 J2-J3	Controlled	Desktop safety assessment
M25 J7-J10	Controlled	Desktop safety assessment
M25 J10-J15	Controlled	Desktop safety assessment
M60 J8-J18	Controlled	Safety review in progress through BAU activities
M6 J8-J10a	DHS	Safety review in progress through BAU activities

We will continue to monitor and evaluate the safety of our network as more data becomes available, including monitoring the safety of sections where the after period has improved compared to the before period.

There are some key considerations in using or referring to the results of this report.

- Due to differences in the amount of data available per scheme, significant caution should be taken in making comparisons either between schemes or between before and after periods for schemes that have less than five-year after data.

- Many controlled motorway schemes opened some time ago, with the earliest opening as far back as 1995. Therefore, the after period rates may not reflect recent safety data. At the moment, it is not appropriate to extrapolate the findings from this analysis to make judgements for the respective road types, especially as they cover different time periods over the last three decades. The desktop safety assessments will also consider recent data for these schemes. In the future, we will assess appropriate ways to aggregate before versus after data over long periods. For comparisons between road types across the strategic road network (SRN), we have published the Smart motorways stocktake – Third year progress report 2023, which considers fixed time periods for all road types.

- While the analysis goes some way to comparing safety data after a scheme was put in place with safety before construction began, it does not explain what has caused the safety changes, such as the smart motorway itself or external factors. Methods such as the counterfactual and statistical significance testing help further increase our understanding of any safety changes. With future applications of these methods, additional safety assessments and reviews, we will have even greater understanding of the reasons behind the scheme-level safety changes.

To gain further confidence in the analysis, ORR undertook additional independent assurance for the supporting analysis in March 2023. ORR noted that we have gone beyond their recommendation from their earlier work to update and extend the analysis, we have continued to follow appropriate analytical assurance processes, and our conclusions are appropriate for this stage of the analysis.

In more detail the ORR review found that:

- we have updated the before vs after analysis of ALR motorways published in the Smart Motorway All Lane Running Overarching Safety report 2019 and also expanded it to cover both DHS and controlled motorways, going beyond the recommendation from ORR's 2021 Quality assurance of all lane running motorway data

- we have developed our approach to the counterfactual and statistical testing of differences in PIC rates, applying methods used in our other analysis, and we have described these clearly in our report

- in updating, expanding and developing our analysis, we have continued to follow appropriate analytical assurance processes to ensure the reliability of our analysis

- we have been cautious in drawing firm conclusions from our analysis. This is appropriate at this stage – for example because the methodological developments applied to PIC rates have not yet been extended to the FWI and KSI rates. This results in more focus on simpler before versus after comparisons, rather than using more complex statistical methods, which could support firmer conclusions.

1. Background and context

In early 2020, we published the Smart Motorway All Lane Running Overarching Safety report 2019, which compared the safety of nine all lane running (ALR) motorway schemes before their construction and after their opening.

The Office of Rail and Road (ORR) 2021 Quality assurance of all lane running motorway data report recommended updating this report to include dynamic hard shoulder (DHS) motorway schemes. In our response to this review, we committed to undertake this analysis.

There are three types of smart motorway: controlled motorways, which have hard shoulders, DHS motorways which use the hard shoulder as a running lane at the busiest times, and the latest type, ALR motorways, where the hard shoulder is permanently converted to a running lane.

This report goes beyond the commitment in response to ORR's report and assesses a total of 37 smart motorway schemes. This report includes schemes which have at least one year's worth of safety data, including 15 ALR, seven DHS and 15 controlled motorways.

The report compares five years' worth of safety data before the schemes were constructed and up to five years after opening[4]. Two-thirds of all the smart motorway schemes and only one-third of ALR motorways have five years' worth of after data. Due to differences in the amount of data available per scheme, any comparisons between schemes' safety should be made with significant caution.

Increased transparency

The safety analysis presented here was developed by National Highways using STATS19 data. STATS19 data is collected by police forces, and then validated and published annually by the Department for Transport (DfT). We then analyse the data to assess safety across road types and different parts of the network. We have published annual smart motorways stocktake progress reports[5]. As with our latest Smart motorways stocktake – Third year progress report 2023, the analysis in this report has been subject to five levels of assurance. For more information, please see Annex C – Methodology.

While a fifth level of assurance is not standard practice, this builds on the approach we followed for the previous annual progress reports[6]. To gain further confidence in the analysis, ORR undertook additional independent assurance for the supporting analysis in March 2023.

ORR noted that we have gone beyond its recommendation from its earlier work to update and extend the analysis, we have continued to follow appropriate analytical

[4] To avoid the effect of seasonality on the rates, only complete 12-month periods have been used in the after-period. These periods begin on the date of scheme opening and a 'year' is the 12-month period from this date, not a calendar year

[5] Referred to as annual progress reports

[6] Previous annual progress reports refer to the Smart motorways stocktake First year progress report 2021 and Smart motorways stocktake Second year progress report 2022

assurance processes, and our conclusions are appropriate for this stage of the analysis.

In more detail the ORR review found that:

- we have updated the before vs after analysis of ALR motorways published in the Smart Motorway All Lane Running Overarching Safety report 2019 and also expanded it to cover both DHS and controlled motorways, going beyond the recommendation from ORR's 2021 Quality assurance of all lane running motorway data

- we have developed our approach to the counterfactual and statistical testing of differences in PIC rates, applying methods used in our other analysis, and we have described these clearly in our report

- in updating, expanding and developing our analysis, we have continued to follow appropriate analytical assurance processes to ensure the reliability of our analysis

- we have been cautious in drawing firm conclusions from our analysis. This is appropriate at this stage – for example because the methodological developments applied to PIC rates have not yet been extended to the FWI and KSI rates. This results in more focus on simpler before versus after comparisons, rather than using more complex statistical methods, which could support firmer conclusions.

To provide greater transparency, we have produced an extensive file with our detailed analysis in Annex D - Detailed tables. This presents all the detailed analysis in tables which can be readily used by other organisations or interested parties.

Alongside this report, to allow other organisations or interested parties to undertake their own analysis, we have published the detailed collision data Annex E - Detailed collision data.

We will be interested to hear your thoughts on how to improve this data. If you want to contact us, please contact roadsafetydivision@nationalhighways.co.uk.

Important considerations

As per the annual progress reports and in line with our response to the ORR Quality assurance of all lane running motorway data in 2021, the safety analysis considers three key metrics. These are:

- Personal injury collisions (PIC) reflect collisions where at least one person was injured, but does not include any consideration of whether more than one person has sustained an injury or the severity of the injuries

- Fatal and weighted injuries (FWI) place greater emphasis on deaths and serious injuries by giving a death 10 times the weighting of a serious injury and a serious injury 10 times the weighting of a slight injury

- Killed and seriously injured (KSI) places equal emphasis on deaths and serious injuries by not giving any weighting between the two.

Generally it is important to consider both the absolute values and rates accounting for traffic flows. This means that while every injury matters independently (absolute values), metrics account for differences in traffic across the SRN (rates) and to some extent over time. Rates may be more meaningful for safety comparisons than absolute values as they avoid some issues, such as suggesting that the least used roads are the safest roads. For this reason and to maintain brevity across the report, we have presented rates across all schemes in the main part of the report. For transparency, alongside this report we have also produced an extensive file with our detailed analysis in Annex D - Detailed tables and have published the detailed collision data in Annex E - Detailed collision data.

Where appropriate, we have also calculated the counterfactual for each scheme, meaning a hypothetical after-period estimating what could have happened if the specific locations had not been converted to smart motorways. Methods such as counterfactual analysis help further increase our understanding of any safety changes. In this report we have undertaken this counterfactual analysis only for personal injury collision (PIC) rates. We estimated the counterfactual using PIC rate trends across motorways within the same region and over the same time periods. For further information on how the counterfactual estimate was calculated, please see Annex C – Methodology.

Before considering the updated safety evidence, it is important to outline a few key considerations that have an impact on safety data, both for 2021 and historically.

- The coronavirus pandemic (Covid-19) and associated travel restrictions affected road safety in 2020 and 2021. For example, due to varying restrictions across regions and therefore varying traffic across roads, certain safety comparisons between roads may not be like-for-like. More recent after scheme data, such as for ALR and DHS are likely to be impacted more by external events, such as Covid-19. We will also assess the most appropriate way to include either longer or more recent time periods within our analysis to mitigate such impacts even further

- Since 2012, many police forces have changed the way they collect safety data. Using the new method, a collision is categorised automatically based on the worst injury, rather than (using the previous method) the judgement of a police officer. Police forces using the new systems report more serious injuries than those which don't. DfT and the Office for National Statistics (ONS) have developed an approach to adjust the data collected from those police forces which are not currently using the automated system. This enables better comparisons across police forces and further increases the confidence in safety data captured by police officers. This adjusted data is published annually by DfT and is the basis for the safety analysis in this report[7]

- Small datasets can be very sensitive to small changes. For example, in statistical terms if there is a single collision on a specific road location which

[7] While the safety analysis for this report is based on STATS19 adjusted data, this report publishes both adjusted and unadjusted statistics in Annex D - Detailed tables for completeness and transparency. More information on injury based reporting and severity adjustments can be found here

had previously had no collisions, the ‘worsening’ of its safety cannot be defined[8]. Such small datasets should always be considered within a broader context

- In this report we have chosen to not calculate a counterfactual for FWI and KSI rates. As highlighted in the ORR 2021 Quality assurance of all lane running motorway data report, when schemes are constructed over different time periods, the counterfactual is specific to each scheme. Because collisions fluctuate from year-to-year, the counterfactual can be very sensitive to the precise years chosen, particularly for FWI and KSI rates. For this reason, we have chosen not to calculate a counterfactual for FWI and KSI rates at this point. We will work closely with specialist statisticians and the ORR to assess the most appropriate way to apply counterfactual analysis to FWI and KSI rates. Estimating the counterfactual for FWI and KSI rates will help make FWI and KSI comparisons between the before and after scheme period even more robust

- In this report we have combined the estimation of a counterfactual (a hypothetical after period estimating what could have happened if the specific locations were not converted to smart motorways) with statistical significance testing (consideration of whether a difference in numbers is likely to be statistically considerable). This has enabled us to undertake the analysis in a concise way. While we will assess the most appropriate way to apply counterfactual analysis to FWI and KSI rates, the statistical significance testing is not likely to be eligible for them. For more information, please see Annex C – Methodology

- Due to differences in the amount of data available per scheme, significant caution should be taken in making comparisons either between schemes or between before and after periods for schemes that have less than five-year after data

- Many controlled motorway schemes opened some time ago, with the earliest opening as far back as 1995. Therefore, the after period rates may not reflect recent safety data. At the moment, it is not appropriate to extrapolate the findings from this analysis to make judgements for the respective road types, especially as they cover different time periods over the last three decades. The desktop safety assessments will also consider recent data for these schemes. In the future, we will assess appropriate ways to aggregate before versus after data over long periods. For comparisons between road types across the strategic road network (SRN), we have published the Smart motorways stocktake – Third year progress report 2023, which considers fixed time periods for all road types

- While the analysis goes some way to comparing safety data after a scheme was put in place with safety before construction began, it does not explain

[8] As dividing 1 by 0 equals infinity

what has caused the safety changes, such as the smart motorway itself or external factors. Methods such as counterfactual analysis and statistical significance testing help further increase our understanding of any safety changes. With future applications of these methods, additional safety assessments and reviews, we will have even greater understanding of the reasons behind the scheme-level safety changes.

These considerations are important as they enable better alignment with police reporting and DfT guidance. As such any comparison with previous or other publications should consider those updates.

When considering the scheme safety, it is also important to consider the results alongside other local factors which may have a role to play in influencing scheme safety. Such factors may be:

- the presence of a motorway incident detection and automatic signalling (MIDAS) system either prior to, or after the opening of the smart motorway scheme. MIDAS identifies queuing traffic or congestion by monitoring traffic speed and flow and can also reduce the risk of secondary incidents in queuing traffic, ie the risk of vehicles colliding with the rear of a queue of traffic
- whether a scheme was widened[9] before or at the same time as it was upgraded to be a smart motorway. Scheme widening may impact the overall safety and amount of traffic at that location, which in turn influence the respective rates
- whether there were any junction improvements either prior to, at the same time as or after the upgrade of the scheme to a smart motorway, which may have resulted in safety improvements or changes in traffic flows in that area
- how the scheme is operated. For example DHS motorways, when the hard shoulder is operating as a live lane, has the speed set at maximum of 60mph.

Although we have delivered the majority of the actions in the 2020 Action Plan, such as the introduction of stopped vehicle detection (SVD) and enabling increased enforcement of Red X signals, the impact of these actions is not yet reflected in the safety data.

Due to the time lag between the actions being delivered and the data being available, it will be later in 2023 before we can start assessing and understanding the impact of the actions. We will continue to assess the data in accordance with our monitoring and evaluation processes.

Such factors and the respective schemes which may have been influenced are listed in detail in Annex B - Smart motorway scheme information.

Across all comparisons below, this report refers to lower and higher rates. Based on the available data, a lower rate in the after period compared to the before or counterfactual means that the specific metric has improved. A higher rate in the after

[9] Providing an additional lane and retaining a hard shoulder. Of all types of smart motorway, this is applicable only to controlled motorways.

period compared to the before or counterfactual means that the specific metric has worsened.

2. Scheme-level headline comparisons

Personal injury collision rates

This report compares five years' worth of safety data before the schemes were constructed and up to five years after opening[10]. Two-thirds of smart motorway schemes and only one-third of ALR motorways have five years' worth of after data. Due to differences in the amount of data available per scheme, any direct comparisons between scheme safety should be made with significant caution. It is also worth noting that some schemes, particularly controlled motorway schemes, opened a while ago, with the earliest opening in 1995. Therefore, because of the amount of time that has elapsed since the after period, safety performance may have changed.

This section simplifies some of the nuanced safety comparisons for each scheme. To do so, it uses the mean values for the before, counterfactual and after periods. To help us make some of these comparisons even more meaningful, we have also undertaken statistical significance testing which reflects the uncertainty behind making comparisons between small numbers. For more information, please see Annex C - Methodology.

Most ALR, DHS and controlled motorway schemes (25 out of 37) have seen a reduction in PIC rates after they were constructed both against before and counterfactual periods[11]. This means the collisions on those schemes are lower than both what they were before and what it is estimated that they would have been without the scheme.

<u>ALR schemes</u>

Of the 15 ALR schemes, only five have five-year after data. Twelve of the ALR schemes not only see lower PIC rates compared to the road they replaced, but also lower PIC rates compared to what these are estimated to have been if no scheme had been put in place (counterfactual).

Two of the remaining schemes see lower PIC rates compared to the road they replaced, but their PIC rates are higher than the counterfactual. One scheme remains unknown due to low confidence in the background counterfactual data.

These conclusions for ALR schemes will continue to evolve as only five out of 15 schemes have five-year after data. We will continue to monitor and evaluate the safety of our network as more data becomes available.

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[10] To avoid the effect of seasonality on the rates, only complete 12-month periods have been used in the after-period. These periods begin on the date of scheme opening and a 'year' is the 12-month period from this date, not a calendar year

[11] For one scheme (M1 J24-25) it was not possible to calculate a counterfactual due to limited background data. This scheme saw lower collision rates in the after period compared to before

DHS schemes

All seven DHS schemes have five-year after data. Out of the seven DHS schemes, six schemes see lower PIC rates compared to the road they replaced, and also lower PIC rates compared to what these are estimated to have been if no scheme had been put in place. One DHS scheme has seen lower collision rates compared to the road it replaced, but a higher PIC rate compared to its counterfactual.

Controlled motorway schemes

Twelve out of 15 controlled motorway schemes have five-year after data. Out of all controlled motorways, 11 schemes saw lower PIC rates after they were constructed compared to before, out of which seven saw lower PIC rates compared to the counterfactual.

Four schemes saw lower PIC rates after the schemes were opened, but their PIC rates are higher compared to the counterfactual. Another four schemes saw higher PIC rates after they were constructed both compared to before and the counterfactual.

These conclusions for controlled motorway schemes will continue to evolve as only 12 out of 15 schemes have five-year after data.

Summary

Table 1.1 includes all schemes which have five-year before and after data (60 months), while table 1.2 includes all schemes which have less than five-year after data.

The purpose of these two tables is to summarise in a simple way the safety data of a scheme after it opened. To enable this, we have presented the mean values of the respective PIC rates[12].

In many cases, making comparisons between small numbers can be challenging due to their underlying variability. To help us make some of these comparisons more meaningful, we have undertaken statistical significance testing. For more information, please see Annex C - Methodology.

[12] The mean value of the counterfactual is equivalent to its central estimate

Table 1.1

Description: The majority of smart motorway schemes have seen a reduction in PIC rates so far, noting two-thirds of all smart motorway schemes have five-year after data (table 1.1) and one-third have less than five years (table 1.2)

Data: PIC rate mean values (injury-adjusted PIC per hundred million vehicle miles) for before, counterfactual and after per smart motorway scheme

Scheme	Type	After Months	Before	Counter-factual	After
M1 J28-J31	ALR	60	11.64	6.76	3.32
M1 J39-J42	ALR	60	7.48	4.39	6.62
M25 J5-J7	ALR	60	13.39	11.06	10.22
M25 J23-J27	ALR	60	13.52	11.99	11.36
M6 J11a-J13	ALR	60	11.16	9.00	5.53
M1 J6a-J10	Controlled	60	58.53	56.77	13.63
M1 J25-J28	Controlled	60	14.58	8.99	6.13
M20 J4-J5	Controlled	60	23.00	20.32	12.42
M20 J5-J7	Controlled	60	15.11	12.33	16.06
M25 J2-J3	Controlled	60	19.58	17.58	23.66
M25 J7-J10	Controlled	60	14.70	12.76	13.41
M25 J10-J15	Controlled	60	18.68	12.05	19.83
M25 J15-J16	Controlled	60	12.58	9.87	13.33
M25 J16-J23	Controlled	60	21.26	19.51	9.82
M25 J27-J30	Controlled	60	17.17	14.98	8.19
M42 J7-J9	Controlled	60	5.54	3.62	4.63
M6 J10a-J11a	Controlled	60	11.23	8.96	3.96
M1 J10-J13	DHS	60	17.45	15.70	13.70
M42 J3a-J7	DHS	60	12.95	10.77	6.99
M4-M5 Interchange	DHS	60	15.54	12.00	6.86
M6 J4-J5	DHS	60	10.73	8.90	8.69
M6 J5-J8	DHS	60	17.45	15.23	13.45
M6 J8-J10a	DHS	60	18.18	16.32	16.39
M62 J25-J30	DHS	60	13.19	10.07	8.47

Source: Analysis from National Highways. Data based on STATS19 with minor amendment[13].

[13] One smart motorway death has historically been omitted from STATS19. This was manually added in the 2020 Stocktake, annual progress reports and will continue to be added in subsequent overall smart motorways reporting, including this report

Table 1.2

Description: The majority of smart motorway schemes have seen a reduction in PIC rates so far, noting two-thirds of all smart motorway schemes have five-year after data (table 1.1) and one-third have less than five years (table 1.2)

Data: PIC rate mean values (injury-adjusted PIC per hundred million vehicle miles) for before, counterfactual and after per smart motorway scheme

Scheme	Type	After Months[14]	Before	Counter-factual	After
M1 J16-J19	ALR	36	5.09	0.92	2.55
M1 J24-J25	ALR	24	3.85	N/A	0.97
M1 J32-J35a	ALR	48	12.76	8.72	5.07
M20 J3-J5	ALR	12	13.81	11.29	7.90
M23 J8-J10	ALR	12	13.32	10.97	5.48
M3 J2-J4a	ALR	48	13.09	9.98	7.12
M5 J4a-J6	ALR	48	5.87	3.98	3.86
M6 J2-J4	ALR	12	9.90	8.09	5.23
M6 J16-J19	ALR	24	12.46	8.51	3.99
M62 J18-J20	ALR	36	8.64	3.61	3.32
M1 J23a-J24	Controlled	36	7.69	3.33	3.70
M1 J31-J32	Controlled	48	9.85	6.35	5.79
M60 J8-J18	Controlled	36	10.20	5.12	7.35

Source: Analysis from National Highways. Data based on STATS19 with minor amendment[15].

Fatal and weighted injuries rates

Most schemes (32 out of 37) have also seen a reduction in FWI rates, which place greater emphasis on deaths and serious injuries, when comparing the before and after periods.

Due to differences in the amount of data available per scheme and given that we have not estimated the counterfactual for FWI in this report, any comparisons between scheme safety should be made with significant caution.

We will assess the most appropriate way to apply counterfactual analysis to FWI and KSI rates. Estimating a counterfactual for FWI and KSI rates will help make comparisons between the before and after-scheme period in terms of FWI and KSI even more meaningful. This means that all comparisons below are between the before and after periods.

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[14] To avoid the effect of seasonality on the rates, only complete 12-month periods have been used in the after-period. These periods begin on the date of scheme opening and a 'year' is the 12-month period from this date, not a calendar year

[15] One smart motorway death has historically been omitted from STATS19. This was manually added in the 2020 Stocktake, annual progress reports and will continue to be added in subsequent overall smart motorways reporting, including this report

ALR schemes

Out of the 15 ALR schemes, only five schemes have five-year after data. Twelve of the ALR schemes see lower FWI rates compared to the road they replaced. All five ALR schemes with five-year data see lower FWI rates compared to the road they replaced.

These conclusions for ALR schemes will continue to evolve as more five-year data becomes available. We will continue to monitor and evaluate the safety of our network as more data becomes available.

DHS schemes

All seven DHS schemes have five-year after data and see lower FWI rates compared to the road they replaced.

Controlled motorway schemes

Twelve out of 15 controlled motorway schemes have five-year after data. Out of all controlled motorway schemes, 13 saw lower FWI rates after they opened compared to before. These conclusions for controlled motorway schemes will continue to evolve as more five-year data becomes available.

Summary

Table 2.1 includes all schemes which have five-year before and after data, while table 2.2 includes all schemes which have less than five years' worth of after data. The purpose of these two tables is to summarise in a simple way the safety data relating to a scheme after it opened. For this reason, we set out the FWI rates before and after.

Table 2.1

Description: The majority of smart motorway schemes have seen a reduction in FWI rates, noting two-thirds of all smart motorway schemes have five-year after data (table 2.1) and one-third have less than five years (table 2.2)

Data: FWI rate (injury-adjusted FWI per hundred million vehicle miles) for before and after per smart motorway scheme

Scheme	Type	After Months	Before	After
M1 J28-J31	ALR	60	0.43	0.23
M1 J39-J42	ALR	60	0.41	0.27
M25 J5-J7	ALR	60	0.47	0.38
M25 J23-J27	ALR	60	0.65	0.49
M6 J11a-J13	ALR	60	0.45	0.29
M1 J6a-J10	Controlled	60	2.28	0.46
M1 J25-J28	Controlled	60	0.59	0.30
M20 J4-J5	Controlled	60	0.61	0.27
M20 J5-J7	Controlled	60	0.91	0.80
M25 J2-J3	Controlled	60	1.12	0.71
M25 J7-J10	Controlled	60	0.55	0.39
M25 J10-J15	Controlled	60	0.79	0.54
M25 J15-J16	Controlled	60	0.36	0.88
M25 J16-J23	Controlled	60	0.90	0.44
M25 J27-J30	Controlled	60	0.97	0.29
M42 J7-J9	Controlled	60	0.17	0.20
M6 J10a-J11a	Controlled	60	0.91	0.34
M1 J10-J13	DHS	60	0.83	0.63
M42 J3a-J7	DHS	60	0.61	0.16
M4-M5 Interchange	DHS	60	0.42	0.21
M6 J4-J5	DHS	60	0.65	0.30
M6 J5-J8	DHS	60	0.78	0.49
M6 J8-J10a	DHS	60	0.74	0.40
M62 J25-J30	DHS	60	0.56	0.37

Source: Analysis from National Highways. Data based on STATS19 with minor amendment.

Table 2.2

Description: The majority of smart motorway schemes have seen a reduction in FWI rates, noting two-thirds of all smart motorway schemes have five-year after data (table 2.1) and one-third have less than five years (table 2.2)

Data: FWI rate (injury-adjusted FWI per hundred million vehicle miles) for before and after per smart motorway scheme

Scheme	Type	After Months	Before	After
M1 J16-J19	ALR	36	0.31	0.42
M1 J24-J25	ALR	24	0.25	0.06
M1 J32-J35a	ALR	48	0.65	0.36
M20 J3-J5	ALR	12	0.63	0.28
M23 J8-J10	ALR	12	0.43	0.53
M3 J2-J4a	ALR	48	0.61	0.31
M5 J4a-J6	ALR	48	0.31	0.32
M6 J2-J4	ALR	12	0.51	0.45
M6 J16-J19	ALR	24	0.55	0.21
M62 J18-J20	ALR	36	0.37	0.05
M1 J23a-J24	Controlled	36	0.14	0.09
M1 J31-J32	Controlled	48	0.51	0.38
M60 J8-J18	Controlled	36	0.29	0.28

Source: Analysis from National Highways. Data based on STATS19 with minor amendment.

Killed and seriously injured rates

Most schemes (29 out of 37) have also seen a reduction in KSI rates, which place equal emphasis on deaths and serious injuries, when comparing the before and after periods.

Due to differences in the amount of data available per scheme and given that we have not estimated a counterfactual for KSI in this report, any comparisons between scheme safety should be made with significant caution. We will assess the most appropriate way to apply counterfactual analysis to FWI and KSI rates. This means that all comparisons below are between the before and after periods.

<u>ALR schemes</u>

Out of the 15 ALR schemes, only five have five-year after data. Ten of the ALR schemes see lower KSI rates compared to the road they replaced. Of the five ALR schemes with five-year data, three schemes see higher KSI rates compared to the road they replaced.

These conclusions for ALR schemes will continue to evolve as more five-year data becomes available. We will continue to monitor and evaluate the safety of our network as more data becomes available.

<u>DHS schemes</u>

All seven DHS schemes have five-year after data. Of the seven DHS schemes, six see lower KSI rates compared to the road they replaced.

Controlled motorway schemes

Twelve out of 15 controlled motorway schemes have five-year after data. Out of all controlled motorway schemes, 13 saw lower KSI rates after they were constructed compared to before. These conclusions for controlled motorway schemes will continue to evolve as more five-year after data becomes available.

Summary

Table 3.1 includes all schemes which have five-year before and after data, while table 3.2 includes all schemes which have less than five years' worth of after data. The purpose of these two tables is to summarise in a simple way the safety data in relation to a scheme after it opened.

Table 3.1

Description: The majority of smart motorway schemes have seen a reduction in the KSI metric which places equal emphasis on deaths and serious injuries, noting two-thirds of all smart motorway schemes have five-year after data (table 3.1) and one-third have less than five years (table 3.2)

Data: KSI rate (injury-adjusted KSI per hundred million vehicle miles) for before and after per smart motorway scheme

Scheme	Type	After Months	Before	After
M1 J28-J31	ALR	60	0.93	0.81
M1 J39-J42	ALR	60	1.06	1.28
M25 J5-J7	ALR	60	1.76	1.98
M25 J23-J27	ALR	60	2.61	1.89
M6 J11a-J13	ALR	60	1.45	1.50
M1 J6a-J10	Controlled	60	7.39	1.49
M1 J25-J28	Controlled	60	2.03	1.00
M20 J4-J5	Controlled	60	3.34	1.08
M20 J5-J7	Controlled	60	3.20	1.88
M25 J2-J3	Controlled	60	4.96	3.31
M25 J7-J10	Controlled	60	1.47	1.23
M25 J10-J15	Controlled	60	3.43	2.42
M25 J15-J16	Controlled	60	1.16	2.37
M25 J16-J23	Controlled	60	3.11	1.76
M25 J27-J30	Controlled	60	4.75	1.09
M42 J7-J9	Controlled	60	0.99	0.42
M6 J10a-J11a	Controlled	60	1.92	1.04
M1 J10-J13	DHS	60	2.09	2.46
M42 J3a-J7	DHS	60	1.96	0.57
M4-M5 Interchange	DHS	60	1.10	0.36
M6 J4-J5	DHS	60	2.21	0.83
M6 J5-J8	DHS	60	2.52	1.43
M6 J8-J10a	DHS	60	2.50	0.76
M62 J25-J30	DHS	60	1.53	1.49

Source: Analysis from National Highways. Data based on STATS19 with minor amendment.

Table 3.2

Description: The majority of smart motorway schemes have seen a reduction in the KSI metric which places equal emphasis on deaths and serious injuries, noting two-thirds of all smart motorway schemes have five-year after data (table 3.1) and one-third have less than five years (table 3.2)

Data: KSI rate (injury-adjusted KSI per hundred million vehicle miles) for before and after per smart motorway scheme

Scheme	Type	After Months	Before	After
M1 J16-J19	ALR	36	1.08	1.17
M1 J24-J25	ALR	24	0.56	0.48
M1 J32-J35a	ALR	48	3.18	1.30
M20 J3-J5	ALR	12	2.12	1.69
M23 J8-J10	ALR	12	1.51	1.17
M3 J2-J4a	ALR	48	1.88	1.69
M5 J4a-J6	ALR	48	0.99	1.07
M6 J2-J4	ALR	12	1.79	1.67
M6 J16-J19	ALR	24	1.76	0.98
M62 J18-J20	ALR	36	0.59	0.00
M1 J23a-J24	Controlled	36	0.23	0.37
M1 J31-J32	Controlled	48	2.29	1.31
M60 J8-J18	Controlled	36	0.77	0.65

Source: Analysis from National Highways. Data based on STATS19 with minor amendment.

3. Scheme-level detailed comparisons

Different types of collisions

To understand what may be driving the different changes in safety for each scheme, we also undertook detailed analysis to better understand the different types of collisions across all smart motorways.

The most common type of collision for all schemes was when the front of a vehicle crashes into the back of another vehicle. According to the analysis we have undertaken for the Smart motorways stocktake – Third year progress report 2023, this is consistent across all roads and therefore is not likely to be a factor affecting why the PIC, FWI and KSI rates for most smart motorway schemes are lower than those for roads they replaced. For more information and detailed data, please see Annex D - Detailed tables.

Moving versus stopped

In all annual progress reports to date, we have reported that the risk of a collision between a moving vehicle and a stopped vehicle is greater on ALR and DHS motorways than on other types of motorway, but that the risk of a collision involving only moving vehicles is lower. This is also suggested by the scheme-level data in this report.

The majority of smart motorway schemes see lower moving vehicle PIC rates, ie single vehicle collisions or incidents involving two or more moving vehicles. More than half of smart motorways see higher stopped vehicle PIC rates, ie moving vehicles colliding with stopped vehicles. This is consistent with the annual progress reports to date, ie the risk of a collision between a moving and a stopped vehicle is greater on ALR and DHS motorways than on other motorway types, but the risk of a collision involving only moving vehicles is lower.

When considering the FWI and KSI rates, the majority of smart motorway schemes see lower moving vehicle FWI and KSI rates involving only moving vehicles and more than half of the schemes see either the same or lower FWI and KSI rates involving at least one stopped vehicle. The lower FWI and KSI rates involving at least one stopped vehicle across all smart motorway schemes are predominantly on controlled motorway schemes.

More than half ALR and DHS schemes see same or lower FWI rates involving at least one stopped vehicle, while more than half of ALR and DHS schemes see higher KSI rates involving at least one stopped vehicle. This aligns with the findings on stopped vehicle collisions in the third year progress report. For more information and detailed data, please see Annex D - Detailed tables.

The majority of the 2020 Action Plan actions, such as introducing SVD, and enabling increased enforcement of Red X signals, are designed to reduce the risk of a collision between a moving and a stopped vehicle, and to address remaining concerns about smart motorways without permanent hard shoulders.

Due to the time lag between the actions being delivered and the data being available, it will be later in 2023 before we can start assessing and understanding the impact of the actions.

Live lane versus non live lane

Live lane collisions take place on all roads, including smart motorways. The majority of smart motorway schemes showed lower PIC, FWI and KSI rates in live lanes after they opened, when comparing the before and after periods.

Some schemes saw lower PIC rates in the after periods, but higher KSI and FWI rates. We will continue to monitor the safety of sections where the after period has improved compared to the before period.

We will also continue to monitor and evaluate the safety of our network as more data becomes available.

Most of the collisions across all schemes took place on live lanes. A very small proportion of all collisions took place in non-live lane locations, such as on hard shoulders or in emergency areas[16].

Based on this analysis, some schemes have shown increases in PIC, FWI and KSI rates which do not involve a live lane, but since these are close to zero, we will continue monitoring them. Any assessments of safety based on such small numbers should be made with significant caution. For more information and detailed data, please see Annex D - Detailed tables.

[16] One in 20 motorway deaths happen on the hard shoulder as presented in the Smart motorways stocktake – Third year progress report 2023

4. Conclusions

Based on available data so far, most ALR, DHS and controlled motorway schemes (25 out of 37) have seen a reduction in PIC rates after they were constructed compared to both the before and the counterfactual[17].

Most schemes (32 out of 37) have also seen a reduction in FWI rates, which place greater emphasis on deaths and serious injuries, when comparing the before and after periods. This has also been the case for most schemes (29 out of 37) in relation to the KSI rate, which places equal emphasis on deaths and serious injuries.

The majority of the 2020 Action Plan actions, such as introducing SVD, and enabling increased enforcement of Red X signals, are designed to reduce the risk of a collision between a moving and a stopped vehicle, and to seek to address concerns about smart motorways without permanent hard shoulders.

In this report we have taken a conservative approach to conducting and presenting the analysis. We will work closely with specialist statisticians and ORR to assess opportunities to continuously improve where possible our analysis over the next years. Such opportunities may include research on statistical significance testing, counterfactual analysis, expanding the safety data over longer periods and aggregating the scheme-level data.

As part of our response to the 2020 Action Plan, we have already completed safety reviews on the:

- M1 junctions 32 to 35a and M1 junctions 39 to 42 (ALR motorways)
- M1 junctions 10 to 13 and M6 junctions 5 to 8 (DHS motorways)[18].

Using the results of this report, we want to better understand why other locations in the after period show increased rates compared to the before period. We have defined these as locations where at least one metric is higher either compared to before (FWI/ KSI) or to counterfactual (PIC).

As part of our BAU activities we are already undertaking safety reviews of the ALR and DHS motorways which have not already been subject to safety reviews following the 2020 Action Plan. We are doing the same for the M60 junction 8 to 18 (controlled motorway) scheme.

For the remaining schemes we will undertake desktop safety assessments to understand the latest safety data (if available) and to better understand why these locations in their after period show increased rates compared to the before period.

We plan to complete both the safety reviews and desktop safety assessments in Autumn 2023, at which point we will review the results and determine the next steps, if any, we need to take.

[17] For one scheme (M1 J24-25) it was not possible to calculate a counterfactual due to limited background data. This scheme saw lower collision rates in the after period compared to before

[18] The safety review already undertaken combined sections of the M1 J28-31 and J32-35a into a single review of the section M1 J30-35. For schemes M1 J28-J31, M1 J32-J35a and M6 J5-J8 we undertook safety reviews particularly for sections M1 J30-35 and M6 J5-6 as part of the 2020 Action Plan. As this report does not suggest an increase in rates, we consider that it is not required to undertake another safety assessment or safety review.

We will continue to monitor the safety of sections where the after period has improved compared to the before period.

We will also continue to monitor and evaluate the safety of our network as more data becomes available.

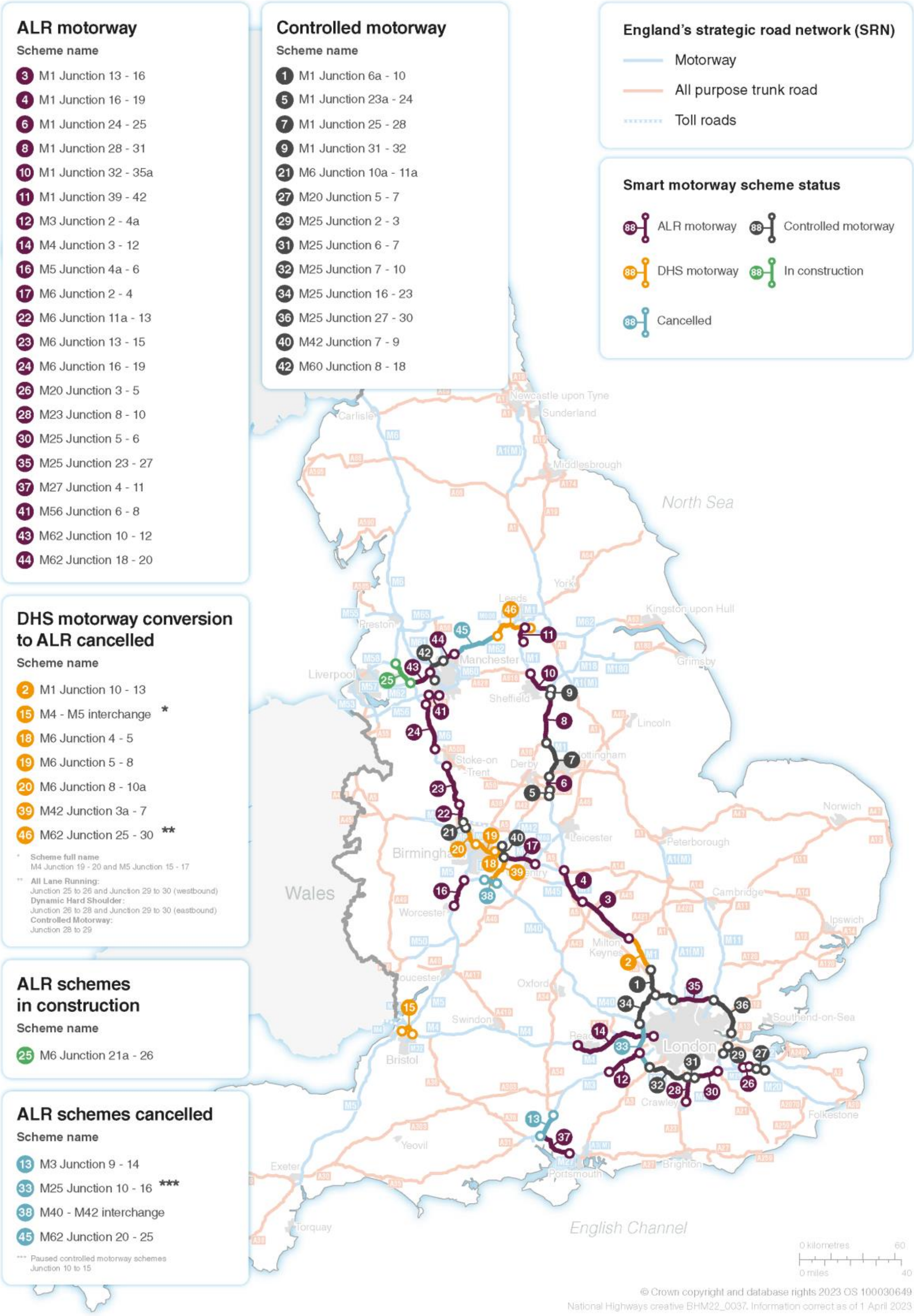
There are some key considerations in using or referring to the results of this report.

- Due to differences in the amount of data available per scheme, significant caution should be taken in making comparisons either between schemes or between before and after periods for schemes that have less than five-year after data

- Many controlled motorway schemes opened some time ago, with the earliest opening as far back as 1995. Therefore, the after period rates may not reflect recent safety data. At the moment, it is not appropriate to extrapolate the findings from this analysis to make judgements for the respective road types, especially as they cover different time periods over the last three decades. The desktop safety assessments will also consider recent data for these schemes. In the future, we will assess appropriate ways to aggregate before versus after data over long periods. For comparisons between road types across the strategic road network (SRN), we have published the Smart motorways stocktake – Third year progress report 2023, which considers fixed time periods for all road types

- While the analysis goes some way to comparing safety data after a scheme was put in place with safety before construction began, it does not explain what has caused the safety changes, such as the smart motorway itself or external factors. Methods such as counterfactual analysis and statistical significance testing help to increase our understanding of any safety changes. With future applications of these methods, additional safety assessments and reviews, we will have even greater understanding of the reasons behind the scheme-level safety changes.

Annex A - Smart motorways map (correct as of June 2023)



Annex B - Smart motorway scheme information

When considering the scheme safety, it is also important to consider the results alongside other local factors which may have a role to play in influencing scheme safety. Such factors may be:

- the presence of a motorway incident detection and automatic signalling (MIDAS) system either prior to or after the opening of the smart motorway scheme. MIDAS identifies queuing traffic or congestion by monitoring traffic speed and flow and can also reduce the risk of secondary incidents in queuing traffic, ie the risk of vehicles colliding with the rear of a queue of traffic

- whether a scheme was widened[19] before or at the same time it was upgraded to be a smart motorway. Scheme widening may impact the overall safety and amount of traffic at that location, which may in turn influence the respective rates

- whether there were any junction improvements either prior to, at the same time as or after the upgrade of the scheme to a smart motorway, which may have resulted in safety improvements or changes in traffic flows in that area

- how the scheme is operated. For example on DHS motorways when the hard shoulder is operating as a live lane it has the speed set at 60mph.

Although we have delivered the majority of the actions in the 2020 Action Plan, such as the introduction of SVD and enabling increased enforcement of Red X signals, the impact of these actions is not yet reflected in the safety data. Due to the time lag between the actions being delivered and the data being available, it will be later in 2023 before we can start assessing and understanding the impact of the actions. We will continue to assess the data in accordance with our monitoring and evaluation processes.

MIDAS

MIDAS is a system set up to identify queuing traffic or congestion by monitoring traffic speed and flow. Once queuing traffic or congestion is detected, the system automatically sets appropriate messages on variable message signs to warn drivers of conditions on the road ahead. It also automatically sets speed limits displayed on the signs and signals at the roadside and overhead on gantries.

MIDAS can also reduce the risk of secondary collisions in queuing traffic, ie the risk of vehicles colliding with the rear of a queue of traffic. It does this by identifying a queue and then automatically reducing speeds and setting accompanying warning messages.

In addition, on smart motorway sections only, it also includes a congestion management function designed to smooth traffic flow and throughput by reducing traffic speed, allowing more space between vehicles, to try and stop traffic queues

[19] Providing an additional lane and retaining a hard shoulder. Of all types of smart motorway, this is applicable only to controlled motorways.

forming. This is done by setting signals and message signs upstream of where congestion is detected.

Widening

One of the most common types of capacity improvements is carriageway widening, providing an additional lane and retaining a hard shoulder. Of all types of smart motorway, this is applicable only to some controlled motorways.

Widening can have a large beneficial impact due to additional lane capacity and minor enhancements from speed management, due to the technology used for controlled motorways. Widening also has a significant adverse impact including significant land take and loss of habitat for additional lane construction.

In before versus after comparisons, it is not possible to disaggregate the impacts of the widening from those of upgrading to a smart motorway. This should be noted when reviewing the results of schemes within this report which included this intervention.

For this analysis, schemes that underwent major (or partial) widening before or during their upgrade to a smart motorway were determined by using publicly available information (such as from Post Opening Project Evaluation reports or public consultation documents), consultation with technical experts and virtual drive-throughs.

Junction improvements

Another frequent measure constructed during the upgrade to a smart motorway is junction improvements, which aim to increase the safety and reliability of customer journeys by reducing the congestion from vehicles entering and leaving the motorway.

In before versus after comparisons, it is not possible to disaggregate the impacts of the junction improvements from those of upgrading to a smart motorway. This should be noted when reviewing the results of schemes within this report which included this intervention.

For this analysis, schemes that underwent junction improvements before or during their upgrade to a smart motorway were determined by using publicly available information (such as from POPEs or public consultation documents), consultation with technical experts and virtual drive-throughs.

Other factors

Other items of note identified that may impact safety include:

- other construction activities in the before or after period
- reduced speed or average speed enforcement for air quality or other reasons
- presence of one type of smart motorway type prior to conversion to another type of smart motorway
- changes to sign or signal setting

- delivery of the 2020 Action Plan, such as introducing more SVD and enabling increased enforcement of Red X signals. Due to the time lag between the actions being delivered and the data being available, it will be later in 2023 before we can start assessing and understanding the impact of the actions. We will continue to assess the data in accordance with our monitoring and evaluation processes.

These factors are not exhaustive but should be able to provide relevant considerations which are important at a local level. Table 5 includes relevant information for each scheme.

Table 4

Data: Scheme considerations

Scheme	Type	Was MIDAS installed prior to/ alongside the scheme?	Was there widening prior to/ alongside the scheme?	Were junction improvement made prior to/ alongside the scheme	Other
M1 J16-J19	ALR	Yes	No	No	Actions delivered through the 2020 Action Plan.
M1 J24-J25	ALR	Yes	No	Yes (J24)	Actions delivered through the 2020 Action Plan.
M1 J28-J31	ALR	Yes	No	No	A 60mph speed limit was enforced to reduce emissions for the majority of the scheme's after period. Actions delivered through the 2020 Action Plan. Further improvements in place due to safety reviews as part of the 2020 Action Plan.
M1 J32-J35a	ALR	Yes	No	No	A 60mph speed limit was enforced to reduce emissions for the majority of the scheme's after period. Actions delivered through the 2020 Action Plan. Further improvements in place due to safety reviews as part of the 2020 Action Plan.
M1 J39-J42	ALR	Yes	Partial (J41-J42 northbound)	No	Actions delivered through the 2020 Action Plan. Further improvements in place due to safety

					reviews as part of the 2020 Action Plan.
M25 J5-J7	ALR	Partial (M25 J6-J7)	No	No	Actions delivered through the 2020 Action Plan.
M25 J23-J27	ALR	No	No	No	Actions delivered through the 2020 Action Plan.
M3 J2-J4a	ALR	No	No	No	The first 3.9 kilometres of the J2 eastbound is 50 mph average speed. This includes 2km of on slips for the J2 eastbound. Actions delivered through the 2020 Action Plan.
M5 J4a-J6	ALR	Yes	No	No	Actions delivered through the 2020 Action Plan.
M6 J2-J4	ALR	Yes	No	Yes (J4)	Actions delivered through the 2020 Action Plan.
M6 J11a-J13	ALR	Yes	No	No	Actions delivered through the 2020 Action Plan.
M6 J16-J19	ALR	Yes	No	No	J19 junction improvement started construction in March 2020. Roadworks may have been in operation around J19 for 10 months of the scheme after period. Actions delivered through the 2020 Action Plan.
M20 J3-J5	ALR	Partial (M20 J4-5) Due to the M20 J4-5 being controlled motorway prior to ALR it is assumed MIDAS was present.	No	No	M20 J4-J5 was converted from controlled motorways to ALR during M20 J3-J5 ALR upgrade. Actions delivered through the 2020 Action Plan.
M23 J8-J10	ALR	No	No	No	Permanent 50mph speed limit on the westbound carriageway of Gatwick Spur from M23 Junction 9 to Junction 9a. Actions delivered through the 2020 Action Plan.

M62 J18-J20	ALR	Yes	No	No	Actions delivered through the 2020 Action Plan.
M1 J6a-J10	Controlled motorway	No	Partial (J6a-J7 southbound, J8-J9 northbound and southbound, J9-J10 southbound)	No	n/a
M1 J23a-J24	Controlled motorway	Yes	No	Yes (J24)	n/a
M1 J25-J28	Controlled motorway	Partial (M1 J27-J28)	Partial (J26-J27 northbound and southbound)	No	n/a
M1 J31-J32	Controlled motorway	Yes	No	No	A 60mph speed limit was enforced to reduce emissions for the majority of the scheme's after period.
M20 J4-J5	Controlled motorway	No	No	No	n/a
M20 J5-J7	Controlled motorway	No	No	No	n/a
M25 J2-J3	Controlled motorway	No	No	No	During the before period the scheme was widened. The works were completed in June 2009. Roadworks may have been in operation for 6 months of the schemes before period.
M25 J7-J10	Controlled motorway	Yes	No	No	n/a
M25 J10-J15	Controlled motorway	Unknown	No	No	One of the earliest smart motorways – queue protection was in development and incremental enhancements were made to the system throughout the before period.
M25 J15-J16	Controlled motorway	Unknown	No	No	n/a
M25 J16-J23	Controlled motorway	No	Yes	No	n/a
M25 J27-J30	Controlled motorway	No	Yes	No	n/a
M42 J7-J9	Controlled motorway	No	No	No	n/a

M6 J10a-J11a	Controlled motorway	Yes	No	No	n/a
M60 J8-J18	Controlled motorway	Yes	No	No	n/a
M1 J10-J13	DHS[20]	Yes	No	Yes (J11 and J12)	J11a started construction in June 2015 and was completed in May 2017. Road works may have been in operation around J11a for 24 months of the scheme after period. When the hard shoulder is operating as a live lane, all live lane speeds are reduced to a maximum 60 miles per hour. Further improvements in place due to safety reviews as part of the 2020 Action Plan.
M42 J3a-J7	DHS	Yes	No	No	For the duration of the after period the queue protection system was enhanced. When the hard shoulder is operating as a live lane, all live lane speeds are reduced to a maximum 60 miles per hour.
M4-M5 Interchange	DHS	No	Partial	No	When the hard shoulder is operating as a live lane, all live lane speeds are reduced to a maximum 60 miles per hour.
M6 J4-J5	DHS	Yes	No	Yes (J4)	When the hard shoulder is operating as a live lane, all live lane speeds are reduced to a maximum 60 miles per hour.
M6 J5-J8	DHS[21]	Yes	No	No	When the hard shoulder is operating as a live lane, all live lane speeds are reduced to a maximum 60 miles per hour. Further improvements in place due to safety

[20] M1 J11a-12 has DHS infrastructure and is a short link with motorway service area slip roads and no hard shoulder for part of the link.

[21] M6 J7-8 has DHS infrastructure and is a very short link with no hard shoulder.

					reviews as part of the 2020 Action Plan.
M6 J8-J10a	DHS	Partial (M6 J8-J9)	No	No	When the hard shoulder is operating as a live lane, all live lane speeds are reduced to a maximum 60 miles per hour.
M62 J25-J30	DHS[22]	Partial (M62 J25-J29)	No	No	When the hard shoulder is operating as a live lane, all live lane speeds are reduced to a maximum 60 miles per hour.

[22] M62 J25-26 has DHS infrastructure and is a short link with motorway service area slip roads and no hard shoulder. M62 J28-29 is a controlled motorway, whereas M62 J29-30 has DHS infrastructure and is a short link with no hard shoulder (westbound only).

Annex C - Methodology

Assurance

The analysis in this report has been subject to five levels of assurance.

- The first level is undertaken by the suppliers delivering the analysis to identify and address any material issues with the inputs, calculations, outputs and supporting methodology
- The second level is undertaken by the team commissioning the analysis within National Highways and includes, but is not limited to, replicating inputs and calculations using the same methodology as the supplier to reach the same results, so called 'dual running' of the analysis
- The third level is then undertaken by a team within National Highways who have not been part of the analysis and can provide a degree of independence. This step highlights potential issues or concerns on the overall approach, specific analysis or supporting methods
- The fourth level is undertaken by DfT who review the analysis, its supporting methods and presentation to gain confidence in the results
- The fifth level is undertaken by ORR to gain further confidence in the safety conclusions of this report.

Data sources

Road injury data in Great Britain is collected via the STATS19 process. These statistics are collected by police forces, either through officers attending the scene of a collision, from members of the public reporting the collision in police stations after the collision, or more recently online and then validated and published annually by DfT. The safety analysis presented here is developed by National Highways using STATS19 data.

STATS19 data is published annually by DfT in the Autumn and provides details of the previous calendar year (for example, DfT published the 2021 calendar year dataset at the end of September 2022).

Injury data can change considerably from year to year, depending on circumstances in any given year, and injury rates can be sensitive to small changes in the number of injuries. Such changes can be more prominent for specific schemes or parts of the SRN, and less so for wider geographical areas (for example the full SRN or Great Britain). Volatility is an issue as it can obscure more meaningful conclusions that can be drawn from the data. This report includes a minimum of one-year after data and where possible highlights uncertainties in the data, such as when less than five-year data is available for specific schemes.

STATS19 data as provided by DfT reflects the situation at the time the annual statistics are produced. Subsequently, further information may become available which may suggest that some collisions should have been either in or out of scope.

Every injury is important. STATS19 database is a collection of all collisions that resulted in a personal injury and were reported to the police within 30 days of the collision. The analysis supporting this report reflects the same threshold of 30 days. One smart motorway death has historically been omitted from STATS19. This was manually added in the 2020 Stocktake and annual progress reports and will continue to be added in subsequent overall smart motorways reporting. To reflect this, relevant table clarifications and footnotes have been added throughout this report.

Mapping process

STATS19 collision data is matched to pre-selected extents, identifying STATS19 collision data that overlap extents using a geographic information system approach.

This two-step process allows us to validate data and potentially identify exceptions/ differences. The data and the extents have some limitations such as:

- the definition of where a smart motorway starts and where it finishes might vary depending on the type of the smart motorway and any assumptions used
- any variation in the definition of the date smart motorways were opened could have an impact on the numbers reported
- the coordinates provided under STATS19 might not always be accurate which could have an impact on the numbers reported
- a mismatch of road name and co-ordinates can increase the uncertainty in collision mapping
- detailed data analysis according to smart motorway type (eg DHS versus ALR) may need caution particularly where road types change from one to another or where multiple road types overlap

To help us provide a greater level of granularity we have undertaken the analysis in this report for each smart motorway section. Due to continuous improvements in mapping and data quality, for example when new information may be available about specific schemes, methods are likely to evolve over time. For this reason, any comparison with earlier data or data from other sources should be interpreted with caution.

Later in 2023 we expect to start adopting a new network model developed with our partners, which is likely to supersede the above mapping method.

Headline safety metrics

The ORR suggested in its 2021 Quality assurance of all lane running motorway data report that ‘a smaller number of headline metrics should be used to communicate safety’. In discussions with the ORR review team, it was acknowledged that selecting a single safety metric may be subject to challenge as each metric will have its own limitations. For this reason, this report uses a set of headline metrics:

Personal injury collisions (PIC) – These are the number of collisions which have resulted in a person sustaining an injury. PICs do not reflect the number of people injured in each collision (injuries). This metric has certain benefits, such as not including uncertainty from (i) random effects, for example a coach accident leading to multiple injuries and (ii) non-random effects on vehicle type and vehicle occupancy, such as socio-demographic effects. On the other hand, collisions do not reflect the number of injured people involved. PIC rates accounting for traffic flow are the rates calculated using the number of PICs and the total miles travelled on a road section or type. This metric allows roads with heavy traffic or span a long distance to be compared against roads which carry less traffic or which span a shorter distance. The rate is presented as the number of collisions per hundred million vehicle miles, which is an established way of assessing rates across the road sector.

Fatal and weighted injuries (FWI) – A metric which weights and aggregates the number of people that have been injured in collisions. It gives a fatality 10 times the weighting of a serious injury, and a serious injury 10 times the weighting of a slight injury. This is calculated as follows: Fatal and Weighted Injuries = Fatal + Serious injuries * 0.1 + Slight injuries * 0.01. In its 2021 Quality assurance of all lane running motorway data report, ORR highlighted that ’the methodology was derived from that used by RSSB [the Rail Safety and Standards Board - here]. RSSB has since adopted new weightings for calculating FWI, but we consider that the weightings used by Highways England were appropriate.’ These weightings continue to be largely aligned with the ‘Average value of prevention per injury’ set out by DfT’s Transport Analysis Guidance data book. While FWI recognises all injuries, it acknowledges that not all injuries are equal. FWI rates accounting for traffic flow are the rates calculated using the aggregate FWI and the total miles travelled on a road section or type. This metric allows roads with heavy traffic or span a long distance to be compared against roads which carry less traffic or which span a shorter distance. The rate is presented as the aggregate FWI per hundred million vehicle miles, which is an established way of assessing rates across the road sector.

Killed and seriously injured (KSI) – The severity-adjusted number of people killed and seriously injured in collisions. KSIs are a simple aggregation of fatal and serious injuries, i.e. no weighting applied to either. While this means that the metric’s methodology is simple, KSIs do not account for slight injuries. Therefore reporting only this metric may undermine the importance of slight injuries. KSI rates accounting for traffic flow are the rates calculated using the number of people who are killed and seriously injured, and the total miles travelled on a road section or type. This metric allows roads with heavy traffic or span a long distance to be compared against roads which carry less traffic or span a shorter distance. The rate is presented as the severity-adjusted number of KSIs per hundred million vehicle miles, which is an established way of assessing rates across the road sector.

Rates may be more meaningful for safety comparisons compared to absolute values as they avoid certain issues, such as suggesting that the least used roads are the safest roads. For this reason and to maintain brevity across the report, we have presented rates across all schemes in the main part of the report. For transparency, alongside this report we have also produced an extensive file with our detailed analysis Annex D - Detailed tables and have published the detailed collision data Annex E - Detailed collision data.

Data periods and external events

Millions of drivers use our network, and fortunately collisions which result in injuries are rare events. As a result the number of collisions, and the number of deaths or injuries resulting from those collisions, are subject to a degree of fluctuation, particularly when being reviewed at a localised level, such as on specific schemes. In order to be certain that the differences, if any, which we see are due to a change in safety rather than falling within what could be seen as the normal range of fluctuation, it is preferable to capture as many years' worth of data as possible.

Periods covering five years before construction and up to five years after scheme opening are included in the analysis, based on the available STATS19 data up to December 2021. This is to minimise year-on-year fluctuation due to low numbers of collisions at scheme level.

Earlier in the report, we also highlighted that due to differences in the amount of data available per scheme, any direct comparisons between schemes' safety should be made with significant caution.

Many schemes do not yet have five full years of collision data available. For these schemes, as long as there is at least one year of available data in the after period, the rate has been calculated. In order to reduce the effect of seasonality on the after period data, only complete 12-month periods have been included. These periods begin on the date of scheme opening and a 'year' is the 12-month period from this date, not a calendar year. To make these schemes clearer, the tables in the report are split between those schemes that have less than five years' worth of data and those that have five-year data. Also, across all tables, we have included the after period number of months against each scheme. The table below outlines the specific dates considered for each scheme.

Table 5

Data: Scheme before vs. after dates

Scheme section	Scheme	Section type	Status	Before start	Before end	After start	After end	After months
M1 J16-J17	M1 J16-J19	ALR	Operational	30/11/2010	29/11/2015	13/11/2017	12/11/2021	48
M1 J17-J18	M1 J16-J19	ALR	Operational	30/11/2010	29/11/2015	22/11/2017	21/11/2021	48
M1 J18-J19	M1 J16-J19	ALR	Operational	30/11/2010	29/11/2015	29/01/2018	28/01/2021	36
M1 J24-J25	M1 J24-J25	ALR	Operational	30/03/2012	29/03/2017	26/02/2019	25/02/2021	24
M1 J28-J31	M1 J28-J31	ALR	Operational	06/09/2008	05/09/2013	31/03/2016	30/03/2021	60
M1 J32-J35a	M1 J32-J35a	ALR	Operational	30/06/2008	29/06/2013	29/03/2017	28/03/2021	48
M1 J39-J42	M1 J39-J42	ALR	Operational	25/11/2008	24/11/2013	01/01/2016	31/12/2020	60
M20 J3-J5	M20 J3-J5	ALR	Operational	29/03/2013	28/03/2018	12/05/2020	11/05/2021	12
M23 J8-J10	M23 J8-J10	ALR	Operational	29/03/2013	28/03/2018	16/09/2020	15/09/2021	12
M25 J5-J6	M25 J5-J7	ALR	Operational	01/09/2007	31/08/2012	01/05/2014	30/04/2019	60
M25 J23-J25	M25 J23-J27	ALR	Operational	01/02/2008	31/01/2013	01/05/2014	30/04/2019	60
M25 J25-J27	M25 J23-J27	ALR	Operational	01/02/2008	31/01/2013	01/11/2014	31/10/2019	60
M3 J2-J4a	M3 J2-J4a	ALR	Operational	01/05/2009	30/04/2014	30/06/2017	29/06/2021	48
M5 J4a-J6	M5 J4a-J6	ALR	Operational	30/11/2010	29/11/2015	25/05/2017	24/05/2021	48
M6 J2-J3a	M6 J2-J4	ALR	Operational	12/03/2013	11/03/2018	17/04/2020	16/04/2021	12
M6 J11a-J13	M6 J11a-J13	ALR	Operational	01/11/2008	31/10/2013	07/02/2016	06/02/2021	60
M6 J16-J17	M6 J16-J19	ALR	Operational	30/11/2010	29/11/2015	20/03/2019	19/03/2021	24
M6 J17-J18	M6 J16-J19	ALR	Operational	30/11/2010	29/11/2015	08/03/2019	07/03/2021	24
M6 J18-J19	M6 J16-J19	ALR	Operational	30/11/2010	29/11/2015	28/01/2019	27/01/2021	24
M62 J18-J20	M62 J18-J20	ALR	Operational	01/07/2009	30/06/2014	26/03/2018	25/03/2021	36
M62 J25-J26	M62 J25-J30	ALR	Operational	13/10/2006	12/10/2011	01/10/2013	30/09/2018	60
M1 J6a-J10	M1 J6a-J10	Controlled	Operational	20/03/2001	19/03/2006	01/07/2009	30/06/2014	60
M1 J23a-J24	M1 J23a-J24	Controlled	Operational	30/03/2012	29/03/2017	13/12/2018	12/12/2021	36
M1 J25-J28	M1 J25-J28	Controlled	Operational	29/10/2002	28/10/2007	01/05/2011	30/04/2016	60
M1 J31-J32	M1 J31-J32	Controlled	Operational	01/02/2009	31/01/2014	29/03/2017	28/03/2021	48
M20 J4-J5	M20 J4-J5	Controlled	Closed	01/04/2005	31/03/2010	01/10/2011	30/09/2016	60
M20 J5-J7	M20 J5-J7	Controlled	Operational	01/04/2005	31/03/2010	01/10/2011	30/09/2016	60
M25 J2-J3	M25 J2-J3	Controlled	Operational	01/12/2006	30/11/2011	09/05/2012	08/05/2017	60
M25 J6-J7	M25 J5-J7	Controlled	Operational	01/09/2007	31/08/2012	01/05/2014	30/04/2019	60
M25 J7-J10	M25 J7-J10	Controlled	Operational	15/11/2005	14/11/2010	01/04/2011	31/03/2016	60
M25 J10-J11	M25 J10-J15	Controlled	Operational	01/01/1989	31/12/1993	01/11/1995	31/10/2020	60
M25 J11-J15	M25 J10-J15	Controlled	Operational	01/01/1989	31/12/1993	01/09/1995	31/08/2020	60
M25 J15-J16	M25 J15-J16	Controlled	Operational	01/01/1995	31/12/1999	01/03/2002	28/02/2007	60
M25 J16-J23	M25 J16-J23	Controlled	Operational	25/05/2004	24/05/2009	01/06/2012	31/05/2017	60
M25 J27-J30	M25 J27-J30	Controlled	Operational	01/07/2004	30/06/2009	01/03/2014	28/02/2019	60
M42 J7-J9	M42 J7-J9	Controlled	Operational	01/09/2003	31/08/2008	01/11/2009	31/10/2014	60
M5 J15-J16	M4-M5 Interchange	Controlled	Operational	25/01/2007	24/01/2012	01/01/2014	31/12/2018	60
M6 J3a-J4	M6 J2-J4	Controlled	Operational	12/03/2013	11/03/2018	17/04/2020	16/04/2021	12
M6 J10a-J11a	M6 J10a-J11a	Controlled	Operational	01/11/2008	31/10/2013	07/02/2016	06/02/2021	60
M60 J8-J12	M60 J8-J18	Controlled	Operational	01/07/2009	30/06/2014	31/07/2018	30/07/2021	36

M60 J12-J18	M60 J8-J18	Controlled	Operational	01/07/2009	30/06/2014	31/07/2018	30/07/2021	36
M62 J28-J29	M62 J25-J30	Controlled	Operational	13/10/2006	12/10/2011	01/10/2013	30/09/2018	60
M1 J10-J13	M1 J10-J13	DHS	Operational	22/12/2004	21/12/2009	01/12/2012	30/11/2017	60
M42 J3a-J7	M42 J3a-J7	DHS	Operational	01/01/2000	31/12/2004	12/09/2006	11/09/2011	60
M4 J19-J20	M4-M5 Interchange	DHS	Operational	25/01/2007	24/01/2012	01/01/2014	31/12/2018	60
M5 J16-J17	M4-M5 Interchange	DHS	Operational	25/01/2007	24/01/2012	01/01/2014	31/12/2018	60
M6 J4-J5	M6 J4-J5	DHS	Operational	01/08/2003	31/07/2008	01/11/2009	31/10/2014	60
M6 J5-J8	M6 J5-J8	DHS	Operational	01/01/2007	31/12/2011	01/05/2014	30/04/2019	60
M6 J8-J10a	M6 J8-J10a	DHS	Operational	01/08/2004	31/07/2009	01/03/2011	29/02/2016	60
M62 J26-J28	M62 J25-J30	DHS	Operational	13/10/2006	12/10/2011	01/10/2013	30/09/2018	60
M62 J29-J30	M62 J25-J30	DHS	Operational	13/10/2006	12/10/2011	01/10/2013	30/09/2018	60

This table also highlights that all schemes have opened at very different time periods. This means that their before, after and where applicable counterfactual periods may be impacted by external factors.

For example, the STATS19 dataset for both 2020 and 2021 collisions is heavily influenced by the Covid-19 pandemic, a rare event which caused three national lockdowns and various regional restrictions throughout the year.

The peak impact of the pandemic saw a significant reduction in traffic in April 2020 compared to the same period the year before (see here). Over more than a year, traffic across the SRN fluctuated as there were three major lockdowns. By June 2021, overall road traffic levels had returned to levels close to those seen before the pandemic.

This is likely to have impacted collisions and injuries in two ways: (i) rates per hmvm are likely to have been influenced by changes in traffic flows and (ii) less congestion on various roads may have impacted driver behaviour.

Similarly the 2008 recession led to a reduction of traffic on many roads between 2008 and 2010. While this may have influenced the rates per hmvm, a recession is likely also to have led to drivers being less able to maintain their vehicles or to continue using older vehicles.

This analysis does not aim to explain the specific impact of such external factors on specific schemes, but in interpreting each scheme's rates it is important to consider whether such factors may have had a role to play.

Road length and traffic statistics

This analysis uses DfT road length and traffic statistics with inputs provided by National Highways. Traffic statistics are usually published by DfT as an annual average. In line with the 2020 Stocktake and annual progress reports, DfT has apportioned the road lengths and traffic flows depending on the month and year that each scheme opened. Additionally, the traffic statistics produced for this report reflect the SRN at the end of each calendar year. Where these are not aligned to a calendar year, the traffic statistics are derived by applying the relevant proportions of flow from different calendar years. This approach assumes an even distribution of flows across the calendar year.

Injury-based reporting in STATS19 data

Since 2012, many police forces have changed the way they collect STATS19 data (for more information see here). These changes mean injury severity is now categorised automatically based on the most severe injury, rather than the judgement of an attending police officer. Police forces using the new systems, called injury-based severity reporting systems, (also known as CRaSH and COPA) report more serious injuries than those which do not.

These changes make it particularly difficult to monitor trends in the number of killed and seriously injured over time, or between different police forces.

In response to these challenges, DfT and the ONS have developed an approach to adjust the data collected from those police forces not currently using injury-based reporting systems. These adjustments are estimates for how the severity of an injury may have been recorded had the new injury-based reporting system been used. These adjusted estimates apply retrospectively from 2004 and adjust historical data to show injury severity 'as if' this was recorded under the new injury-based system. This enables better comparisons across police forces and further increases the confidence in safety data captured by police officers.

Until all police forces have started using the new systems, these historical adjustments will continue to be updated every year. Using these adjusted totals allows for more consistent and comparable reporting when tracking severity over time, across a region, or nationally. While there is no impact on collisions, total injuries and deaths, these adjustments do impact serious and slight injuries.

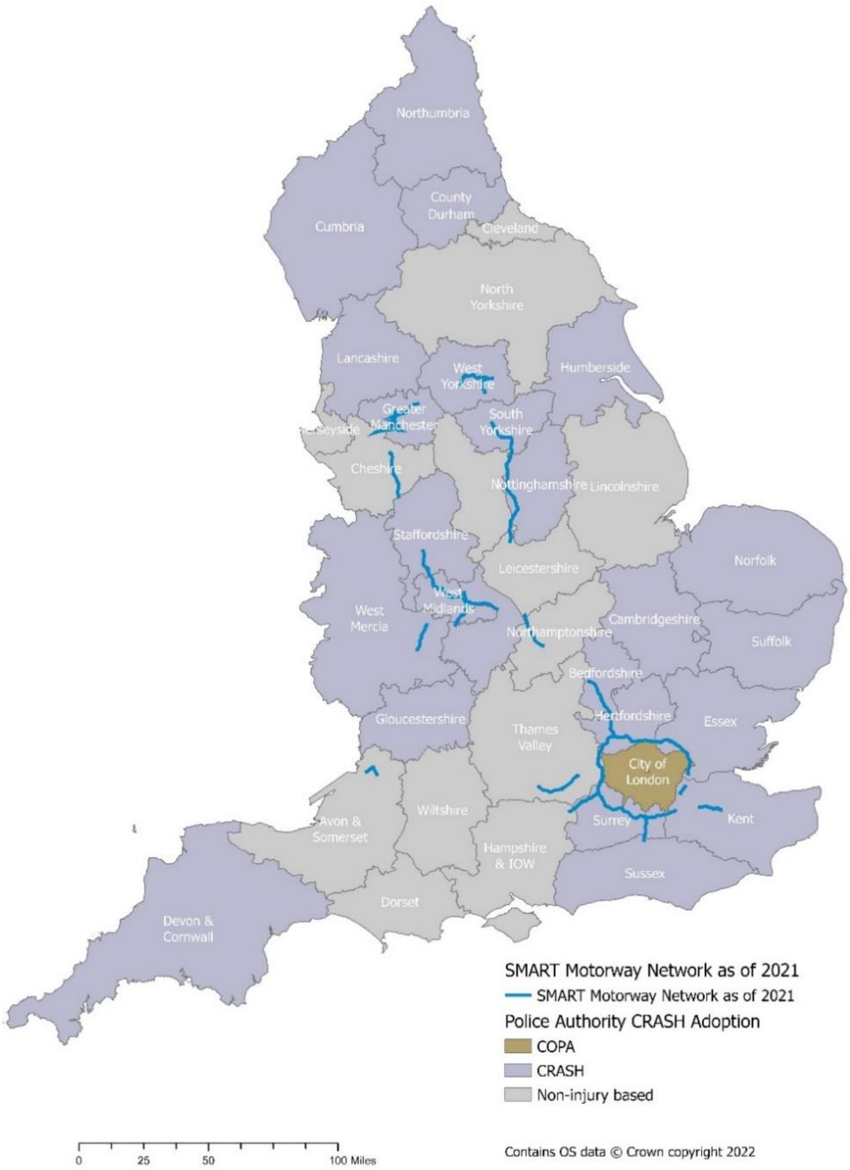
DfT analytical guidance was updated in October 2021 to further strengthen advice on including injury-based adjusted figures where possible. Following the same approach as in the second year progress report, this means that the injury figures reported in the main part of the report are adjusted, ie KSI and FWI, but not PIC as the latter is not influenced by these adjustments. For more information, please see here.

The map below shows the smart motorway network as of 31 December 2021. It highlights non-injury-based reporting police forces, CRaSH (Collision Reporting and Sharing) reporting forces and the Metropolitan Police area which has adopted COPA (Case Overview Preparation Application). The map below outlines the variances in the collection and reporting of data across individual police forces and highlights the need for a consistent comparison, supporting the application of injury-based reporting adjustments. For more information, please see here.

The table after the map also summarises which police force is responsible for each scheme section and based on their adoption of CRaSH and COPA reporting, whether injury-based adjustments are required.

Three police forces adopted CRaSH 'during 2021'. These are Greater Manchester, Nottinghamshire and West Yorkshire. No information has been released as to when during 2021 these forces adopted CRaSH. There are two schemes where there is a potential overlap between the after period and CRaSH adoption (M60 junction 8 to 18 and M62 junction 18 to 20). Based on DfT advice, if CRaSH or COPA was adopted during the analysis period severity adjustment should be applied. However, because the 'after' period only covers complete 12-month periods, and therefore ends part way through 2021, and we don't know exactly when in 2021 these police forces adopted CRaSH, we have not applied severity adjustment for these two schemes.

Figure 1
Data: Smart motorway network across police forces per injury-based reporting status as of 31 December 2021



Source: Visualisation from National Highways

Table 6

Data: Scheme location, police force information and CRASH/COPA dates

Scheme section	Scheme	Section type	Region	Police force(s)	CRaSH/COPA date	Adjustment required
M1 J16-J17	M1 J16-J19	ALR	East Midlands	Northamptonshire	N/A	N
M1 J17-J18	M1 J16-J19	ALR	East Midlands	Northamptonshire	N/A	N
M1 J18-J19	M1 J16-J19	ALR	East Midlands	Northamptonshire; Leicestershire	N/A	N
M1 J24-J25	M1 J24-J25	ALR	East Midlands	Leicestershire; Derbyshire	N/A	N
M1 J28-J31	M1 J28-J31	ALR	East Midlands	Derbyshire; South Yorkshire	N/A	N
M1 J32-J35a	M1 J32-J35a	ALR	Yorkshire and The Humber	South Yorkshire	01/01/2016	Y
M1 J39-J42	M1 J39-J42	ALR	Yorkshire and The Humber	West Yorkshire	During 2021	N
M20 J3-J5	M20 J3-J5	ALR	South East	Kent	01/01/2016	Y
M23 J8-J10	M23 J8-J10	ALR	South East	Surrey; Sussex	01/11/2012	N
M25 J5-J6	M25 J5-J7	ALR	South East	Kent; Surrey	01/11/2012	Y
M25 J23-J25	M25 J23-J27	ALR	East of England	Hertfordshire; Met	01/04/2016	Y
M25 J25-J27	M25 J23-J27	ALR	East of England	Essex; Met	01/11/2015	Y
M3 J2-J4a	M3 J2-J4a	ALR	South East	Surrey; Hampshire	01/11/2012	Y
M5 J4a-J6	M5 J4a-J6	ALR	West Midlands	West Mercia	01/12/2015	Y
M6 J2-J3a	M6 J2-J4	ALR	West Midlands	Warwickshire; West Midlands	01/11/2015	Y
M6 J11a-J13	M6 J11a-J13	ALR	West Midlands	Staffordshire	01/05/2015	Y
M6 J16-J17	M6 J16-J19	ALR	North West	Cheshire	N/A	N
M6 J17-J18	M6 J16-J19	ALR	North West	Cheshire	N/A	N
M6 J18-J19	M6 J16-J19	ALR	North West	Cheshire	N/A	N
M62 J18-J20	M62 J18-J20	ALR	North West	Greater Manchester	During 2021	N
M62 J25-J26	M62 J25-J30	ALR	Yorkshire and The Humber	West Yorkshire	During 2021	N
M1 J6a-J10	M1 J6a-J10	Controlled	East of England	Hertfordshire; Bedfordshire	01/04/2016	N
M1 J23a-J24	M1 J23a-J24	Controlled	East Midlands	Leicestershire	N/A	N
M1 J25-J28	M1 J25-J28	Controlled	East Midlands	Nottinghamshire; Derbyshire	During 2021	N
M1 J31-J32	M1 J31-J32	Controlled	Yorkshire and The Humber	South Yorkshire	01/01/2016	Y
M20 J4-J5	M20 J4-J5	Controlled	South East	Kent	01/01/2016	Y
M20 J5-J7	M20 J5-J7	Controlled	South East	Kent	01/01/2016	Y
M25 J2-J3	M25 J2-J3	Controlled	South East	Kent	01/01/2016	Y
M25 J6-J7	M25 J5-J7	Controlled	South East	Surrey	01/11/2012	Y
M25 J7-J10	M25 J7-J10	Controlled	South East	Surrey	01/11/2012	Y
M25 J10-J11	M25 J10-J15	Controlled	South East	Surrey	01/11/2012	N
M25 J11-J15	M25 J10-J15	Controlled	South East	Surrey; Met	01/11/2012	N
M25 J15-J16	M25 J15-J16	Controlled	South East	Thames Valley	N/A	N
M25 J16-J23	M25 J16-J23	Controlled	East of England	Hertfordshire; TVP	01/04/2016	Y
M25 J27-J30	M25 J27-J30	Controlled	East of England	Essex; Met	01/11/2015	Y
M42 J7-J9	M42 J7-J9	Controlled	West Midlands	Warwickshire	01/11/2015	N
M5 J15-J16	M4-M5 Interchange	Controlled	South West	Avon and Somerset	N/A	N
M6 J3a-J4	M6 J2-J4	Controlled	West Midlands	Warwickshire	01/11/2015	Y

M6 J10a-J11a	M6 J10a-J11a	Controlled	West Midlands	Staffordshire	01/05/2015	Y
M60 J8-J12	M60 J8-J18	Controlled	North West	Greater Manchester	During 2021	N
M60 J12-J18	M60 J8-J18	Controlled	North West	Greater Manchester	During 2021	N
M62 J28-J29	M62 J25-J30	Controlled	Yorkshire and The Humber	West Yorkshire	During 2021	N
M1 J10-J13	M1 J10-J13	DHS	East of England	Bedfordshire	01/04/2016	Y
M42 J3a-J7	M42 J3a-J7	DHS	West Midlands	West Midlands; Warwickshire	01/11/2015	N
M4 J19-J20	M4-M5 Interchange	DHS	South West	Avon and Somerset	N/A	N
M5 J16-J17	M4-M5 Interchange	DHS	South West	Avon and Somerset	N/A	N
M6 J4-J5	M6 J4-J5	DHS	West Midlands	West Midlands; Warwickshire	01/11/2015	N
M6 J5-J8	M6 J5-J8	DHS	West Midlands	West Midlands	01/11/2015	Y
M6 J8-J10a	M6 J8-J10a	DHS	West Midlands	West Midlands; Staffordshire	01/11/2015	Y
M62 J26-J28	M62 J25-J30	DHS	Yorkshire and The Humber	West Yorkshire	During 2021	N
M62 J29-J30	M62 J25-J30	DHS	Yorkshire and The Humber	West Yorkshire	During 2021	N

Counterfactual estimation

Where appropriate, we have calculated a counterfactual, meaning a hypothetical after-period estimating what could have happened if the specific sections of motorways had not been converted into smart motorways. This implicitly takes into account known background factors during each period, such as changes in overall vehicle safety, recessions etc. In this report we have undertaken this counterfactual only for PIC rates.

As highlighted in the ORR 2021 Quality assurance of all lane running motorway data report, when schemes are constructed over different time periods, the counterfactual is specific to each scheme. Because collisions fluctuate from year-to-year, a counterfactual can be very sensitive to the precise years chosen, particularly for FWI and KSI rates. For this reason, we have chosen not to calculate the counterfactual for FWI and KSI rates. We will now work closely with specialist statisticians and ORR to assess the most appropriate way to apply the counterfactual to FWI and KSI rates.

We have used a standard method to estimate a counterfactual collision rate for ‘observed’ versus ‘counterfactual’ scheme assessments. Collision rates on the SRN have lowered over time. For this analysis, we assume that the PIC rate at the scheme location would have followed the same trend as that observed for all motorways in the same regions, had the scheme not been constructed.

This method estimates a counterfactual collision rate from the slope of the regional background trend. This is then used as the rate parameter in a Poisson distribution to derive confidence limits, so we can compare the confidence limits for the ‘observed’ and ‘counterfactual’ case in the same way that we do for before and after.

Considering the regional trends is appropriate as it is more specific than national trend data. In the future, depending on data availability, we will consider whether an even more specific trend, such as at scheme or road type level, can be used to further specify the background counterfactual estimates.

Methods such as counterfactual analysis and statistical significance testing help further increase our understanding of the uncertainty of the comparisons between small numbers and any safety changes before and after a scheme was put in place. With future applications of these methods and additional in-depth safety assessments, we will have even greater confidence on the reasons behind the scheme-level safety changes.

Statistical significance testing

We assume that the available statistics, ie the collisions recorded on STATS19, have been correctly recorded. This assumption may mean therefore that there is a degree of uncertainty, which arises from partial observation of events, such as when working with survey data collected from a sample, or as is the case here, from natural variability. This is the fundamental unpredictability of the natural world and in particular of rare events such as road traffic collisions. Due to this natural variability, we can treat the statistics – for example the observed collision rate of a road - as an estimate of an underlying hypothetical quantity that we cannot measure directly – for example the 'true' underlying collision rate of the road.

The ORR recognised this in its 2021 Quality assurance of all lane running motorway data report, which noted that our 'analysis of uncertainty in the Overarching Safety Report focused heavily on the tests of statistical significance. There is very little sensitivity testing to demonstrate the robustness of results to other sources of uncertainty. We think this should be strengthened in future and could cover areas such as the counterfactual (as discussed in the previous section) and testing the impact of individual projects on the overall ALR-level results.' Ever since, this analysis has used an improved methodology of statistical significance testing and has applied this to the counterfactual estimates.

We are still limited in the high-level statistics with which these methods can be used. As highlighted in the ORR 2021 Quality assurance of all lane running motorway data report, when schemes are constructed over different time periods, the counterfactual is specific to each scheme. Because collisions fluctuate from year-to-year, the counterfactual can be very sensitive to the precise years chosen. This is particularly the case for FWI and KSI rates. Both of these metrics are influenced by the STATS19 adjustment factors which are explained later in this report, whereas PICs are not. For this reason, we have chosen not to calculate a counterfactual for FWI and KSI rates. We will now assess the most appropriate way to apply counterfactual analysis to FWI and KSI rates.

In this report, we have applied these methods to the headline PIC rates. We have applied a Poisson rate ratio test which is comparable with the 'bootstrap simulation' method adopted in recent annual progress reports, comparing two collision rates by estimating a p-value. The hypothesis tested is that the collision rate ratio (eg after period rate / before period rate) is different to 1.0 by a significant amount, or in other words that the two rates are significantly different to each other. The Poisson rate ratio test has also been used for other analysis work for the DfT and the methodology has been previously reviewed by DfT statisticians, for example within the annual reports for the longer semi-trailer trial. In this report, p-values are based on 95% confidence intervals.

The 95% confidence interval is a range of values that you can be 95% confident contains the ‘true’ mean of a sample. Similarly, there is a 5% chance that the sample mean lies outside of the upper and lower confidence interval. Due to natural variability, the sample mean (centre of the confidence interval) will vary from sample to sample. The confidence is in the method, not in a particular confidence interval. As the sample size increases, the range of interval values will narrow, meaning that you know that mean with more accuracy compared with a smaller sample. In the future, we will consider whether different confidence intervals suggest different results.

The table below includes the mean PIC rates (injury-adjusted PIC per hundred million vehicle miles) for before, counterfactual and after in relation to each smart motorway scheme. In the brackets, we have included the lower/upper end of the confidence intervals for each value.

Table 7

Data: PIC rate values (injury-adjusted PIC per hundred million vehicle miles) for before, counterfactual and after per smart motorway scheme. Mean values are presented on top and lower/upper end of the confidence intervals in brackets

Scheme	Type	After Months	Before	Counterfactual	After	p-values after/ before	p-values after/ counterfactual
M1 J16-J19	ALR	36	5.09 (4.28 – 6.00)	0.92 (0.54 - 1.45)	2.55 (1.89 - 3.36)	0.000	0.000
M1 J24-J25	ALR	24	3.85 (2.84 - 5.10)	N/A	0.97 (0.26 - 2.48)	0.002	N/A
M1 J28-J31	ALR	60	11.64 (10.63 - 12.72)	6.76 (6.00 - 7.60)	3.32 (2.79 - 3.92)	0.000	0.000
M1 J32-J35a	ALR	48	12.76 (11.23 - 14.44)	8.72 (7.34 - 10.28)	5.07 (4.03 - 6.29)	0.000	0.000
M1 J39-J42	ALR	60	7.48 (6.08 - 9.11)	4.39 (3.39 - 5.60)	6.62 (5.38 - 8.07)	0.393	0.012
M20 J3-J5	ALR	12	13.81 (11.72 - 16.16)	11.29 (6.90 - 17.43)	7.90 (4.32 - 13.26)	0.043	0.392
M23 J8-J10	ALR	12	13.32 (11.79 – 15.00)	10.97 (7.29 - 15.85)	5.48 (3.00 - 9.20)	0.000	0.044
M25 J5-J7	ALR	60	13.39 (12.11 - 14.75)	11.06 (9.92 - 12.30)	10.22 (9.12 - 11.41)	0.000	0.329
M25 J23-J27	ALR	60	13.52 (12.33 - 14.8)	11.99 (10.96 - 13.09)	11.36 (10.36 - 12.44)	0.008	0.422
M3 J2-J4a	ALR	48	13.09 (11.81 - 14.47)	9.98 (8.72 - 11.36)	7.12 (6.07 - 8.31)	0.000	0.001
M5 J4a-J6	ALR	48	5.87 (4.89 - 6.99)	3.98 (3.09 - 5.06)	3.86 (2.98 - 4.92)	0.006	0.931
M6 J2-J4	ALR	12	9.90 (8.75 - 11.16)	8.09 (5.60 - 11.30)	5.23 (3.28 - 7.92)	0.002	0.141
M6 J11a-J13	ALR	60	11.16 (9.51 - 13.02)	9.00 (7.42 - 10.81)	5.53 (4.31 - 6.98)	0.000	0.001
M6 J16-J19	ALR	24	12.46 (11.38 - 13.61)	8.51 (7.01 - 10.23)	3.99 (2.99 - 5.22)	0.000	0.000
M62 J18-J20	ALR	36	8.64 (7.05 - 10.49)	3.61 (2.34 - 5.33)	3.32 (2.11 - 4.99)	0.000	0.885
M1 J6a-J10	Controlled	60	58.53 (55.60 - 61.57)	56.77 (53.98 - 59.66)	13.63 (12.28 - 15.08)	0.000	0.000
M1 J23a-J24	Controlled	36	7.69 (5.32 - 10.74)	3.33 (1.52 - 6.33)	3.70 (1.78 - 6.81)	0.043	1.000
M1 J25-J28	Controlled	60	14.58 (13.30 - 15.94)	8.99 (8.00 - 10.08)	6.13 (5.31 - 7.03)	0.000	0.000
M1 J31-J32	Controlled	48	9.85 (7.58 - 12.57)	6.35 (4.40 - 8.88)	5.79 (3.94 - 8.22)	0.017	0.804

M20 J4-J5	Controlled	60	23.00 (19.32 - 27.17)	20.32 (16.93 - 24.20)	12.42 (9.80 - 15.52)	0.000	0.001
M20 J5-J7	Controlled	60	15.11 (12.28 - 18.40)	12.33 (9.86 - 15.23)	16.06 (13.22 - 19.32)	0.680	0.075
M25 J2-J3	Controlled	60	19.58 (16.57 - 22.99)	17.58 (14.72 - 20.83)	23.66 (20.32 - 27.39)	0.097	0.011
M25 J7-J10	Controlled	60	14.70 (13.59 - 15.87)	12.76 (11.73 - 13.85)	13.41 (12.36 - 14.53)	0.106	0.412
M25 J10-J15	Controlled	60	18.68 (17.29 – 20.15)	12.05 (11.01 – 13.17)	19.83 (18.49 – 21.24)	0.262	0.000
M25 J15-J16	Controlled	60	12.58 (10.88 – 14.48)	9.87 (8.37 – 11.56)	13.33 (11.58 – 15.27)	0.584	0.005
M25 J16-J23	Controlled	60	21.26 (20.01 - 22.57)	19.51 (18.41 - 20.67)	9.82 (9.04 - 10.64)	0.000	0.000
M25 J27-J30	Controlled	60	17.17 (15.78 - 18.64)	14.98 (13.77 - 16.26)	8.19 (7.30 - 9.15)	0.000	0.000
M42 J7-J9	Controlled	60	5.54 (4.29 - 7.03)	3.62 (2.62 - 4.88)	4.63 (3.49 - 6.03)	0.365	0.266
M6 J10a-J11a	Controlled	60	11.23 (8.46 - 14.61)	8.96 (6.48 - 12.07)	3.96 (2.38 - 6.18)	0.000	0.003
M60 J8-J18	Controlled	36	10.20 (9.13 - 11.36)	5.12 (4.14 - 6.27)	7.35 (6.17 - 8.70)	0.001	0.008
M1 J10-J13	DHS	60	17.45 (15.94 - 19.06)	15.70 (14.40 - 17.09)	13.70 (12.49 - 15.01)	0.000	0.034
M42 J3a-J7	DHS	60	12.95 (11.50 - 14.53)	10.77 (9.51 - 12.14)	6.99 (5.98 - 8.11)	0.000	0.000
M4-M5 Interchange	DHS	60	15.54 (13.44 - 17.86)	12.00 (10.25 - 13.96)	6.86 (5.55 - 8.37)	0.000	0.000
M6 J4-J5	DHS	60	10.73 (8.70 - 13.09)	8.90 (7.12 - 10.99)	8.69 (6.93 - 10.76)	0.158	0.939
M6 J5-J8	DHS	60	17.45 (15.61 - 19.44)	15.23 (13.64 - 16.96)	13.45 (11.96 - 15.08)	0.001	0.129
M6 J8-J10a	DHS	60	18.18 (16.07 - 20.50)	16.32 (14.36 - 18.48)	16.39 (14.42 - 18.55)	0.253	1.000
M62 J25-J30	DHS	60	13.19 (12.00 - 14.47)	10.07 (9.08 - 11.13)	8.47 (7.56 - 9.45)	0.000	0.025

The figures below visualise the comparisons between after and before, and after and counterfactual per smart motorway scheme.

Figure 2

Data: PIC rate (injury-adjusted PIC per hundred million vehicle miles) confidence intervals for after and before per smart motorway scheme based on a Poisson rate test with 95% confidence intervals

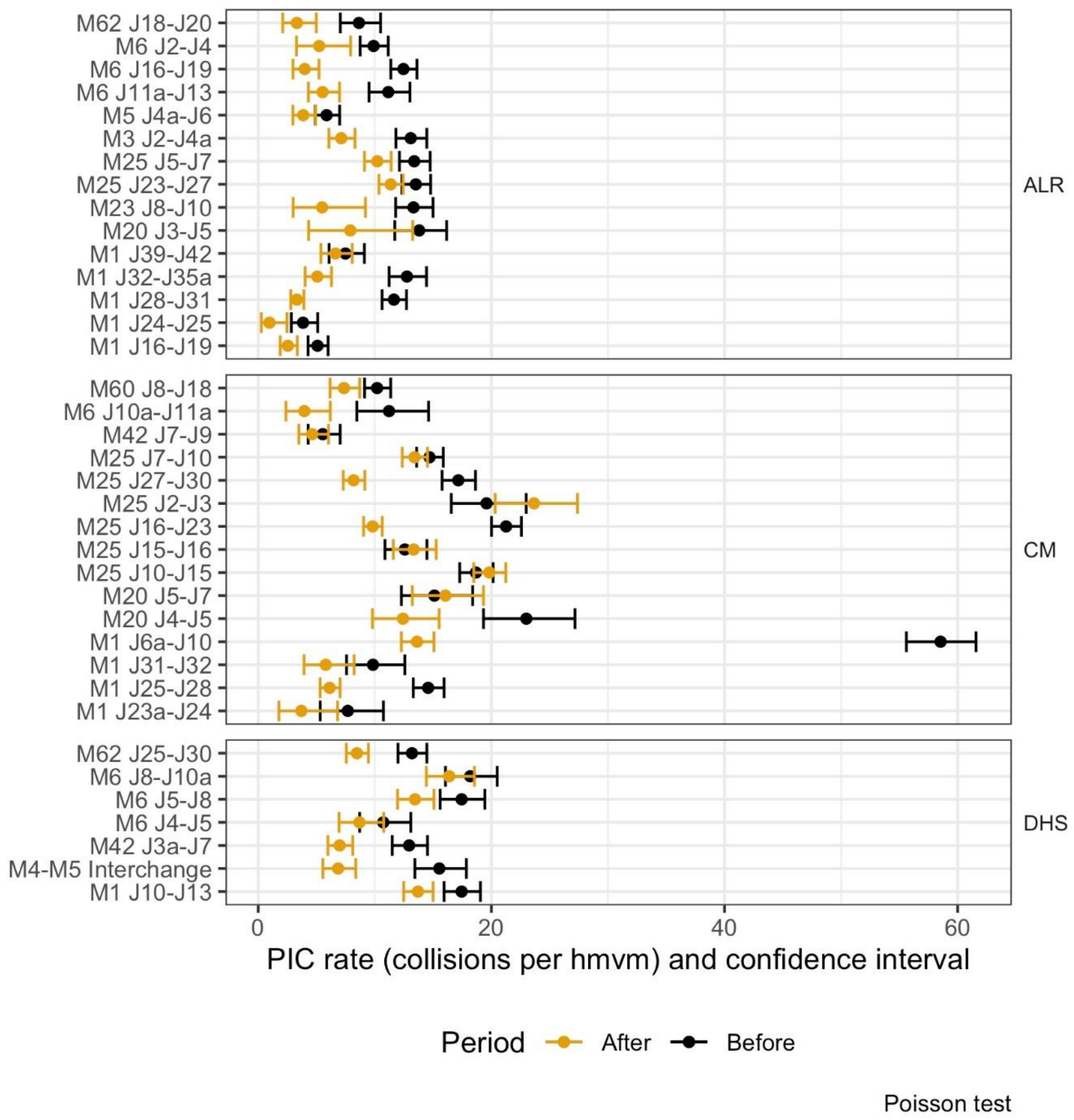
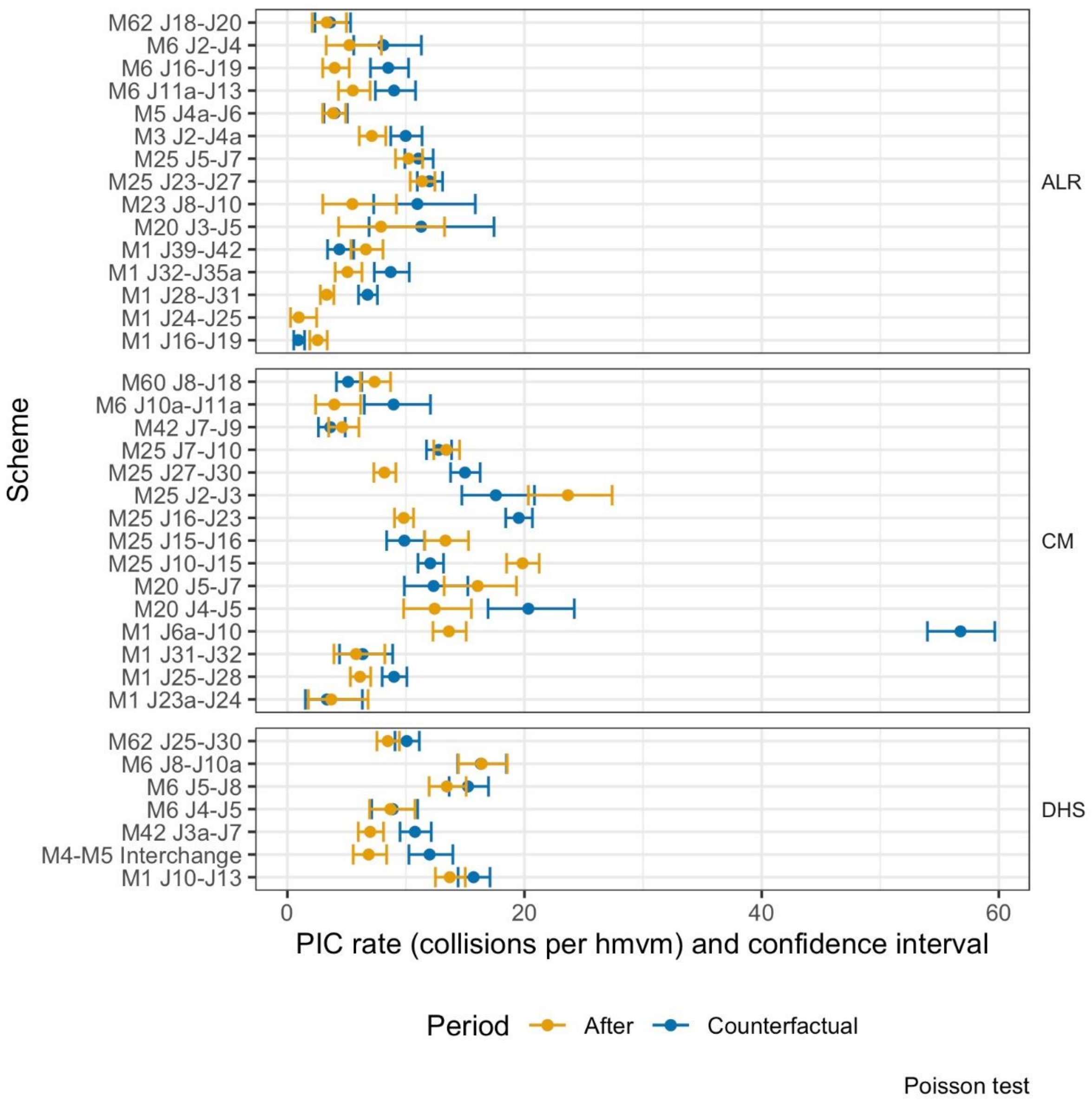


Figure 3

Data: PIC rate (injury-adjusted PIC per hundred million vehicle miles) confidence intervals for after and counterfactual per smart motorway scheme based on a Poisson rate test with 95% confidence intervals



Annex D - Detailed tables

To continue providing transparency on the analysis, alongside this report we have published the detailed safety tables spreadsheet here.

As per Annex C - Methodology, the figures included in this spreadsheet are the statistics used in this report. These reflect DfT's latest guidance on injury-based reporting, ie using adjusted STATS19 data where possible.

It should be noted that these adjustments influence (i) injuries (but not total collisions reported here) and (ii) serious and slight severities (not fatal). In addition, as these are based on a probabilistic model developed and used by ONS and DfT, adjusted figures are no longer whole numbers, but are decimal values.

Figures not including these adjustments have also been included for completeness. Such figures are categorised as 'unadjusted for injury-based reporting.'

Annex E - Detailed collision data

To provide greater transparency, alongside this report we have published the detailed collision data spreadsheet here.

This document and accompanying data have been prepared by National Highways with assistance from its consultants (where employed). The document and its accompanying data remain the property of National Highways.

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The methodology used to generate the data in this document should only be considered in the context of this ‘Smart motorways - scheme safety comparison report - ‘Before’ versus ‘after’ assessment’.

This methodology, and its subsequent outputs may differ from methodologies used in different analyses at different points in time. This is due to continuous improvements of data mapping, capture and quality. As these factors evolve over time, any comparison with earlier data or data from other sources, should be interpreted with caution.

This dataset will be refreshed when updated information becomes available. We will be interested to hear your thoughts on how to improve this data. If you want to contact us, please use roadsafetydivision@nationalhighways.co.uk.

Annex F - Glossary of terms

Term	Explanation
All lane running (ALR) motorways	All lane running (ALR) motorways add variable mandatory speed limits to control the speed and smooth the flow of traffic and increase capacity by permanently converting the hard shoulder into a running lane. ALR motorways feature emergency areas, which are places to stop in an emergency. To further enhance safety, stopped vehicle detection technology is put in place on all ALR motorways.
BAU	Business as usual
Controlled motorways	Controlled motorways apply variable mandatory speed limits to a conventional motorway to control the speed and smooth the flow of traffic and retain a permanent hard shoulder. Overhead electronic signs display messages to drivers, such as warning of an incident ahead.
DfT	Department for Transport
Dynamic hard shoulder (DHS) motorways	Dynamic hard shoulder (DHS) motorways apply variable mandatory speed limits to control the speed and smooth the flow of traffic and temporarily increase capacity by using the hard shoulder as a running lane at the busiest times. Electronic signs and signals instruct drivers when hard shoulder is available to use for live running. When the hard shoulder is operating as a live lane, the speed is set at a maximum of 60mph. DHS motorways feature emergency areas, which are places to stop in an emergency.
Emergency area	Smart motorways feature emergency areas. They are orange, set back from live traffic lanes and have an emergency phone which connects directly to our control room so help can be arranged. These are spaced regularly on a motorway with no hard shoulder and are marked with blue signs featuring an orange SOS telephone symbol. Emergency areas are for when a driver has no alternative but to stop and it has not been possible to leave the motorway or reach a motorway service area. Other places to stop in an emergency include sections of remaining hard shoulder, such as on slip roads at junctions.
Fatal and weighted injuries (FWI) metric	This gives a fatality 10 times the weighting of a serious casualty, and a serious casualty 10 times the weighting of a slight casualty. Specifically, it is calculated as: Fatal and Weighted Injuries = Fatal casualties + Serious Casualties * 0.1 + Slight Casualties * 0.01.
Fatal and weighted injuries (FWI) rate	The FWI rate takes the FWI metric and controls for the volume of traffic on the road and is more specifically defined as the number of FWI casualties per hundred million vehicle miles travelled.
Killed & seriously injured (KSI) metric	The number of people killed and seriously injured in a road traffic collision.
Killed & seriously injured (KSI) rate	The KSI rate takes the KSI metric and controls for the volume of traffic on the road and is more specifically defined as the number of KSI casualties per hundred million vehicle miles travelled.
Motorway incident detection and	MIDAS is a system set up to identify queuing traffic or congestion by monitoring traffic speed and flow. Once queuing traffic or congestion is detected, the system automatically sets appropriate messages on variable message signs to warn drivers of conditions of the road ahead. It also

automatic signalling (MIDAS)	automatically sets speed limits displayed on the signs and signals at the roadside and overhead on gantries. MIDAS can also reduce the risk of secondary incidents in queuing traffic, i.e. the risk of vehicles colliding with the rear of a queue of traffic. It does this by identifying a queue and then automatically reducing speeds and setting accompanying warning messages. In addition, on smart motorway sections only, it also includes a congestion management function designed to smooth traffic flow and throughput by reducing traffic speed, allowing reduced headway between vehicles, to try and stop traffic queues forming. This is done by setting signals and message signs upstream of where congestion is detected.
ONS	Office for National Statistics
ORR	Office of Rail and Road
Personal injury collisions (PIC) metric	The number of collisions which have resulted in a person sustaining an injury. PICs do not reflect the number of people injured in each collision (casualties).
Personal injury collisions (PIC) rate	The PIC rate takes the PIC metric and controls for the volume of traffic on the road and is more specifically defined as the number of PICs per hundred million vehicle miles travelled.
Serious casualties	People sustaining injuries requiring hospitalisation, or any of the following injuries whether or not the individual went to hospital: fractures, concussion, internal injuries, crushings, burns (excluding friction burns), severe cuts, severe general shock requiring medical treatment and injuries causing death 30 or more days after the incident.
Slight casualties	People sustaining a minor injury such as a sprain (including neck whiplash), bruise or cut which is not judged to be severe, or slight shock requiring roadside attention. This definition includes injuries not requiring medical treatment.
Smart motorway	Smart motorway is a generic term for a section of motorway that uses traffic management methods to increase capacity and reduce congestion in particularly busy areas. These methods include using the hard shoulder as a running lane and using variable speed limits to control the flow of traffic. There are three types of smart motorway – as defined in this glossary – all lane running, dynamic hard shoulder and controlled.
STATS19	The STATS19 database is a collection of all road traffic accidents (collisions) that resulted in a personal injury (casualty) and were reported to the police within 30 days of the accident. More information can be found here. One collision may give rise to several casualties, which are categorised according to their severity (slight, serious or fatal). In this report we predominantly use the terms ‘collisions’ and ‘casualties’. The term ‘injuries’ is used particularly in line with widely adopted definitions and metrics or in order to reduce the technical language of the report.
Stopped vehicle	Vehicles that are stationary or parked. This may be due to various reasons, including a vehicle breakdown, collision with another vehicle or medical episode of the driver or passenger.
Stopped vehicle detection (SVD)	Stopped vehicle detection (SVD) is a technology which enables the detection of vehicles which have stopped on the carriageway or in an emergency area. Currently a radar-based system, it is in place on ALR sections of smart motorway. When SVD identifies a stopped vehicle, it

	provides an alert to our regional control room and at the same time automatically sets a message sign on the road to warn of a report of obstruction whilst the alert is verified by an operator. Our operators can then respond quickly to close lanes with a Red X signal, display speed limits and deploy traffic officers.
Strategic road network (SRN)	In England, the strategic road network (SRN) is made up of motorways and trunk roads (the most significant A-roads). They are administered by National Highways, a Government-owned company.
Vehicle miles	Traffic statistics are presented in units of vehicle miles (billion or hundred million vehicle miles – bvm or hmvm respectively), which combines the number of vehicles on the road and how far they drive. This is a standard way of presenting traffic volumes.