Department
for Transport

Smart Motorway Safety
Evidence Stocktake and Action Plan

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Foreword

Smart motorways keep the country moving. They help us cope with a 23 per cent rise in traffic since 2000. They save motorists thousands of hours sitting in jams. They reduce the disruption and destruction which would otherwise be needed to widen our busiest roads.

But they must be safe. And though all motorways - smart or conventional - are far safer than A roads, I have been greatly concerned by a number of fatal incidents on smart motorways. My thoughts are with the families of those who have died.

As I have publicly made clear, I want smart motorways to be safer than the conventional kind. That is why last year, I commissioned this analysis to better understand what is happening on smart motorways and to recommend how to make them safer.

It was envisaged to be swift, but during the course of our investigations a complex picture has emerged – which I believed warranted further work.

We looked at the last four years for which there are figures, 2015 to 2018 inclusive. We looked both at the number of casualties and the rate - that is, the number set against the amounts of traffic using each stretch of motorway.

In all four years, the fatal casualty rate for smart motorways without a permanent hard shoulder was lower than it is on motorways with a hard shoulder.

In three of these four years, the "weighted rate" - that is, all casualties (fatal, serious and slight) weighted by seriousness - was lower for smart motorways without a permanent hard shoulder than it is on motorways with a hard shoulder.

The evidence on serious injuries alone is more mixed. In 2018, the serious casualty rate was slightly lower on motorways without a permanent hard shoulder. In 2015, 2016 and 2017, however, the serious casualty rate was slightly higher.

Reading all this, you may be asking, as I asked: how can a motorway without a hard shoulder have a lower fatal casualty rate than one with a hard shoulder? The answer is that while some risks on these roads are greater, others are less.

As the report shows, the risk of a collision between a moving vehicle and a stationary vehicle is higher on non hard-shoulder motorways. But the risk of a collision between two or more moving vehicles is lower. Because when the hard shoulder is removed, technology is installed to smooth traffic flow with variable speed limits, enforced by cameras. Messages warning motorists of incidents ahead are displayed on electronic signs. This means less speeding, less tailgating and fewer rapid changes of speed. This gives drivers more time to react if something happens. The emergency areas we have created on smart motorways, if you can reach one, are also safer places to stop than a hard shoulder.

Overall, what the evidence shows is that in most ways, smart motorways are as safe as, or safer than, the conventional ones. But not in every way. So I am clear that more work is needed to ensure that smart motorways are as safe as they can be.

Alongside this report, and annexed to it, therefore, I am launching an extended package of measures - an Action Plan - to raise the bar on smart motorway safety. It will include:

- abolishing the confusing "dynamic hard shoulder" smart motorways, where the hard shoulder operates only part-time and is a live running lane the rest of the time;

- substantially speeding up the deployment of "stopped vehicle detection" technology across the entire "all lane running" smart motorway network, so stopped vehicles can be detected and the lanes closed more quickly;

- increasing traffic officer patrols on those smart motorways where places to stop in an emergency are more than one mile apart to reduce the average attendance time when a vehicle is stopped from 17 minutes to 10 minutes;

- reducing the distance between places to stop in an emergency to 3/4 of a mile where feasible so that on future schemes motorists should typically reach one every 45 seconds at 60mph. The maximum spacing will be 1 mile;

- installing more emergency areas on the existing M25 smart motorways and considering a national programme to install more;

- making emergency areas more visible;

- installing more signs to direct motorists to emergency areas;

- committing £5m extra to improve public information and awareness about smart motorways and what to do in an emergency, more than doubling previously planned spend.

The last point is important. Motorists could be better informed about this change in our motorways. Many do not know exactly what a smart motorway is, and are not aware of when they are on one or not. We need to tackle the public perception of, and public confidence in, the safety of smart motorways as much as the reality.

By these measures we place safety at the heart of our smart motorway programme and will rebuild public confidence in the motorway network.

The Rt Hon Grant Shapps MP

Secretary of State for Transport

Introduction

In October 2019, the Secretary of State asked the Department to carry out an evidence stocktake to gather the facts on the safety of smart motorways and make recommendations. A wide range of data has been considered and conclusions drawn on what the evidence tells us about the safety of this type of motorway. This work is set out in the Evidence Stocktake in Part A of this document. The action the Government is taking in response to this work is set out in the Action Plan in Part B of this document.

Why do we have smart motorways?

The number of miles driven on motorways in England has increased by 23% since 2000.[1] Smart motorways are needed to keep the country moving. They have raised the capacity of our busiest motorways by up to a third. A smart motorway can carry 1,600 additional vehicles an hour in each direction and studies on the M25 have shown that these roads have enabled an additional 11,000 journeys a day. On the M6 Junctions 16 to 19 smart motorway, around Crewe, the average commute over a week has reduced by 40 minutes and journey reliability has also demonstrably improved.

The alternative is time-consuming and destructive: building new motorways, or widening the existing ones. Widening also causes far more disruption - not just to road users on the motorway itself, but to the roads and railways which cross it, since it often requires bridges across the motorway to be demolished and rebuilt.

Without smart motorways, many people's homes would have to be destroyed and hundreds of acres of green space would have to be built on. We estimate that the smart motorway network (in operation or planned) has saved, or will save, land equivalent to more than 700 Wembley Stadium-sized football pitches from being lost.

What are smart motorways and how do they work?

The term 'smart motorways' describes a set of three motorway designs, comprising:

- **Controlled Motorways (CM)**, which add variable and mandatory speed limits to a conventional motorway to control the speed of traffic, while retaining a permanent hard shoulder. Overhead electronic signs display messages to drivers, such as warning of an incident ahead;
- **All Lane Running (ALR) motorways**, which apply the controlled motorway technology, permanently convert the hard shoulder as a running lane, and feature emergency areas. Emergency areas are

[1] DfT statistics on road length and traffic: https://www.gov.uk/government/organisations/department-for-transport/about/statistics. Comparison between vehicle miles driven in 2000 and 2018, the latest year for which data is available.

places to stop in an emergency. They are approximately 110 yards long (the average length of a football pitch) by fifteen feet wide and set back from the left-hand edge of the motorway. An emergency telephone from which to alert Highways England of an issue and call for help is provided in each emergency area and increasing numbers of them have orange surfacing to make them more visible. 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. The distance between places to stop in an emergency varies across the smart motorways, from 0.3 miles apart to 1.6 miles apart; and

- **Dynamic Hard Shoulder Running (DHS) motorways**, which apply the above controlled motorway technology. The hard shoulder is some of the time, but not always, used as a live running lane, with electronic signs to guide drivers when it is safe to use for live running. Emergency areas are installed as on ALR motorways.

Since 1995 with the first Controlled Motorway, smart motorways have been progressively introduced to the SRN. The first DHS motorway opened in 2006 and the first major ALR motorways in 2014. They are an enhancement of the existing motorway network aiming to achieve the benefits of increasing capacity, reducing congestion, and applying technology to manage traffic, while keeping the road as safe as, or safer than, the road it replaced. Smart motorways have therefore tended to be introduced on the busiest, most congested, sections of the SRN.

Figure 1 shows the infrastructure and technology installed on an 'all lane running' type of smart motorway. Figure 2 shows an all lane running smart motorway in operation.

Figure 1 - Infrastructure and technology on an all lane running smart motorway

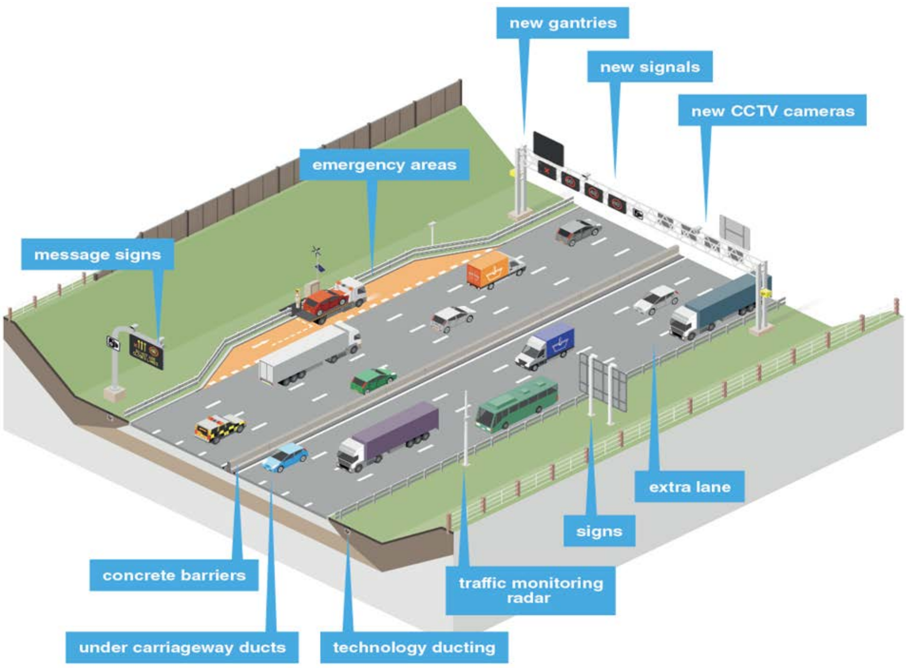

Figure 2 - All lane running smart motorway

How do motorways compare to other UK roads?

Motorways - smart or conventional - are far safer than any other major roads. There are no pedestrians and cyclists. There are far fewer junctions than on other roads, and those junctions which are there are designed to allow traffic to join or leave in greater safety. There are fewer sharp bends and gradients are less steep. Traffic crossing the motorway uses bridges or tunnels.

Within Great Britain, motorways are comparatively the safest major roads to travel on - in 2018 motorways carried 21% of the road traffic but had only 6% of fatal collisions. Highways England's 2017 Safety Report showed how the killed and serious injury accident rate varied across road types on the strategic road network in 2017. This showed a risk that was 2.7 times greater on A-roads compared to motorways, or 6.2 times greater when comparing a single-carriageway A-road to a motorway.

How do fatalities on smart motorways compare to motorways as a whole?

Public concern has been focused on fatalities occurring on ALR and DHS motorways - those without a permanent hard shoulder. In three of the last four years, the share of fatalities occurring on these motorways was lower than the share of traffic carried, suggesting that a lower share of fatalities occur on DHS and ALR compared to the motorway network as whole. The only exception was 2017, when the share of fatalities was higher than the share of traffic carried.

- In 2018, ALR and DHS motorways carried 13.8 per cent of the traffic on the motorway network. They accounted for 12.8 per cent of the fatalities.
- In 2017, ALR and DHS motorways carried 11.7 per cent of the traffic on the motorway network. They accounted for 12.8 per cent of the fatalities.
- In 2016, ALR and DHS motorways carried 9.6 per cent of the traffic on the motorway network. They accounted for 3.9 per cent of the fatalities.

- In 2015, ALR and DHS motorways carried 7.6 per cent of the traffic on the motorway network. They accounted for 5.4 per cent of the fatalities.

How do they compare on serious casualties?

In 2018, serious casualty rates were slightly lower on ALR and DHS motorways than on the motorway network as a whole. That year, ALR and DHS motorways carried 13.8 per cent of the traffic on the motorway network. They accounted for 13.2 per cent of the serious casualties.

However, the serious casualty rate on ALR and DHS motorways combined has been slightly higher in the past. Over the four years 2015-18 (inclusive), ALR and DHS motorways carried, on average, 10.7 per cent of the traffic on the motorway network. They accounted for, on average, 11.4 per cent of the serious casualties.

How do they compare on fatal and weighted injuries (FWI), weighting casualties by their seriousness?

In 2018, the ‘fatal and weighted injuries’ rate on ALR and DHS motorways combined was slightly lower than on the motorway network as a whole. That year, ALR and DHS motorways carried 13.8 per cent of the traffic on the motorway network. They accounted for 13.5 per cent of the ‘fatal and weighted’ injuries.

Over the four years 2015-18 (inclusive), ALR and DHS motorways carried, on average, 10.7 per cent of the traffic on the motorway network. They accounted for, on average, 10.1 per cent of fatal and weighted injuries.

Surely the live lane collision risk is greater if there's no hard shoulder?

The risk of a live lane collision between a moving vehicle and a stopped vehicle is greater on ALR and DHS motorways. But the risk of a collision between two or more moving vehicles is lower. This is because ALR and DHS motorways have variable mandatory speed limits to smooth traffic flow and electronic signs to warn drivers of incidents ahead. This means less speeding, tailgating and fewer rapid changes of speed. This gives drivers more time to react if something happens.

The emergency areas provided on ALR and DHS motorways are designed to be safer places to stop, if you can reach them, than conventional hard shoulder. This is because they are offset from the motorway and wider than conventional hard shoulders. As we describe in more detail in Part B of this document, one of the reforms we are introducing is to reduce the distance between emergency areas on new smart motorways, and on some existing ones.

How do the UK's motorways compare to those of other countries?

The United Kingdom has some of the safest roads in the world. The number of road deaths per million inhabitants is lower in the UK than in almost every country within Europe. The UK ranks just behind the top performers, Norway and Switzerland, with 28 deaths per million inhabitants in 2018.

PART A - EVIDENCE STOCKTAKE

1. Summary of Analysis

Background

1.1 The Strategic Road Network (SRN) connects England's regions, cities, airports, ports and businesses. It is made up of motorways (including smart motorways) and major A roads. These roads enable reliable and efficient journeys for people and businesses that are important to our society and the economy. Highways England motorways handled 22% of all road traffic in England in 2018 and the number of miles driven on them has risen by 23% since 2000.

1.2 England's roads are amongst the safest in the world. Of the 1,522 fatalities on our roads in 2018, 86 were on the SRN motorway network, of which 19 were on the 'smart motorway' sections of the network. Across 2015-2018 there were on average 1,507 fatalities per year.[2] Of these, 87 were on the SRN motorway network including 11 on the 'smart motorway' sections.[3]

This Report

1.3 Following concerns about safety, this report has been compiled by the Department for Transport at the request of the Secretary of State. It uses evidence comprising material in the public domain; information Highways England has generated and intends to publish in due course; and, newly collated information and analysis for the purposes of this stocktake.

1.4 Understanding the relative safety of smart motorways involves considering several factors. It involves both comparing the safety performance of the motorway types as the network stands, and considering the safety effects of converting a conventional motorway to a smart motorway on a like-for-like basis. It also involves understanding not just differences in the scale of casualty risk, but also how the nature of the underlying risks varies.

1.5 As smart motorways have been progressively introduced, Highways England has developed a body of evidence to monitor and evaluate their safety performance, alongside evaluation of other benefits, in line with evaluation standards for major enhancement schemes on the SRN. This report takes stock of that and newly collated evidence, in order to draw conclusions about the relative safety performance of smart motorways. This stocktake considers the full set of smart motorway types,

[2] High level casualty data can be volatile from year to year, and casualty rates can be sensitive to small changes in the absolute number of casualties. When considering such statistics, this volatility can be reduced by looking at the average over a recent set of years. Note: 2018 is the latest year of available data.

[3] DfT analysis of fatalities on England's roads and motorway network, Highways England analysis of fatalities on smart motorways. This draws on STATS19 data, and takes into consideration any further information on casualties on specific motorway types relevant to this exercise.

with a particular focus on DHS and ALR as they both utilise the hard shoulder as a live lane.

1.6 The conclusions of the evidence stocktake have informed the recommendations found in Part B of this report.

Understanding the Evidence

1.7 There are several sources of evidence on the relative safety of the different motorway types. These include modelling of potential and outturn[4] risks, high level statistics, plus before and after studies. There are also several challenges in understanding the relative safety performance of roads.

1.8 Modelling how overall safety might be expected to change requires assessing the changes in a wide variety of risks (for example, inappropriate speeds and live lane breakdowns). Assessing how safety has changed after converting a motorway to a smart motorway needs to take account of other factors which vary between individual roads such as usage and congestion levels. It also needs to establish what may have happened if there had been no intervention (the counterfactual scenario). Also, the limited number of years of post-opening scheme data, and the relatively infrequent nature of fatalities on individual roads, introduces uncertainty in establishing the statistical significance[5] of results. The evidence base also has the potential to evolve, as more years of data become available and analytical methods develop.

1.9 Different analytical approaches can be used to offer insights into the relative safety of the different motorway types. The high-level statistics are helpful in understanding safety performance as the network stands. The before and after studies are better suited to considering the effect of converting a section of motorway, like-for-like; as is the risk modelling, which additionally is useful for looking at the nature of risks.

Findings

1.10 This section summarises the current evidence on the safety performance of the motorway types as the network stands, and the safety effects of converting a conventional motorway to a smart motorway on a like-for-like basis. It considers both how the scale of casualties, and how the profile of risks and collisions, varies between motorway types. Public concern has been centred on ALR and DHS motorways - those without a permanent hard shoulder. As such, this report focuses more on these motorways.

High Level Casualty Statistics

1.11 To understand smart motorways, it is useful to begin by considering them in their context as part of the network of roads connecting the nation, before going on to compare them with motorways more specifically. In 2018, DHS and ALR collectively

[4] Outturn refers to actual, observed data rather than what was expected.

[5] This is a standard statistical technique which helps to establish whether a difference in two casualty rates reflects a variation in the underlying casualty risks, or is within the statistical margin of error which results from natural variability in the figures over time. The use of this statistical term is not intended to imply any judgement about the importance of the events recorded by these statistics.

comprised around 4% of the SRN road length, 9% of SRN traffic, and 4% of SRN fatalities. It is also important to look at an average, given the volatility of casualty data and the growing nature of the network. Across 2015-2018 DHS and ALR collectively comprised, on average, around 3% of the SRN road length, 7% of SRN traffic, and 3% of SRN fatalities. This indicates that DHS and ALR roads on average carry more traffic and have a proportionately lower number of fatalities than the SRN as a whole (see section 2b and section 4b).

1.12 Comparing DHS and ALR to the motorway network more specifically: In 2018, DHS and ALR accounted for 12.8% of fatal casualties on the motorway network, whilst carrying 13.8% of motorway traffic. The share of fatal casualties was also lower than the share of traffic for the three years prior (2015-2017). For serious casualties, DHS and ALR accounted for 13.2% of serious casualties compared to 13.8% of motorway traffic. Whilst this suggests a lower share of serious casualties occurs on DHS and ALR compared to the motorway network as a whole, it should be noted that the three previous years of data suggested the opposite with a larger share of serious casualties on DHS and ALR (see section 4b).

1.13 Looking at slight casualties in 2018, DHS and ALR accounted for 15% of slight casualties, compared to 13.8% of motorway traffic. The share of slight casualties was also higher than the share of traffic for the three years prior (2015-17) (see section 4b).

1.14 To more directly illustrate the risks experienced by road users, we can also look at the 'casualty rate'. This is the number of casualties on a road type relative to the volume of traffic (measured in hundred million vehicle miles, or hmvm). Where there are slight differences in casualty rates between motorway types, given that the casualty data can be based on small samples and shows volatility over time, these differences may not reflect underlying differences in risk. These statistics (see section 4b) are an average over 2015-2018, and showed that:

- **Slight casualty rates** are higher on controlled (14 per hmvm) and DHS (15 per hmvm), compared to conventional motorways (10 per hmvm), while ALR rates are slightly higher (11 per hmvm)
- **Serious casualty rates** on controlled (1.2 per hmvm), DHS (1.2 per hmvm) and ALR (1.3 per hmvm) are slightly higher than conventional motorways (1.1 per hmvm).
- **Fatal casualty rates** on controlled (0.07 per hmvm), DHS (0.07 per hmvm) and ALR (0.11 per hmvm) are lower than conventional motorways (0.16 per hmvm).

1.15 Reflecting the great distress caused by fatal and serious casualties, Highways England has used for many years an additional metric to assess the safety of roads, called Fatal and Weighted Injuries (FWI). This gives a fatality ten times the weight of a serious casualty, and a serious casualty ten times the weight of a slight casualty. The Fatal and Weighted Injuries (FWI) rates on controlled (0.33 per hmvm), DHS (0.33 per hmvm) and ALR (0.35 per hmvm) schemes are slightly lower than conventional motorways (0.38 per hmvm) (see section 4b).

1.16 However, while these high-level figures adjust for the extent of the network and traffic volume, they are not like-for-like comparisons of motorway types. So, while these statistics help to illustrate variations in the safety performance of the network as it stands, they are less useful for other considerations, such as the effect of converting a specific section of motorway or understanding the underlying risks.

Profile of Risk and Collisions

1.17 In addition to looking at how the scale of casualties varies between motorway types, it is important to understand whether the profile of risks and collisions varies between motorway types.

1.18 Given the differences between motorway types in their features, information to users, and degree of control, the profile of incidents and collisions can reasonably be expected to vary between motorway types. As part of the introduction of smart motorways, Highways England estimated how the profile of risk would be expected to vary between the motorway types. This suggested that on smart motorways, the expected effect was an overall reduction in risk, but with some risks being reduced, and some being increased. For example, risks expected to reduce on ALR included collisions involving speeding or tailgating, while risks expected to increase included collisions involving vehicles stopped in a live lane (see section 4a).

1.19 Outturn data - looking at actual, observed risk rather than expected - has been used to further assess these changes in risk after the introduction of smart motorways. It shows that, as predicted, some risks have reduced. These include tailgating, driver loses control of vehicle, rapid change of vehicle speed, vehicle drifts off carriageway and vehicle driving too fast. However, some risks have increased, including the risk of unsafe lane changing and a vehicle stopping in a live lane. Overall the collision risk declined after ALR was introduced, consistent with earlier modelling. However, this analysis does not look at how the collision risk translates into risks of casualties of different severities (see section 4c).

Places of relative safety and live lane breakdowns

1.20 The hard shoulder on a conventional motorway is a place to stop in an emergency, however doing so still involves a risk to personal safety, as it is immediately adjacent to running traffic lanes, and a person stopped on a hard shoulder is at risk from other vehicles entering the hard shoulder. On average, 1 in 12 fatalities on motorways (8%) occur on the hard shoulder (amounting to 27 between 2014 and 2017). Smart motorways without full-time hard shoulders have emergency areas to stop in. They are wider than hard shoulders, set further away from traffic and at regular intervals – and so a vehicle in one is less likely to be struck by traffic. There have been zero fatal collisions in smart motorway emergency areas since they were first introduced in 2006 (see section 4c).

1.21 More generally, evidence suggests that there have been fewer personal injury collisions in places of relative safety on sections of road converted to ALR, compared to previously on the hard shoulder. It also suggests that breaking down and stopping in a live lane is an infrequent experience for road users. But when a vehicle breakdown does occur, it is less likely to occur in a place of relative safety on DHS or ALR than it is on a conventional motorway. For ALR schemes, as expected in the risk modelling, the likelihood of collisions involving a vehicle stopped in a live lane has increased (see section 4c).

Before and After Studies

1.22 A valuable approach is to consider safety ‘before and after’ the conversion of roads to be smart motorways, because this holds constant many of the other factors, and so provides a like-for-like comparison of the motorway types. The evidence can also make use of a counterfactual scenario, which asks 'what would have happened, if the change in motorway type had not occurred?', and can be compared more meaningfully with the 'after opening' safety position. This both avoids conflating the type of motorway with other factors such as congestion level, and controls for background trends in safety over time.

1.23 Highways England has produced a 'Smart Motorway All Lane Running Overarching Safety Report', which provides an overarching 'before and after' assessment of the first nine ALR schemes, including a counterfactual scenario. This used one year of post-opening data for the majority of the schemes, and three years for some.

1.24 There has been a 28% reduction in the all casualty rate from 16.8 per hmvm to 12.1 per hmvm when simply comparing the 'Before' and 'After' period. The counterfactual scenario indicates that a 12% reduction in the casualty rate from 16.8 per hmvm to 14.7 per hmvm might otherwise have been expected. Overall, there has been a statistically significant reduction of 18% in the all casualty rate[6] from 14.7 per hmvm to 12.1 per hmvm when compared to what might otherwise have been expected (see section 4d).

1.25 The fatal and serious casualty rate across the nine schemes has increased by 14% from 1.19 per hmvm to 1.35 per hmvm when simply comparing the 'Before' and 'After' period, this is line with what might otherwise have been expected (a 12% increase from 1.19 per hmvm to 1.32 per hmvm). Overall, there has been an increase (2%) in the fatal and serious casualty rate from 1.32 per hmvm to 1.35 per hmvm when compared to what might otherwise have been expected (though this is within the statistical margin of error). This reflects an increase in the serious casualty rate and a decrease in the fatal casualty rate from the 'before' to 'after' periods (see section 4d).

1.26 The FWI rate across the nine schemes has decreased by 25% from 0.41 per hmvm to 0.31 per hmvm when simply comparing the 'Before' and 'After' period. The counterfactual scenario indicates that a 2% reduction in the FWI rate from 0.41 per hmvm to 0.4 per hmvm might otherwise have been expected. Overall, there has been a reduction of 23% in the FWI rate from 0.4 per hmvm to 0.31 per hmvm when compared to the counterfactual (although the statistical significance of this reduction could not be ascertained) (see section 4d).

1.27 The results of these before and after studies indicate that when a motorway is converted to ALR: the overall casualty rate declines significantly; the fatal and serious casualty rate increases slightly, but within the statistical margin of error; and the FWI rate declines (see section 4d).

1.28 For DHS schemes, of the five Post-Opening Project Evaluation (POPE)[7] reports and one three-year safety report reviewed, half saw a statistically significant fall in personal injury collision rates, while the other half saw an increase in these collision rates, although these were in most cases within the statistical margin of error. All schemes saw a fall in the FWI rates (see section 4d).

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[6] The casualty rate is the number of casualties per million vehicle miles travelled. This represents risk in a consistent way across schemes with different traffic levels.

[7] POPE assesses whether the benefits set out in a road scheme's business case are on track to be realised through systematically evaluating metrics in relation to traffic flows, journey times, journey time reliability, safety and environmental impacts. These are undertaken after the scheme has been open to traffic for one year and then again after five years

1.29 Highways England provided additional collision data for a wider group of eight DHS schemes. The data suggests that personal injury collisions of each severity reduced after the introduction of the schemes. This considered several years of data before and after the schemes opened, but did not take into account background trends or perform statistical significance testing (see section 4d).

1.30 This section summarised the evidence on the effect of converting conventional motorways to DHS or ALR. The following section brings this together with the other types of evidence, including the high level statistics and profile of risks, to form an overall conclusion on the safety of smart motorways.

Conclusion

1.31 Understanding the relative safety of smart motorways involves considering several factors. It involves both comparing the safety performance of the motorway types as the network stands, and considering the safety effects of converting a conventional motorway to a smart motorway on a like-for-like basis. It also involves understanding not just differences in the scale of casualty risk, but also how the nature of the underlying risks varies.

1.32 Substantial effort has been made to build the evidence base on the relative safety of smart motorways, over many years. The high level statistics are helpful in understanding safety performance as the network stands. The before and after studies are better suited to considering the effect of converting a section of motorway, like-for-like; as is the risk modelling, which additionally is useful for looking at the nature of risks. This evidence base has the potential to evolve, as more years of data become available and analytical methods develop.

1.33 The high level statistics suggest that fatal casualty rates on the ALR network as it stands are lower, while injury rates are slightly higher. The risk modelling suggests that when converting conventional motorways to ALR, many risks decrease, while some increase. For example, the risks of a vehicle being driven too fast, and of a vehicle drifting off the carriageway, reduce whilst the risks of unsafe lane changing and of a vehicle stopping in a live lane increase. Looking at like-for-like studies of specific roads which have been converted to ALR: the overall casualty rate declines significantly; the fatal and serious casualty rate increases slightly, but within the statistical margin of error; and the FWI rate declines. The same studies further indicate that the motorway types differ in terms of the underlying risks.

1.34 The high level statistics show that DHS motorways, compared to conventional motorways, have a lower rate of fatal casualties and a higher rate of slight casualties, while serious casualty rates are slightly higher. Before and after collision data for DHS schemes suggested that personal injury collisions reduced.

1.35 Overall, the evidence shows that in most ways, smart motorways are as safe as, or safer than, conventional motorways, but not in every way. Part B of this report sets out our Action Plan, which includes continuing to monitor the evidence as it evolves.

2. Smart Motorways on the Strategic Road Network

a) What are Smart Motorways and how do they work?

2.1 A smart motorway is 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.

2.2 Smart motorways aim to increase road capacity, reduce congestion and disruption, whilst minimising the environmental impacts typically associated with road enhancements.

2.3 Smart motorways can operate in one of three ways:

- **Controlled Motorway (CM)** - with three or more lanes, a hard shoulder and variable speed limits (figure 1 below).
- **Dynamic Hard Shoulder Running (DHS)** – with variable speed limits and the hard shoulder selectively opened as a running lane during periods when there is a lower speed limit in force, and emergency areas at regular intervals (figure 2 below).
- **All Lane Running (ALR)** – with variable speed limits and the hard shoulder converted to a permanent running lane, and emergency areas at regular intervals (figure 3 below).

2.4 These technology-enabled sections of motorways have enhancements as shown in figure 4, such as:

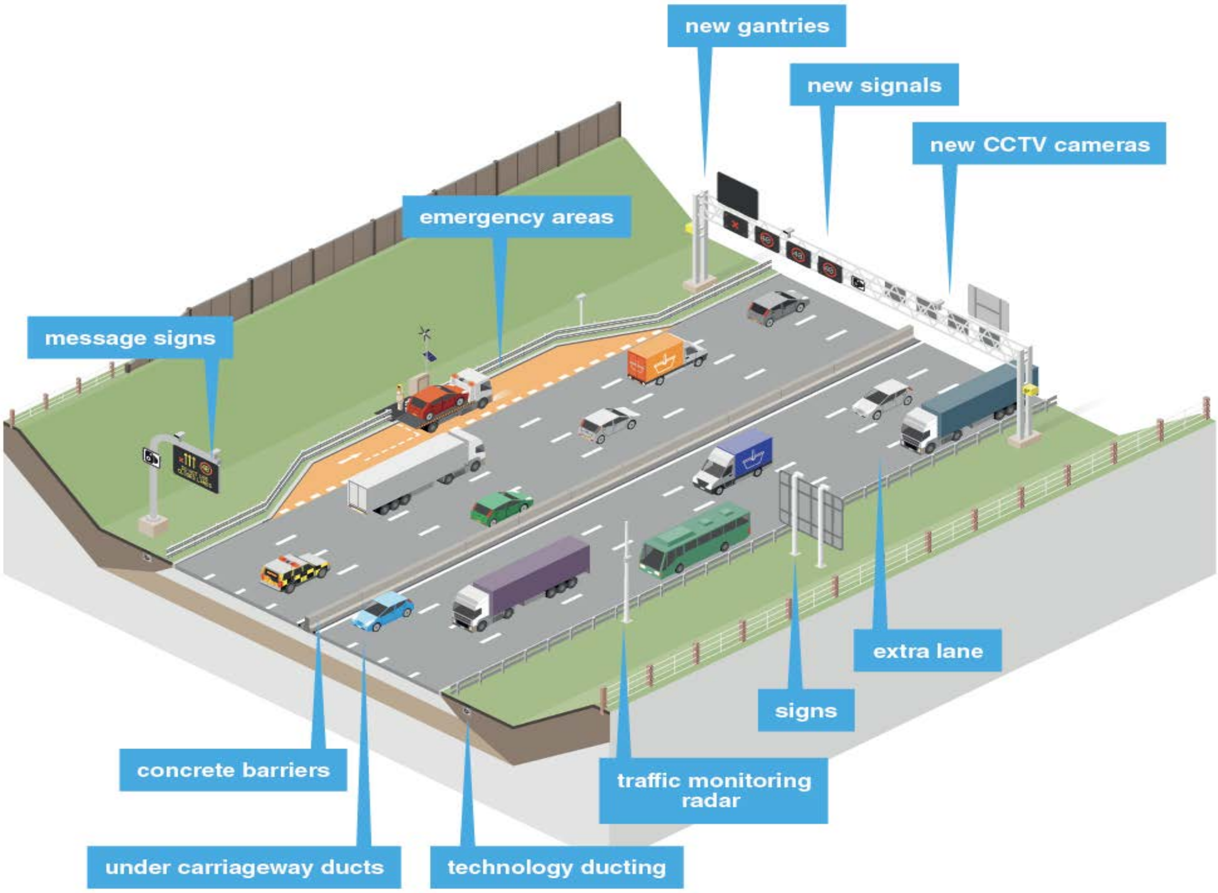
- Electronic message signs that display variable speed limits and Red X signs when lanes are closed;
- Sensors to monitor traffic volumes and automatically set signs and signals;
- CCTV cameras;
- Enforcement cameras; and,
- Emergency areas with emergency roadside telephones.

Figure 1 – Controlled Motorway

Figure 2 – Dynamic Hard Shoulder Running

Figure 3 – All Lane Running

Figure 4 – All Lane Running Infrastructure and Technology



2.5 This enhanced technology allows Highways England to monitor traffic flows, change the speed limit to smooth traffic flow, alert drivers to hazards and congestion, and close lanes. With this additional infrastructure, and smoother traffic flow within a more controlled environment, smart motorways were expected to reduce overall risk, compared to conventional motorways.

b) How has the Smart Motorway Network developed?

2.6 The SRN has been expanding and evolving since the 1960's, and in 2018 was 4,513 miles in length. The last 25 years has also seen conversion of parts of the motorway network to become smart motorways:

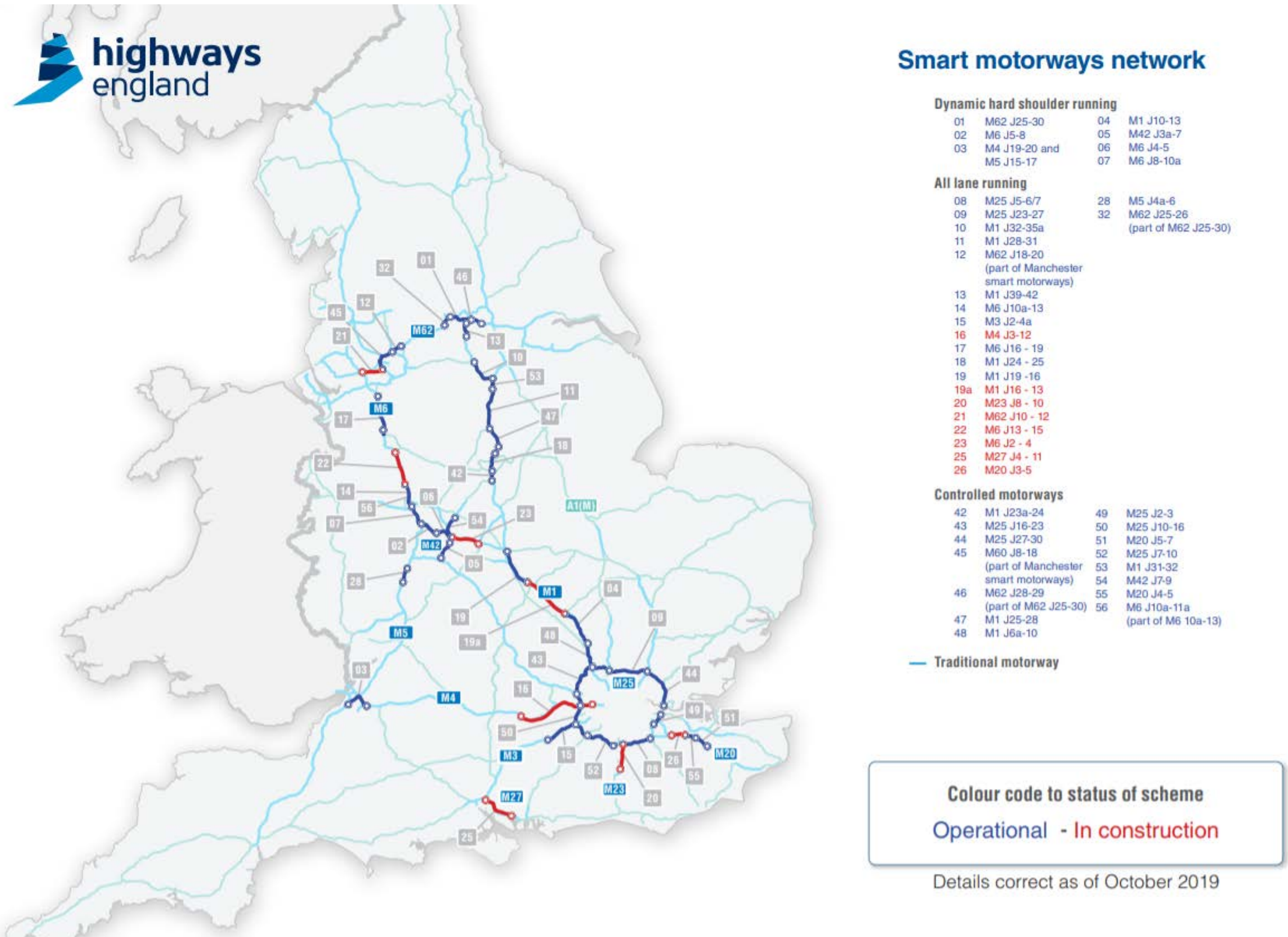
- **Controlled Motorway (CM)** - in 1995 the first mandatory variable speed limits used on the English motorway network were introduced on the M25 J10-J15[8]. By the end of 2018, controlled motorways covered 137 miles of the network (around 3% of the SRN) and carried 7 billion vehicle miles of traffic (around 8% of total SRN traffic).[9]
- **Dynamic Hard Shoulder Running (DHS)** - in 2006 the first hard shoulder to be opened to traffic was put into operation on the M42 J3a-7. This pilot scheme was originally known as active traffic management. By the end of 2018, Dynamic Hard Shoulder Running motorways covered 66 miles of the network (around 1% of the SRN) and carried 3 billion vehicle miles of traffic (around 3% of total SRN traffic)[4].
- **All Lane Running (ALR)** - in 2014 the first ALR schemes went into operation on the M25 J5-7 and J23-27. By the end of 2018, ALR motorways covered 123 miles of the network (around 3% of the SRN) and carried 5 billion vehicle miles of traffic (around 5% of total SRN traffic).[4]

[8] Expanded to J10-J16 in 2001.

[9] DfT estimates of road length and traffic.

2.7 The map below in figure 5 shows the current spread of smart motorways in England.

Figure 5 – Smart Motorways Across the Strategic Road Network



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2.8 Specifically, the locations of smart motorways as of November 2019 are shown in table 1 below.[10]

Table 1 - Smart Motorways Operating Across the Strategic Road Network

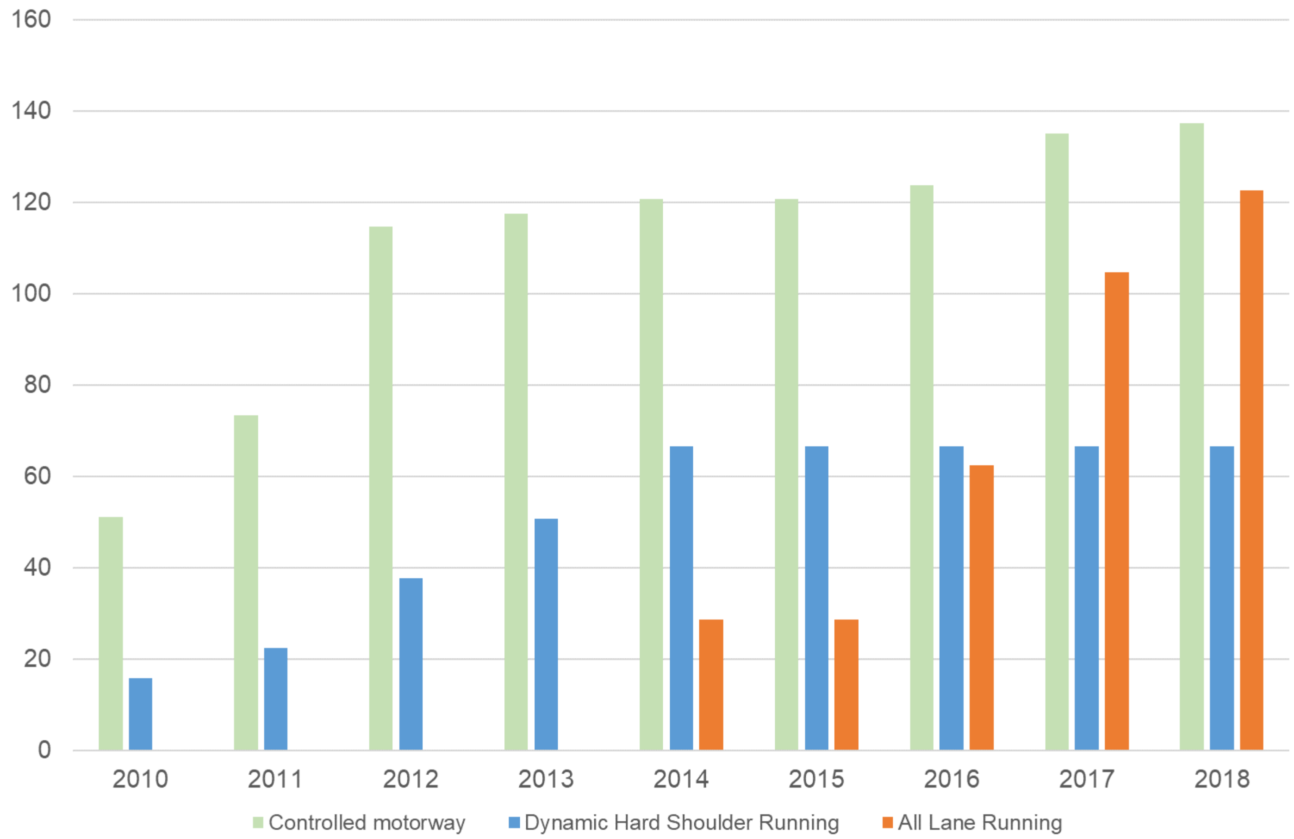
Motorway	Controlled Motorway	Dynamic Hard Shoulder Running	All Lane Running
M1	J6a-10, J23-24, J25-28. J31-32	J10-13	J16-19, J24-25, J28-31, J32-35a, J39-42
M3	-	-	J2-4a
M4	-	J19-20	-
M5	-	J15-17	J4a-6
M6	J10a-11a	J4-10a	J11a-13, J16-19
M20	J4-7	-	-
M25	J2-3, J7-23, J27-30	-	J5-7, J23-27
M40	J16-M42 J3a (northbound)	-	-
M42	J7-9	J3a-7	-
M60	J8-18	-	-
M62	J28-29	J26-28, J29-30 (eastbound)	J18-20, J25-26, J29-30 (westbound)

2.9 This tells us what smart motorways are, how they work, and where they are. To understand them further, it is also necessary to know how many miles of smart motorway network there is, and how much traffic they carry.

2.10 Figures 6 and 7 illustrate how the length of the smart motorway network has grown since 2010, and what share of the SRN they comprise. They show that smart motorways have grown since 2010, while DHS has been stable since 2014, after which the length of ALR started to grow. Overall, smart motorways make up a relatively small proportion of the SRN, comprising 7% of its road length in 2018.

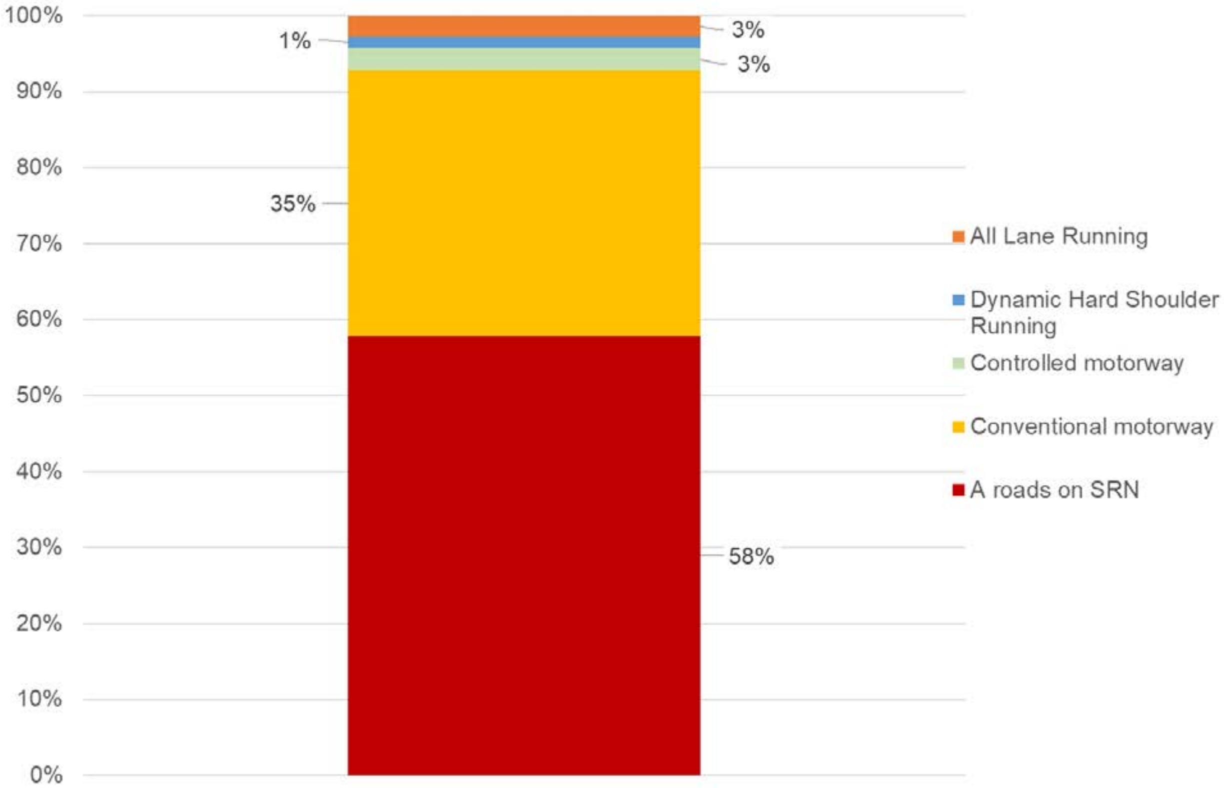
[10] https://www.rac.co.uk/drive/advice/driving-advice/smart-motorways/

Figure 6 – Miles of Smart Motorway on the Strategic Road Network (2010-2018)



Source: DfT analysis based on DfT statistics (see Annex A).

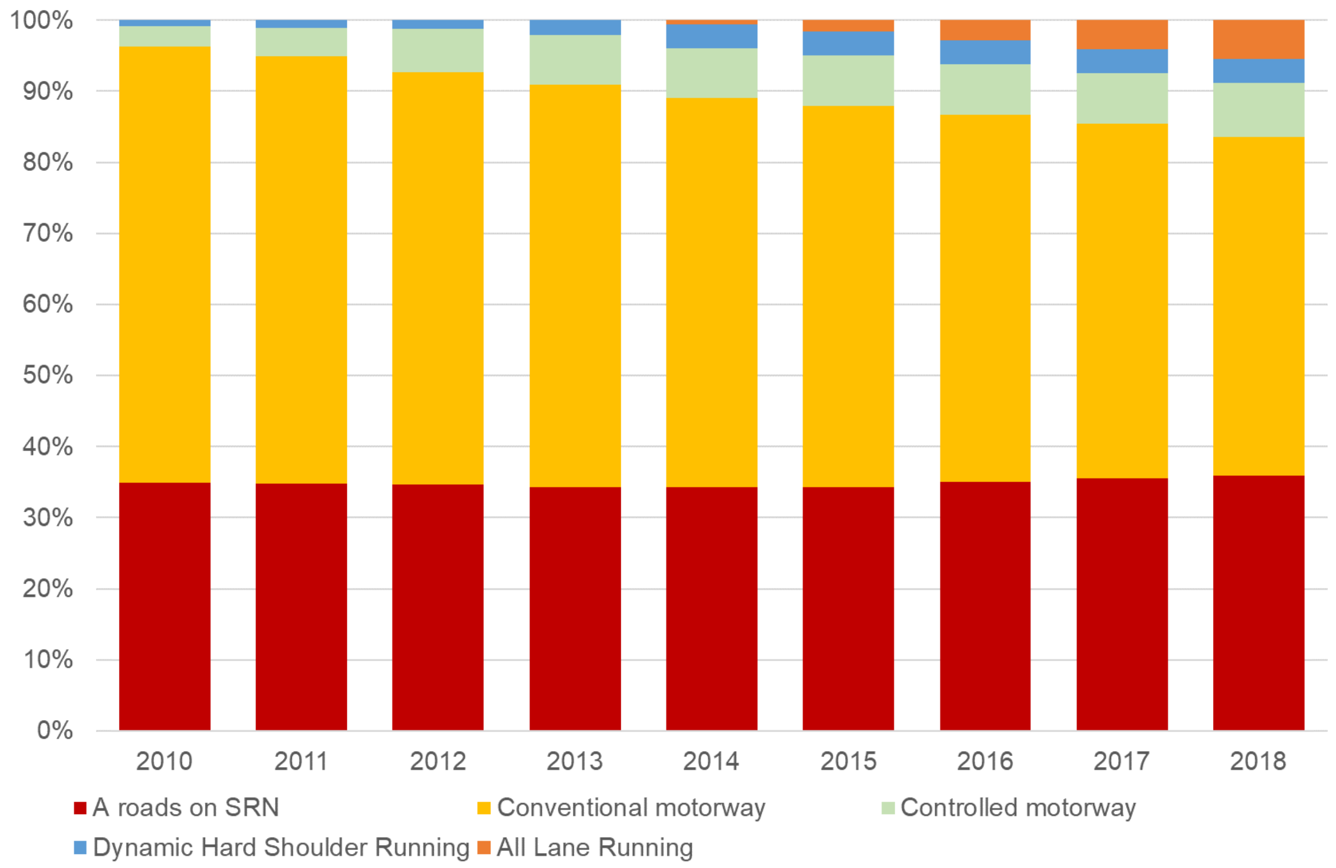
Figure 7 – Proportion of Strategic Road Network, by Road Type (2018)



Source: DfT analysis based on DfT statistics (see Annex A).

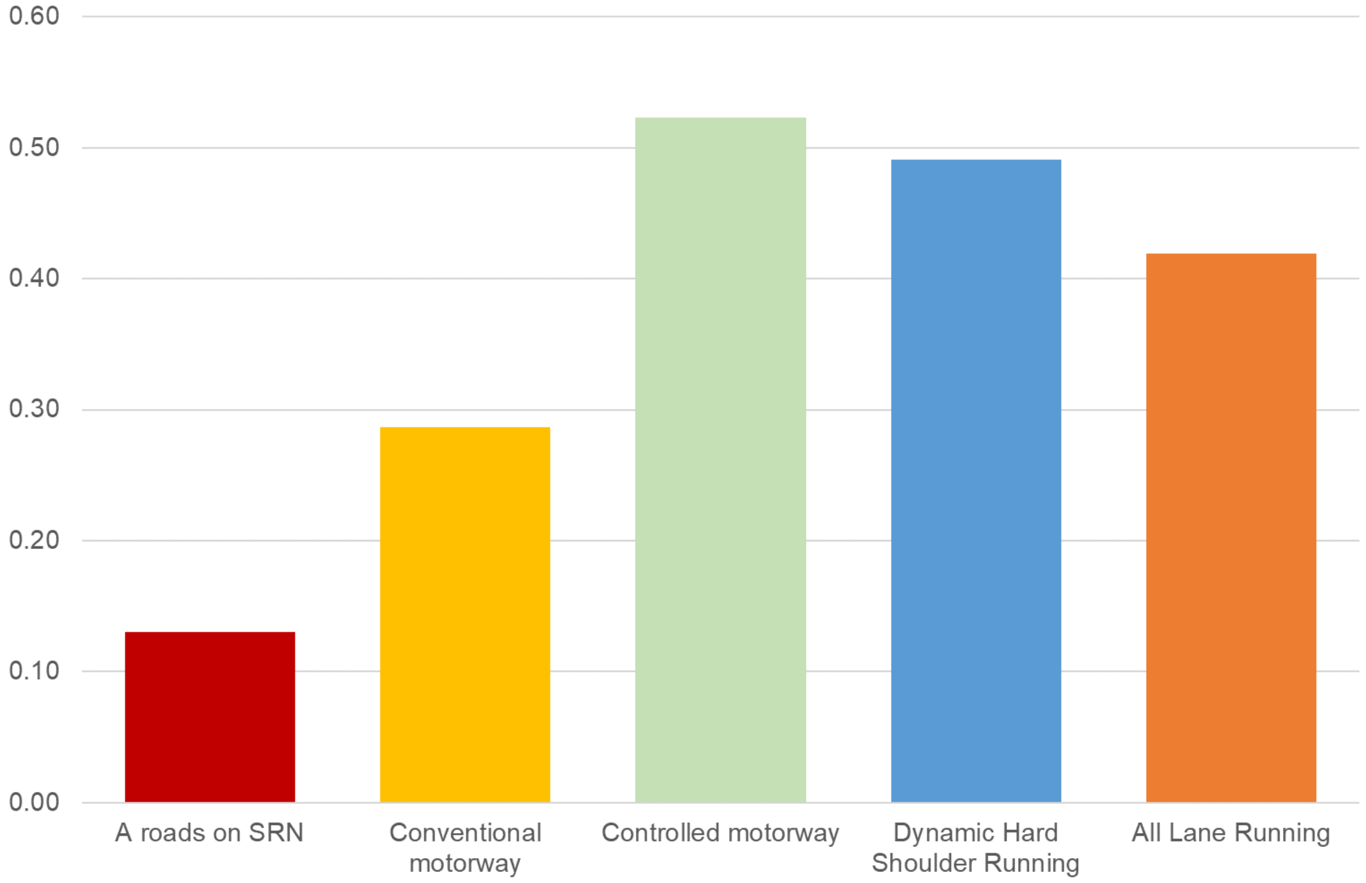
2.11 While smart motorways are not a large proportion of the SRN, they carry a larger proportion of traffic, due to their introduction on the busier sections of the network. As figure 8 illustrates, smart motorways make up around 16% of all SRN traffic, and figure 9 shows how the intensity of use is greater for smart motorways than for conventional motorways. This is an important factor that needs to be accounted for, when considering the relative safety of different motorway types on a like-for-like basis.

Figure 8 – Annual Proportion of Traffic on the Strategic Road Network, by Road Type (2010-2018)



Source: DfT analysis based on DfT statistics (see Annex A).

Figure 9 – Hundred Million Vehicle Miles Travelled per Mile of Road, by Road Type (2018)



Source: DfT analysis based on DfT statistics (see Annex A).

3. Safety on the Strategic Road Network - Statistics, Monitoring and Evaluation

3.1 To set the scene for the evidence on the relative safety of motorway types, it is useful to first understand the overall safety of the UK's roads, and in particular its motorways. It is also helpful to understand what casualty statistics are collected and categorised, and how Highways England monitors and evaluates the safety of its road schemes. The next three sections set this out.

a) Safety of UK Roads and Motorways

3.2 Compared to other nations, the United Kingdom has some of the safest roads in the world. Figure 10 below shows that the number of road deaths[11] per million inhabitants is lower in the UK than the majority of countries within Europe. Within Great Britain, motorways are comparatively the safest roads to travel on. For example, in 2018 motorways carried 21% of the road traffic but had only 6% of fatal collisions (figure 11). Highways England's 2017 Safety Report[12] also showed that SRN users were 2.7 times more likely to be killed or seriously injured per mile driven on an A-road than on a motorway in 2017, or 6.2 times more likely, when comparing a single-carriageway A-road to a motorway.

[11] Deaths and fatalities are used as interchangeable terms.

[12] https://www.gov.uk/government/publications/highways-england-reported-road-casualties-on-the-strategic-road-network-srn-2014-and-2015

Figure 10: Road Deaths per Million Inhabitants (European Transport Safety Council, 2018)[13]

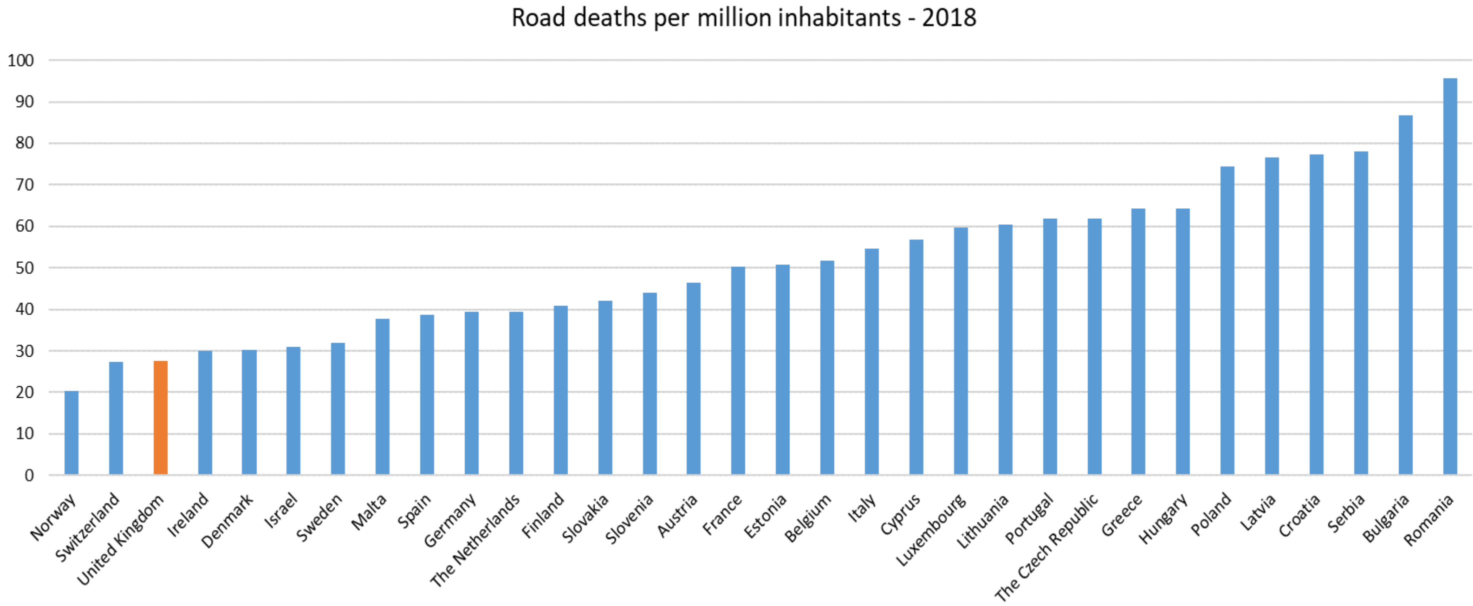
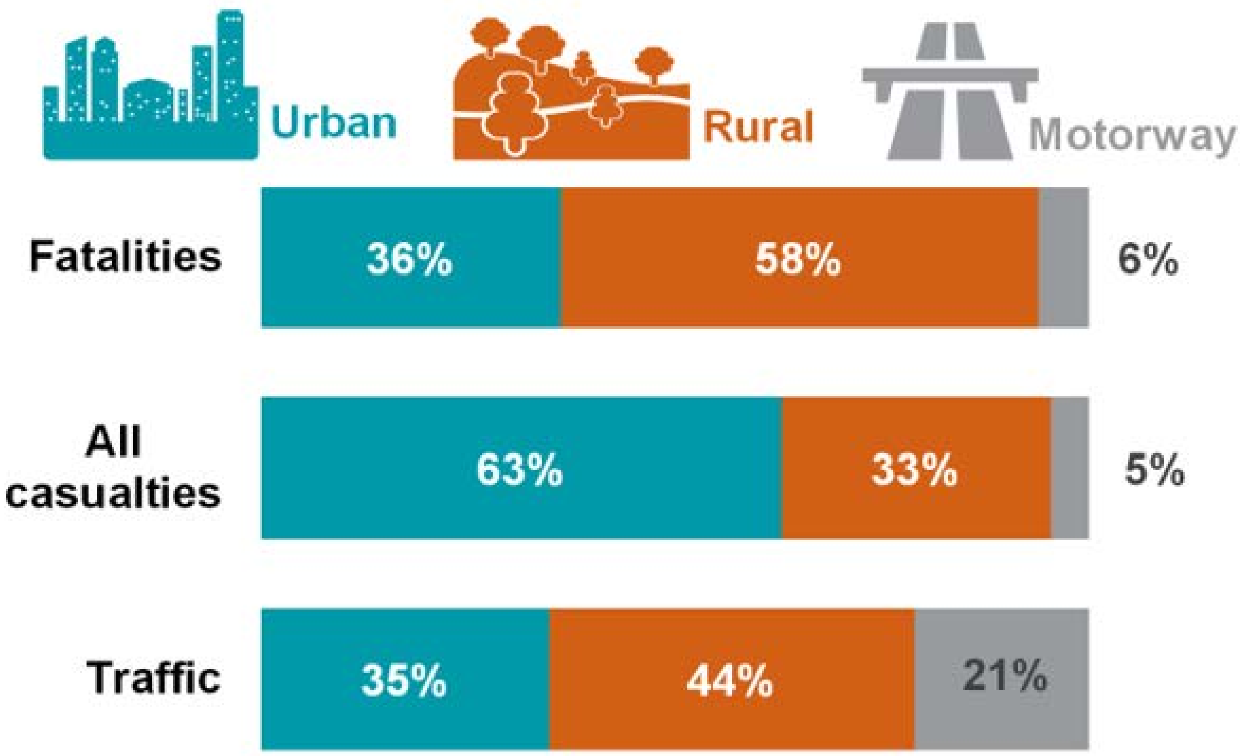


Figure 11: Proportion of Reported Casualties and Traffic Carried by Road Type in 2018 (Great Britain)[14]



[13] https://etsc.eu/euroadsafetydata/

[14] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/834585/reported-road-casualties-annual-report-2018.pdf

b) Collection of Collision and Casualty Statistics

3.3 Data on road traffic collisions on the roads in Great Britain are collected via the STATS19 process.[15] These statistics are collected by police forces, either through officers attending the scene of accidents or from members of the public reporting the accident in police stations after the incident, or more recently online.

3.4 There are three main categories of casualty that are recorded for STATS19:

- **Slight casualties** - minor injury such as a sprain (including neck whiplash), bruise or cut which are not judged to be severe, or slight shock requiring roadside attention. This definition includes injuries not requiring medical treatment.
- **Serious casualties** - 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 accident.[16]
- **Fatal casualties** - when a person has died from their injuries up to 30 days after the accident.

3.5 In addition to casualty data, or where casualty data is not available, collision data is used in the evaluation studies that make up the growing evidence base on smart motorway safety. Personal Injury Collisions (PIC) are collisions involving at least one vehicle where there was a personal injury. The severity classification applied to the collision is based on the most severe casualty resulting from the collision.

3.6 After engaging with the Rail Safety and Standards Board (RSSB) and the Office of Rail and Road (ORR), Highways England decided to use Fatal and Weighted Injuries, as used in the rail industry, as a measure in assessing the safety performance of smart motorways, alongside existing measures, such as 'Killed or Serious Injured (KSI)' collision/casualty rates. The Fatal and Weighted Injuries measure counts all fatal injuries, then adds serious injuries with a 10% weighting and slight injuries with a 1% weighting. Specifically, it is calculated as:

$$Fatal\ and\ Weighted\ Injuries = Fatal\ casualties + Serious\ Casualties * 0.1 + Slight\ Casualties * 0.01$$

3.7 As with many collections of statistics, issues arise that need to be highlighted and understood so that the data can be robustly assessed and interpreted. With respect to statistics on safety the main statistical issues are underreporting of slight-injury collisions and changes in the reporting casualty severity, which are discussed in more detail below.

[15] The STATS19 database is a collection of all road traffic accidents that resulted in a personal injury and were reported to the police within 30 days of the accident. More information can be found at: https://data.gov.uk/dataset/cb7ae6f0-4be6-4935-9277-47e5ce24a11f/road-safety-data

[16] Casualties are recorded as slight or serious by the police based on information available within a short time of the accident. This may not reflect results of a medical examination, but may be influenced according to whether the casualty is hospitalised or not.

Under-Reporting of Slight Collisions

3.8 Comparisons of road accident reports with death registrations show that very few, if any, road accident fatalities are not reported by the police. However, it has long been known that a considerable proportion of non-fatal casualties are not known to the police, as hospital, survey and compensation claims data all indicate a higher number of casualties than those recorded in police accident data.

Severity Reporting (Injury-Based Reporting) Changes

3.9 Approximately half of English police forces adopted the CRASH (Collision Recording and Sharing) system for recording reported road traffic collisions at the end of 2015 or the first part of 2016, although Surrey has been using the system since November 2012. In addition, the Metropolitan Police Service (MPS) switched to a new reporting system called COPA (Case Overview Preparation Application), which went live to police officers from November 2016. These are injury-based severity reporting systems, where the officer records the most severe injury for the casualty. The injuries are then automatically converted to a severity level from ‘slight’ to ‘serious’.

3.10 The remaining police forces use a wide variety of systems to report accidents, in which police officers use their own judgement and guidance to determine directly the severity of a casualty (‘slight’ or ‘serious’).

3.11 Eliminating the uncertainty in determining severity that arises from the officer having to make their own judgement means that the new severity level data observed from these systems using injury-based methods are expected to be more accurate than the data from other systems.

3.12 Following the introduction of CRASH and COPA, the number of casualties recorded as serious has increased in Great Britain. The differences in the impact of the introduction of injury-based reporting systems is likely to depend on the practices within a police force that were in place before these new systems were introduced.

3.13 The Office for National Statistics (ONS) Methodology Advisory Service have completed analysis to quantify the effect of the introduction of injury reporting systems (CRASH and COPA) on the number of slight and serious injuries reported to the police.

3.14 The methodology[17] developed by the ONS has been used to provide adjusted figures which are presented alongside the actual reported figures in the main results publication tables. The adjustments provide the statistically ‘expected’ number of serious and slight injuries (i.e. what might be expected on average) if all forces were using injury-based severity reporting approaches. The adjustments are published for further breakdowns of slight and serious including speed limit, road class, casualty road user type, casualty age, quarter, police force, and local authority. But this does not include a breakdown for smart motorways.

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17 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/833813/annex-update-severity-adjustments-methodology.pdf

c) Highways England's Monitoring and Evaluation Process

3.15 Monitoring and evaluation processes start at the beginning of a new major road scheme and continue through the lifecycle of a project. Some of the processes check that projects follow appropriate rules and regulations (road safety audits), some assess the safety effectiveness of these projects (monitoring operations) and others confirm whether projects delivered against what was previously anticipated (evaluations). Highways England undertakes reviews on major road schemes to measure impact against forecast. The main mechanism for evaluating a new scheme is the Post Opening Project Evaluation (POPE) which evaluates the realisation of scheme benefits once they have been open to traffic for one and five years.

3.16 The monitoring and evaluation undertaken by Highways England and local areas is set out below.

Road Safety Audit

3.17 This is a UK wide, long standing process regarding the design and construction of road schemes. The aim of a road safety audit is to identify aspects of engineering interventions that could give rise to road safety problems and to suggest modifications that could improve road safety. Road safety audits are undertaken by staff with experience of collision data analysis, road safety engineering experience and a reasonable understanding of highway design principles such as design requirements and best practice.

3.18 The road safety audit process helps to manage the interaction of different design requirements for highway schemes[18]. This is through the application of established highways standards which are based on road safety considerations.

3.19 Road safety audits are undertaken at key stages in the design, construction and early operation of a highway scheme as follows:

- Stage 1 - Completion of preliminary design
- Stage 2 - Completion of detailed design
- Stage 3 - Completion of construction
- Stage 4 - Post opening monitoring (when 12 months of validated post highway scheme-opening road traffic collision data is available)

Monitoring Operations

3.20 Highways England undertakes monitoring of the operation of any new schemes in the first days, weeks and months following opening to identify any issues in the early operation of a scheme. This is especially important for smart motorway schemes that represent a system which deliver benefits based on infrastructure, technology and process working successfully together. This is an established process that is part of Highways England's Project Control Framework for Major Schemes.

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18 http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol5/section2/GG%20119%20Road%20Safety%20Audit-web.pdf

Special Monitoring – Safety Reports

3.21 For the first scheme(s) of a new type of smart motorway Highways England undertook additional targeted assessment of performance, focussed largely on safety. This has been done at 12 months and 3 years for the M42 pilot (the pilot of DHS) which opened in 2006 and 1 year, 2 years and 3 years for the first ALR schemes, which were on the M25 and opened in 2014.

Post Opening Project Evaluation (POPE) Reports

3.22 POPE assesses whether the benefits set out in a road scheme's business case are on track to be realised through systematically evaluating metrics in relation to traffic flows, journey times, journey time reliability, safety and environmental impacts.

3.23 Plans for scheme evaluation are agreed before construction starts on the scheme and post opening evaluation is undertaken after the scheme has been open to traffic for one year and then again after five years. An independent 'meta report' is undertaken periodically, taking an overview of the evaluation evidence base.

3.24 In order to determine whether any changes in collision numbers observed before and after the scheme opened are statistically significant, chi-square tests are undertaken. This test uses the before and after collision numbers and collision rates (personal injury collisions/hundred million vehicle miles) to establish whether the changes are significant or likely to have occurred by chance.[19]

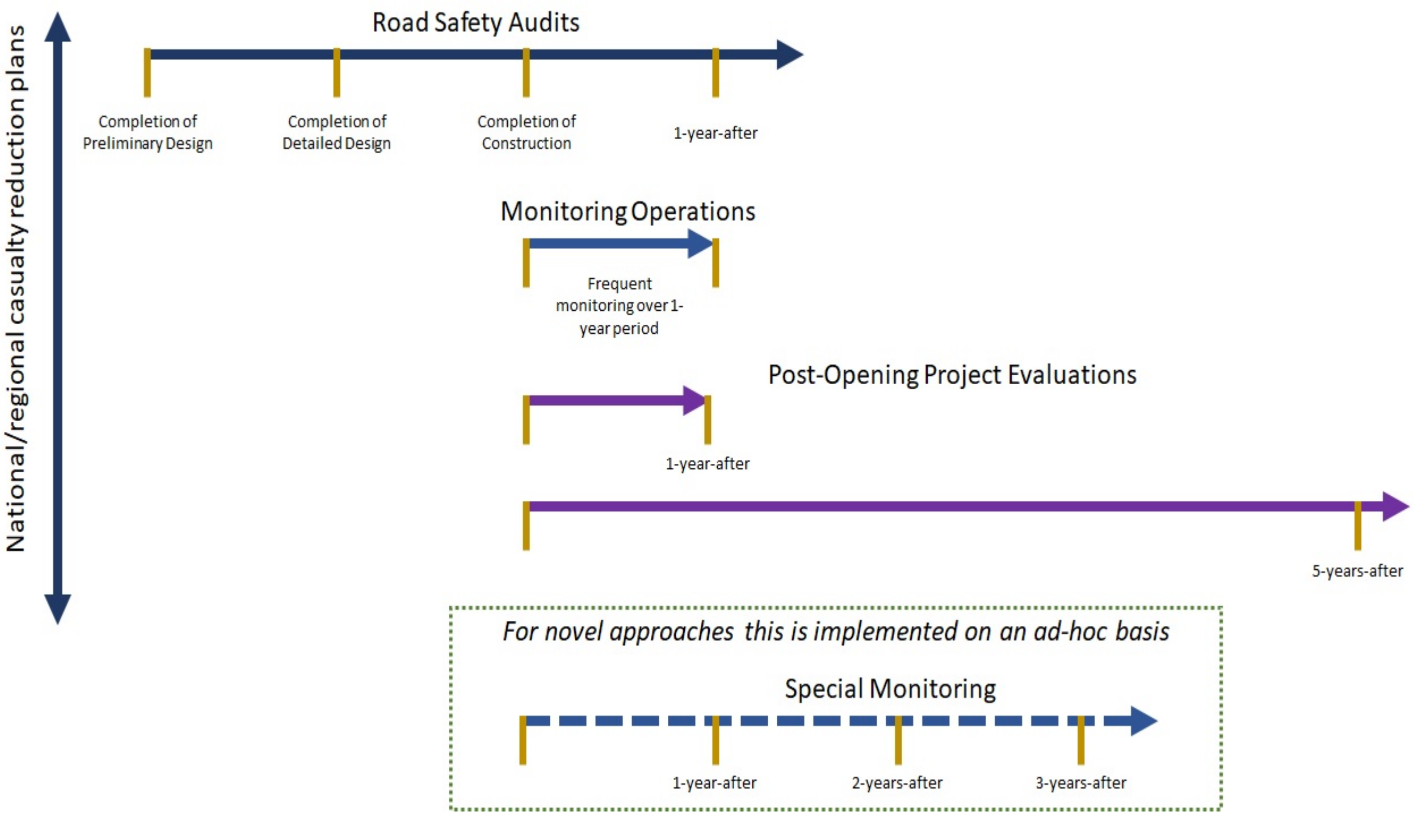
National/Regional Casualty Reduction Plans

3.25 Highways England is currently reviewing and updating the 2016 'National Incident and Casualty Reduction Plan', which sets out their approach to road safety and supports the 'Home Safe and Well Strategy' to prepare for the next Road Investment Strategy (RIS) period.

3.26 In support of the national plan each region has also developed a comprehensive 'Regional Incident and Casualty Reduction Plan' which tracks performance in their region. These regional plans set out what is currently being undertaken in terms of engineering and non-engineering interventions and what plans are being developed to address future progress.

[19] This is done by comparing the observed data after the scheme opened with an expected value based on the data observed before the scheme, multiplied by a weighting factor to account for national trends in safety data over that time-period.

Figure 12 – Highways England's Monitoring and Evaluation Timeline for a New Scheme



3.27 Taken together, these processes illustrate how Highways England uses a range of activities to monitor and evaluate safety on its network (see figure 12). In addition to providing information on safety, these monitoring and evaluation processes have provided a body of evidence on the scale and nature of casualty and collision risks, which can be used in considering the relative safety of the smart motorway network. This runs from the pre-design phase of new schemes to five years after these schemes have been completed.

4. Evidence on the Safety of Smart Motorways

4.1 As outlined in the previous section, there are several sources of evidence on the relative safety of the different motorway types. These include modelling of potential and outturn risks, high level statistics, plus before and after studies. There are also several challenges in understanding the relative safety performance of roads.

4.2 Modelling how overall safety might be expected to change requires assessing the changes in a wide variety of risks. Assessing how safety has changed after converting a motorway to a smart motorway needs to control for other factors which vary between individual roads such as usage and congestion levels; and, to establish what may have happened if there was no intervention (the counterfactual scenario). Also, the limited number of years of post-opening scheme data for some smart motorway schemes, and the relatively infrequent nature of fatalities on individual roads, introduces uncertainty in considering the statistical significance of any observed differences between motorway types.

4.3 Different analytical approaches can be used to offer insights into different aspects of the relative safety of the different motorway types. The high level statistics are helpful in understanding safety performance as the network stands. The before and after studies are better suited to considering the effect of converting a section of motorway, like-for-like; as is the risk modelling, which additionally is useful for looking at the nature of risks.

4.4 This section sets out the evidence on the relative safety of the different motorway types. It begins with modelling of relative risks on motorway types, sets out high-level statistics on casualties that currently occur on different types of SRN roads, then proceeds to the evidence from before and after studies.

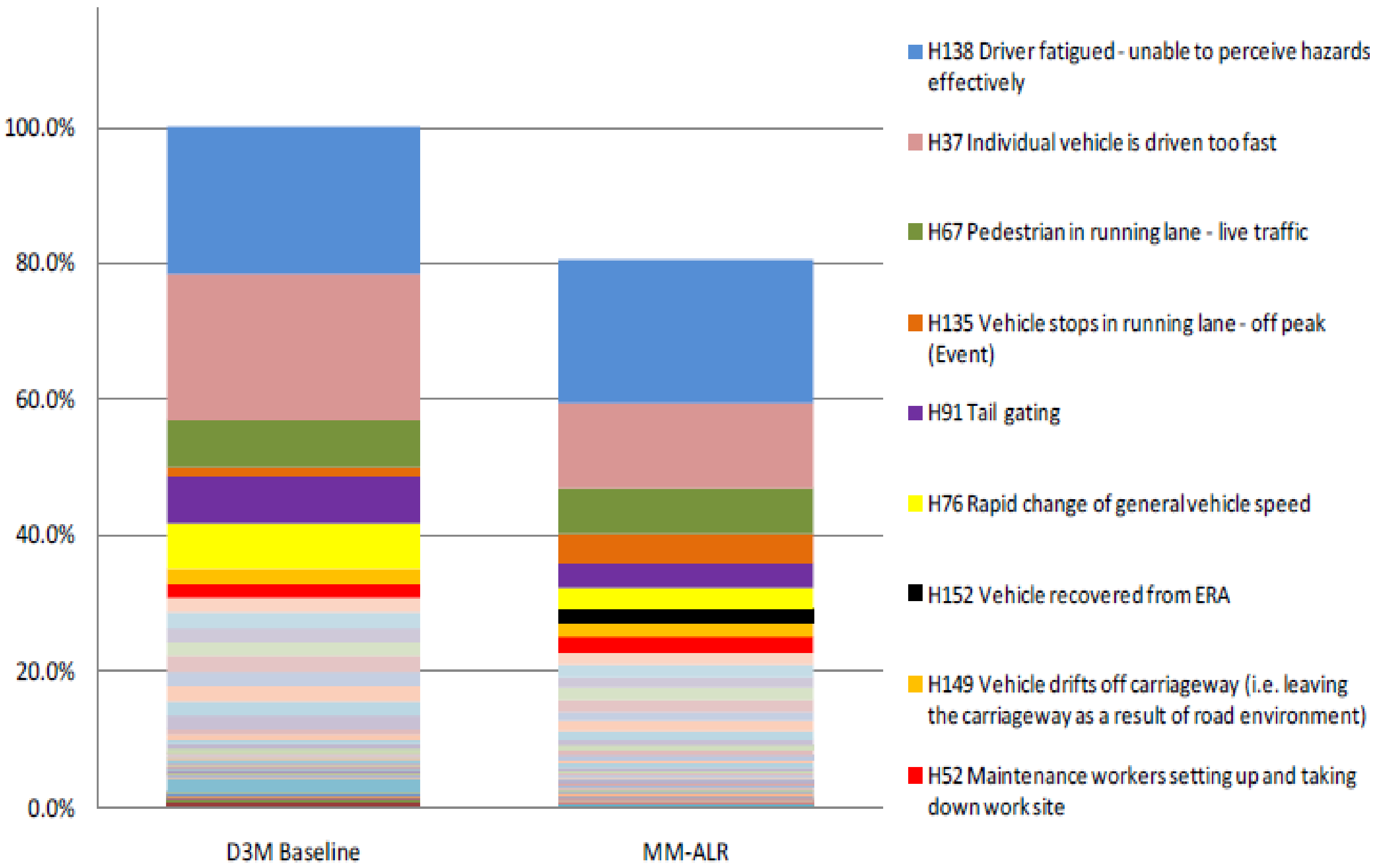
a) Modelling of Relative Risks on Motorway Types

4.5 In addition to delivering the expected benefits of increased capacity and reduced congestion, a smart motorway scheme is expected to reduce some forms of risk. This is delivered through traffic speeds becoming more consistent, the speed differential between lanes reducing, signage alerting drivers to hazards, and by providing emergency areas which are expected to be a safer place to stop than a hard shoulder. However, some other forms of risk were expected to be greater than on conventional motorway, such as the risk of a vehicle stopping in a live lane.

4.6 To understand the overall effect, prior to the introduction of DHS and ALR as types of motorway, Highways England developed a method of hazard analysis to compare the relative safety risks of the design concepts with those of a conventional motorway. This enabled Highways England to consider how the likelihood and impact of around 140 hazards (and mitigations) could vary between motorways types. This assessment was further informed by a series of workshops, and evidence from additional research and testing, including a driving simulator with members of the public.

4.7 This created an assessment of risk exposure, combining the probability of risks occurring and the severity of the consequences. An example of this analysis for a conventional three lane motorway and an ALR motorway is illustrated in figure 13 below, where ‘D3M’ is a conventional 3 lane motorway, and ‘MM-ALR’ is an All-Lane Running motorway. This suggested that on smart motorways, some risks would be reduced, and some would be increased. For example, risks expected to reduce on ALR included collisions involving speeding or tailgating, while risks expected to increase included collisions involving vehicles stopped in a live lane. However, the overall expected effect was a reduction in risk. This demonstrated that while the nature of the risks varied between the motorway types, ALR was expected to reduce the overall level of risk by 20% and be as safe as, or safer than, conventional motorways.

Figure 13 - *ALR Hazard Assessment (Highways England, 2012)*



Source: Highways England

b) High Level Casualty Statistics on Smart Motorways and the Wider Strategic Road Network

4.8 For this section on high level statistics, we have reviewed available data on the number of casualties occurring across the SRN, comparing casualties between different types of road. This draws from the STATS19 statistics described in section 3b earlier. To ensure the information is as relevant as possible for the purposes of this evidence stocktake, Highways England has provided an additional breakdown of the STATS19 data, to set out casualties by severity across different types of motorway, including Dynamic Hard Shoulder Running and All Lane Running (see Annex B, Annex C and Annex D), taking into consideration any further information on casualties on specific motorway types relevant to this exercise. The matching of casualties to specific motorway types requires each casualty location to be manually allocated to a motorway type, to enable a revised version of the dataset to be produced, which is then validated and quality assured.

4.9 When considering statistics on casualties across the SRN and the different types of road that it consists of, a range of metrics could be considered including:

- Casualties per year – which gives a total figure, but does not control for the length of the road or how intensely the roads are used.
- Casualties per mile – which gives greater understanding on the safety of different types of road, by taking the total length of road into account. However, this does not consider the volume of traffic on the roads and therefore how intensely they are used.
- Casualties per hundred million vehicle miles travelled – which considers and controls for the volume of traffic roads carry, also known as the 'casualty rate'.

4.10 In addition, the analysis has considered the different severities of casualty that can occur, i.e.slight, serious and fatal. Recognising the difference in personal and social consequences that result from each of these types of casualty we have also considered the Fatal and Weighted Injuries (FWI) measure. As noted in section 3b, the FWI applies a weighting to the different severities of casualty, to give a single composite metric in which to assess changes in safety.

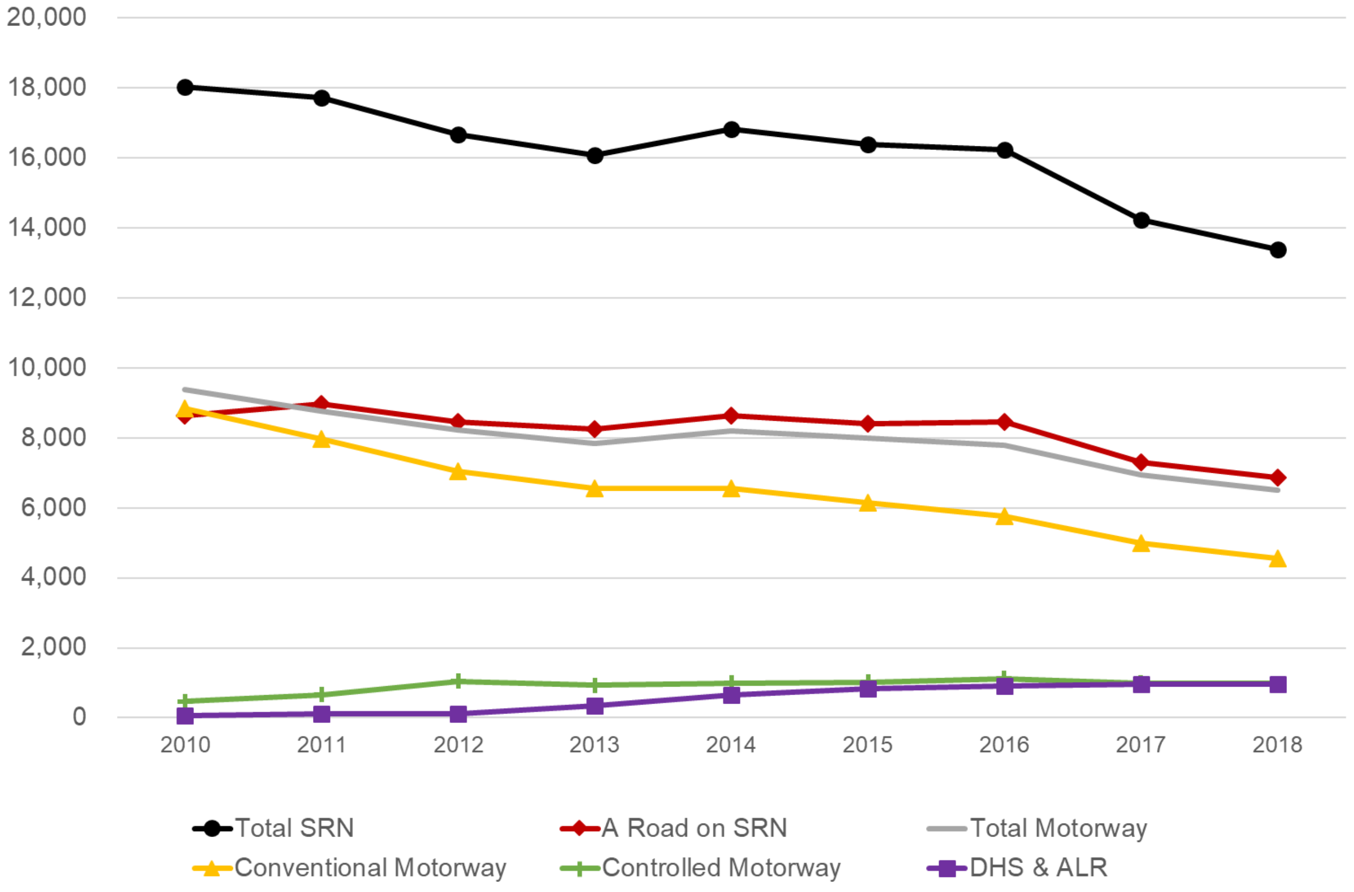
4.11 We have considered all of these metrics, but in this section have focused on casualty rates, as this takes into account the extent of the network and the volume of traffic.

Casualty Count Statistics

4.12 These statistics indicate that total casualties per year across the SRN has generally been declining since the start of the decade, falling 26% over 2010-2018 (Figure 14). Within the SRN, around half of total casualties occur on the motorway network and the other half on A Roads, both of which have shown a general decline since 2010.

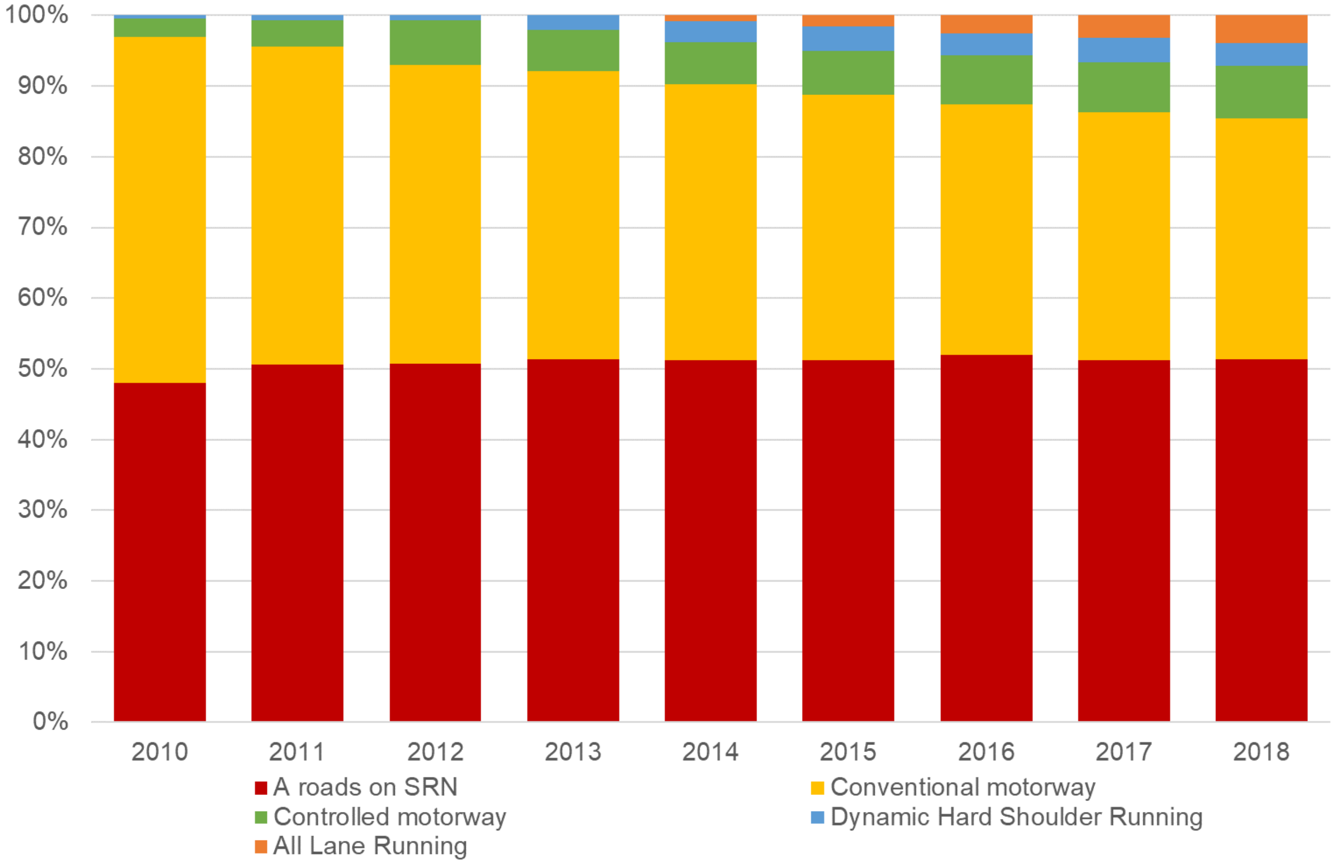
4.13 The total length of roads that have been converted to smart motorways more than quadrupled over 2010-2018. As conventional motorways are converted to smart motorways, there has been a decline in the total number of casualties recorded on the former and a rise in the number recorded on the latter. As can be seen in Figure 15, the total proportion of casualties on the SRN that occurred on smart motorways was 15% in 2018, steadily rising since the start of the decade as more roads were converted. The expansion of the smart motorway network is why the rise in total casualties since 2010 on these roads is not informative, but the casualty rates considered later in this section are more relevant.

Figure 14 – Annual SRN Total Casualties, by Road Type (2010-2018)



Source: Data from Highways England based on STATS19.

Figure 15 – Proportion of Total Casualties on the SRN, by Road Type (2010-2018)

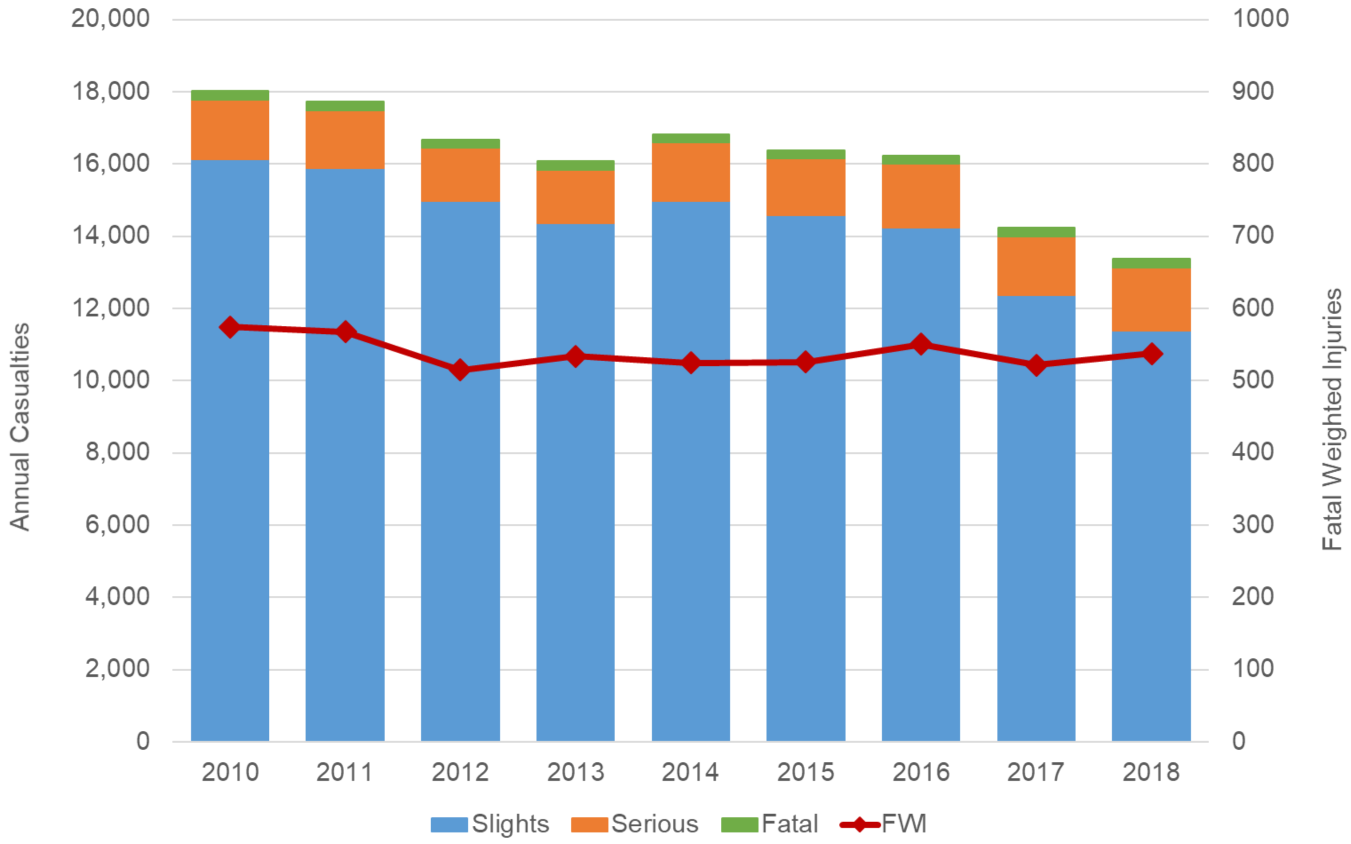


Source: Data from Highways England based on STATS19.

4.14 Figure 16 illustrates how total casualties across the SRN, broken down by severity, has changed since the start of the decade. The majority of the fall in total casualties has been due to the fall in slight casualties. Figure 17 illustrates that at the start of the decade serious casualties initially declined, but have risen again since 2013. Fatal and Weighted Injuries initially declined at the start of the decade but have been stable since 2013.[20]

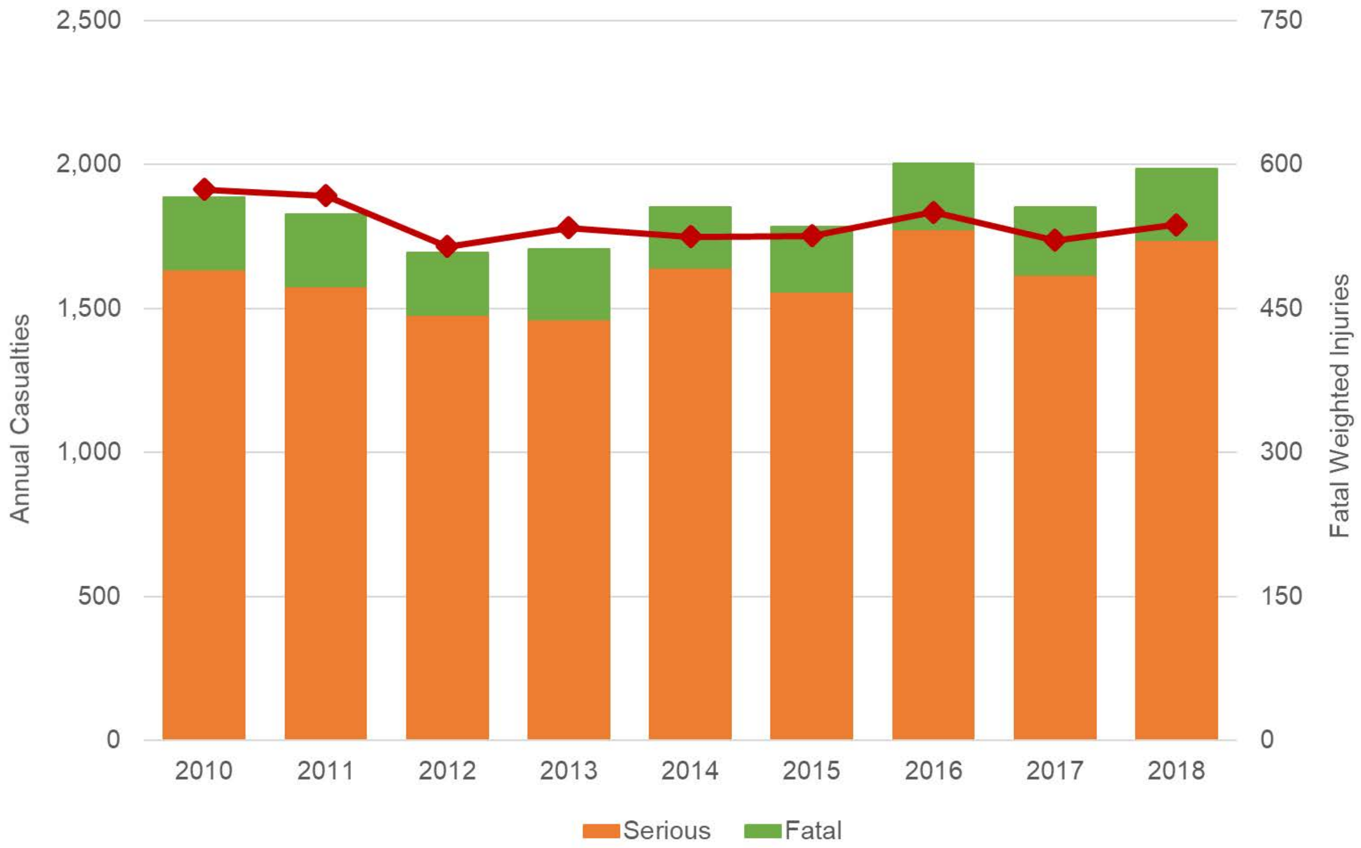
[20] Part of the explanation for this rise in serious casualties may be due to the impact of changes in injury-based reporting as discussed in Section 3b.

Figure 16 – Total SRN Casualties Split by Severity & Fatal and Weighted Injuries (2010-2018)



Source: Data from Highways England based on STATS19.

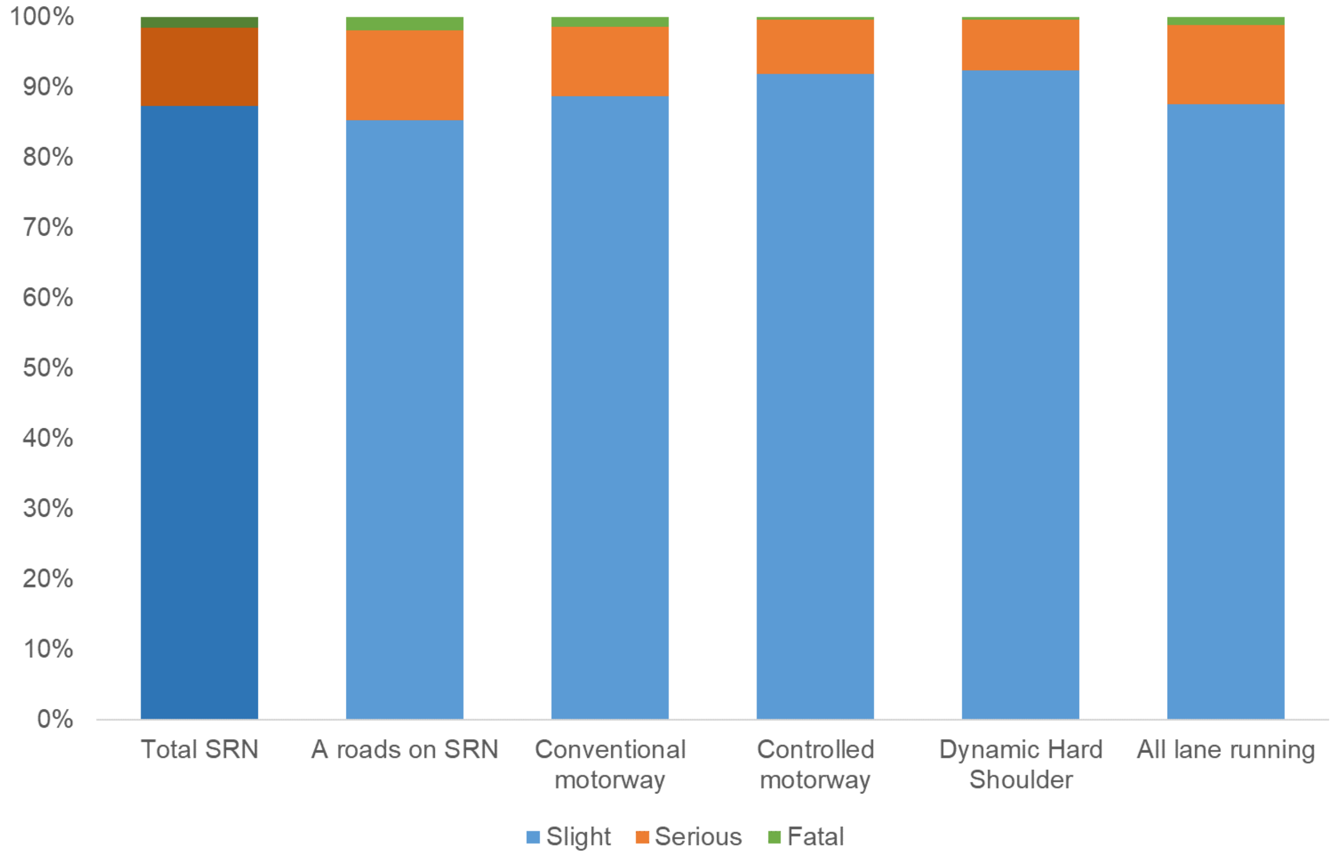
Figure 17 – Total SRN Fatal and Serious Casualties & Fatal and Weighted Injuries (2010-2018)



Source: Data from Highways England based on STATS19.

4.15 When considering the split of casualties by severity, A Roads have a higher proportion of fatal and serious casualties than other roads on the SRN. Slight casualties make up a consistently large proportion of casualties across all road types, and the proportion of serious and fatal casualties on smart motorways is similar to conventional motorways, being slightly lower for controlled motorways and DHS, and slightly higher for ALR (Figure 18).

Figure 18 – Casualties Split by Severity, by Type of Road (2015-2018 average)



Source: Data from Highways England based on STATS19.

4.16 High level statistics on total casualties, while useful for general context, do not take account of the different road types varying in their length. These figures also do not consider differences in the volumes of traffic on the different motorway types, which this analysis will now consider.

Casualty Rate Statistics

4.17 To take account of the fact that different types of roads carry different quantities of traffic, we can consider the number of casualties relative to the volume of traffic, i.e. the road type's 'casualty rate'. This is measured as number of casualties per hundred million vehicles miles (hmvm) travelled. Figures 19-22 present casualty rates for the different severities of casualty and the FWI.

4.18 In 2018, DHS and ALR accounted for 12.8% of fatal casualties on the motorway network, whilst carrying 13.8% of motorway traffic. The share of fatal casualties was also lower than the share of traffic for the three years prior (2015-2017), suggesting that a lower share of fatalities occur on the DHS and ALR compared to the motorway network as a whole. Looking at slight casualties in 2018, DHS and ALR accounted for 15% of slight casualties, compared to 13.8% of motorway traffic. The share of slight casualties was also higher than the share of traffic for the three years prior (2015-17). For serious casualties, DHS and ALR accounted for 13.2% of serious casualties compared to 13.8% of motorway traffic. Whilst this suggests a lower share of serious casualties occurs on DHS and ALR compared to the motorway network as a whole, it should be noted that the three previous years of data suggested the opposite with a larger share of serious casualties on DHS and ALR (see table 2).

Table 2 - England SRN Casualties and Road Traffic for DHS and ALR as a Proportion of All SRN Motorways, 2015-2018

	ALR and DHS as a % of All SRN Motorways			
	2015	**2016**	**2017**	**2018**
% Slight Casualties	10.6%	11.9%	13.9%	15.0%
% Serious Casualties	9.1%	10.4%	13.0%	13.2%
% Fatal Casualties	5.4%	3.9%	5.5%	12.8%
% Fatal and Weighted Injuries	8.1%	8.6%	10.1%	13.5%
% Total Casualties	10.4%	11.7%	13.7%	14.8%
% Motor Vehicle Traffic (Billion Vehicle Miles)	7.6%	9.6%	11.7%	13.8%

Source: 1 - STATS19, Highways England Statistics on motorway casualties in England from 2015-18. 2 -DfT Road Traffic Statistics on the Strategic Road Network in England from 2015-18.

4.19 Casualty data can be volatile from year to year, and casualty rates can be sensitive to small changes in the absolute number of casualties. Volatility is an issue as it can obscure the more meaningful information that can be drawn from the data. When considering such statistics, this volatility can be reduced by looking at the average over a recent set of years. As such, this report uses the last four years of available data as an average (2015-2018) .[21] See Annexes B, C and D.

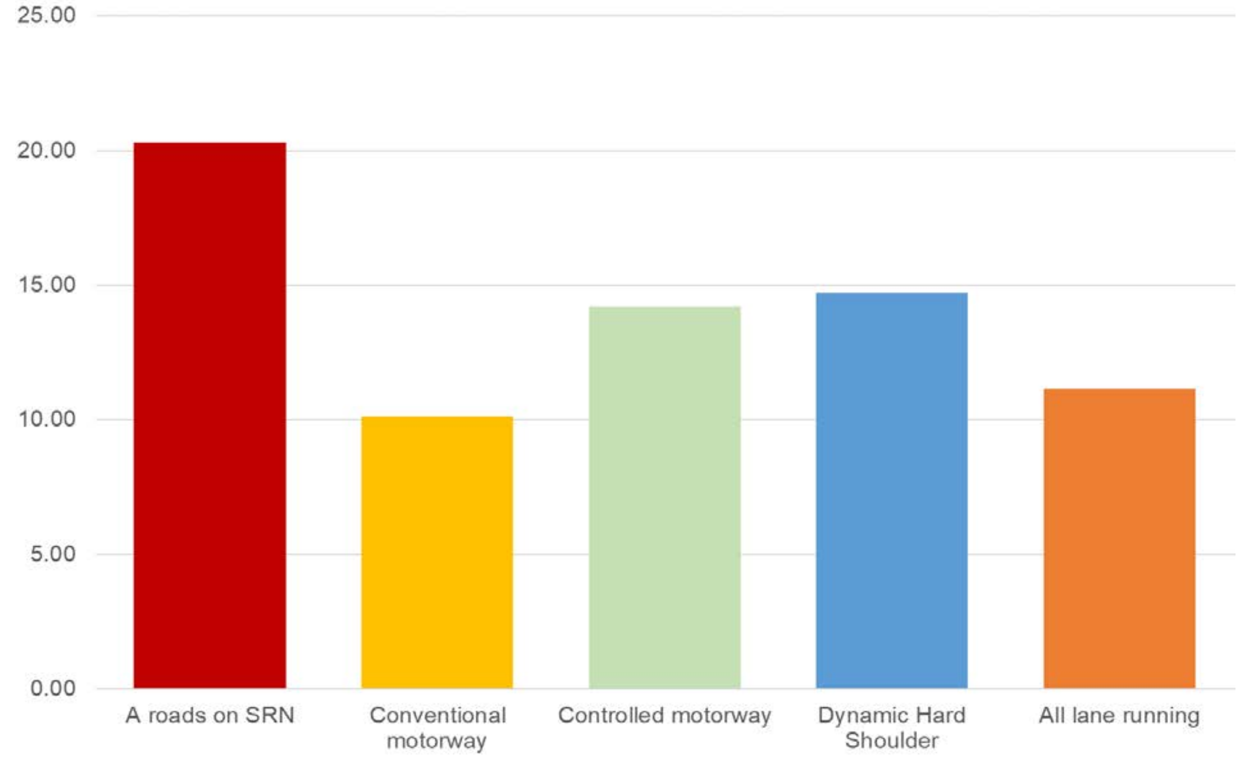
4.20 Where there are slight differences in casualty rates between motorway types, given that the casualty data can be based on small samples and shows volatility over time, these differences may not reflect underlying differences in risk.

4.21 These figures suggest that:

- **Casualty rates** on all motorway types are lower than A Roads on the SRN, for each type of severity and the Fatal and Weighted Injuries measure.
- **Slight casualty rates** are higher on controlled (14 per hmvm) and DHS (15 per hmvm) compared to conventional motorways (10 per hmvm), while ALR roads are slightly higher (11 per hmvm)
- **Serious casualty rates** on controlled (1.2 per hmvm), DHS (1.2 per hmvm) and ALR (1.3 per hmvm) schemes are slightly higher to conventional motorways (1.1 per hmvm).
- **Fatal casualty rates** on controlled (0.07 per hmvm), DHS (0.07 per hmvm) and ALR (0.11 per hmvm) are lower than on conventional motorways (0.16 per hmvm).
- **Fatal and Weighted Injury rates** on controlled (0.33 per hmvm), DHS (0.33 per hmvm) and ALR (0.35 per hmvm) schemes are slightly lower than on conventional motorways (0.38 per hmvm)

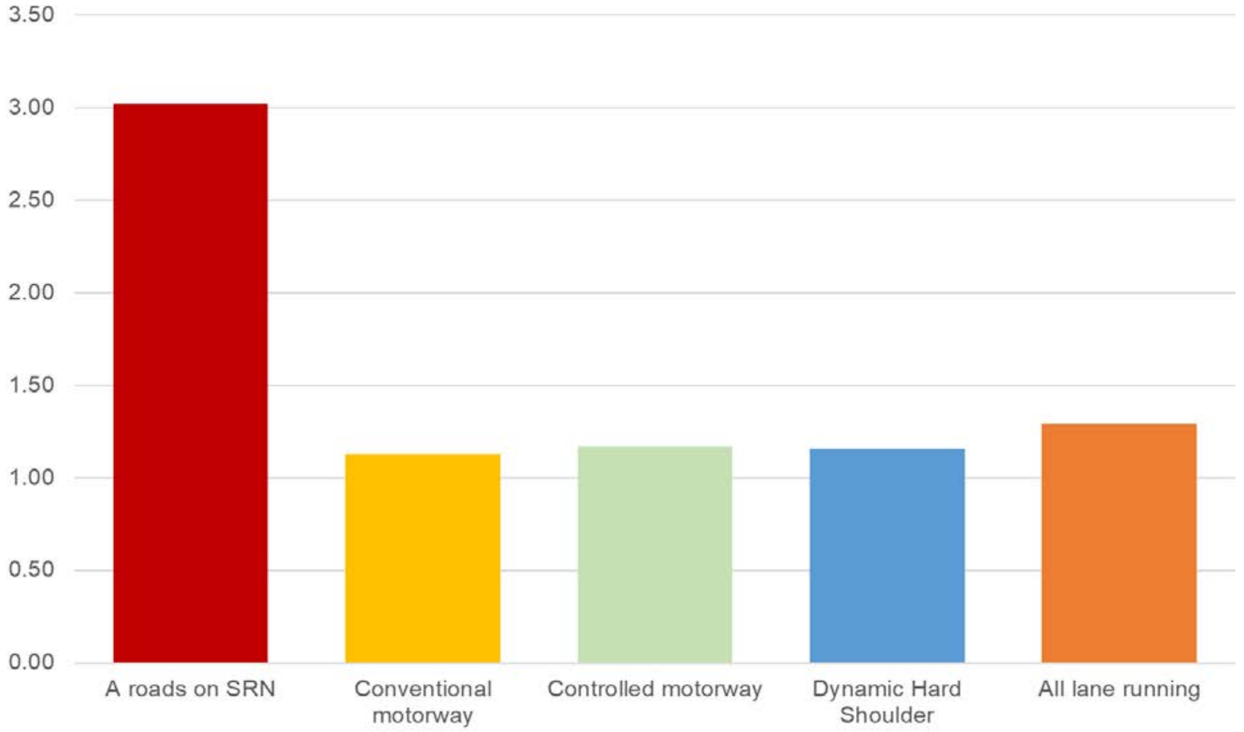
[21] This is weighted by volume of traffic.

Figure 19 – Annual Average Slight Casualties per Hundred Million Vehicle Miles Travelled, by SRN Road Type (2015-2018 average)



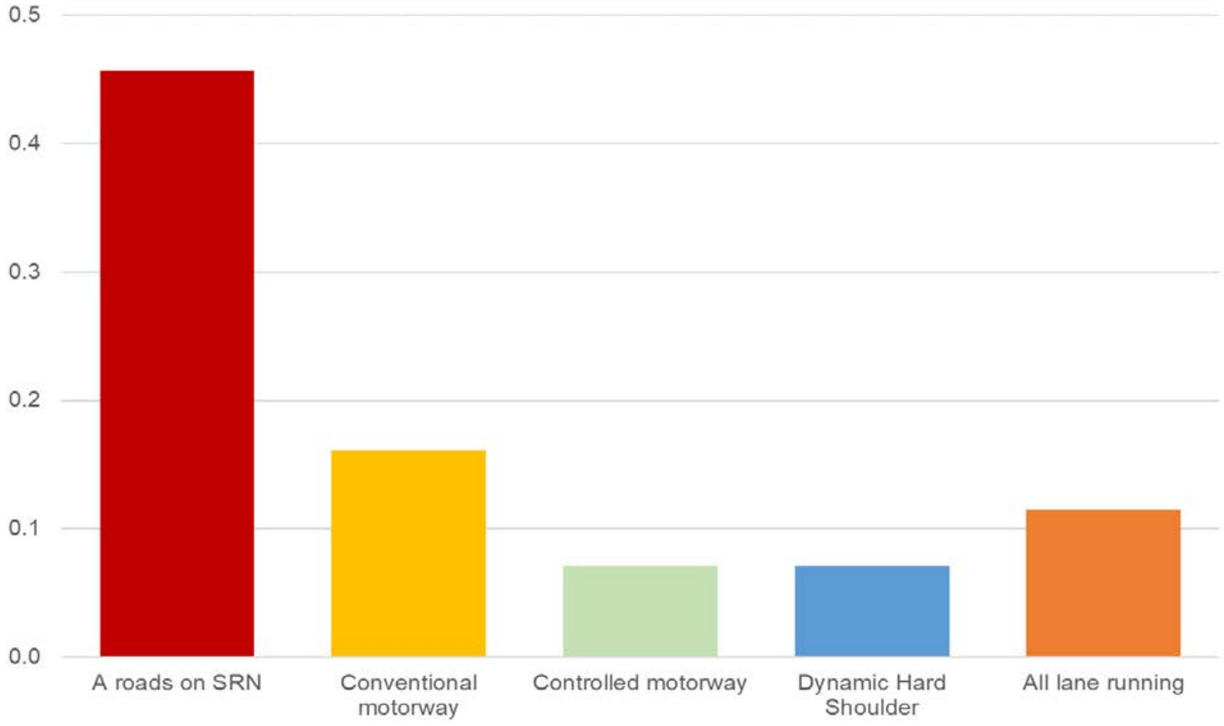
Source: DfT analysis based on casualty data from Highways England and DfT statistics on traffic.

Figure 20 – Annual Average Serious Casualties per Hundred Million Vehicle Miles Travelled, by SRN Road Type (2015-2018 average)



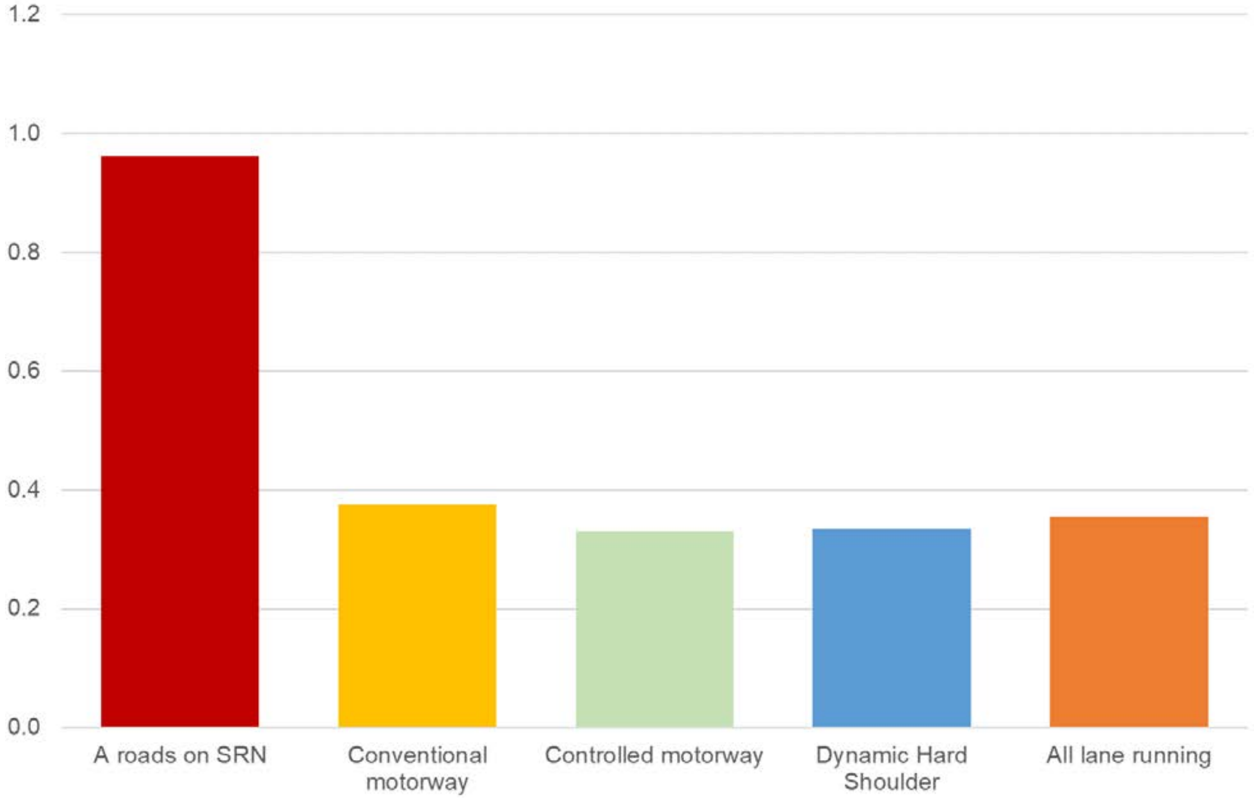
Source: DfT analysis based on casualty data from Highways England and DfT statistics on traffic.

Figure 21 – Annual Average Fatal Casualties per Hundred Million Vehicle Miles Travelled, by SRN Road Type (2015-2018 average)



Source: DfT analysis based on casualty data from Highways England and DfT statistics on traffic.

Figure 22 – Annual Average FWI per Hundred Million Vehicle Miles Travelled, by SRN Road Type (2015-2018 average)



Source: DfT analysis based on casualty data from Highways England and DfT statistics on traffic.

4.22 These high-level statistics have provided useful information on the safety performance of the network as it stands. However, even though they adjust for network extent and traffic volume, these statistics do not consider the safety effects of converting a conventional motorway to a smart motorway on a like-for-like basis. To more reliably consider the relative safety of converting a specific section of motorway from one type to another, it is necessary to look at how risks have changed and at the findings of the before and after studies.

c) Outturn Risk Analysis, Places of Relative Safety, and Live Lane Breakdowns

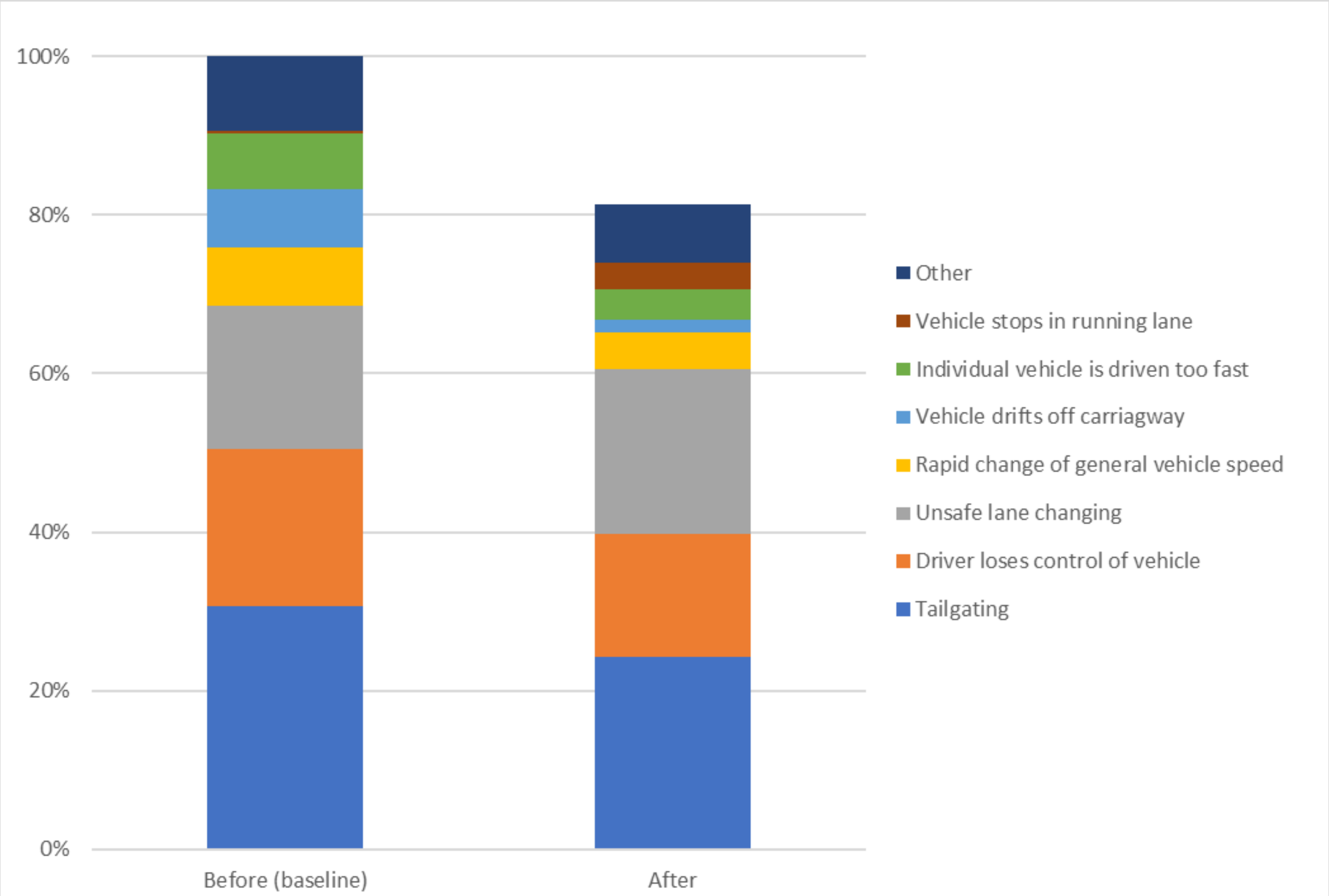
4.23 In addition to looking at how the scale of casualties varies between motorway types, it is also important to understand whether the profile of risk and collisions varies between motorway types. Given the differences between motorway types in their features, the profile of incidents and collisions can also reasonably be expected to vary between motorway types.

4.24 Section 4a of this report set out how, as part of the introduction of DHS and ALR, Highways England estimated how the profile of risks was expected to vary between the motorway types. This suggested that while some risks would be reduced and some would be increased, the overall level of risk would be reduced.

4.25 To confirm this, Highways England has used outturn data[22] to further examine how, in practice, the outturn set of potential risks manifested before and after ALR was introduced (see figure 23). The figure presents how many times different incidents occurred per billion vehicle kilometres travelled. It shows that as predicted, some risks reduced. These include tailgating, driver loses control of vehicle, rapid change of vehicle speed, vehicle drifts off carriageway and vehicle driven too fast. However, some risks increased, including unsafe lane changing and a vehicle stopping in a live lane. Although the risk of an accident involving a vehicle stopped in a live lane has grown, the level of this risk compared to other hazards remains small. Overall the risks declined after ALR was introduced, consistent with the earlier modelling.

[22] Outturn refers to the actual, observed amounts, results etc. rather than those that were expected. In this case, outturn refers to the actual risks that have occurred after the introduction of ALR.

Figure 23 - Relative ALR Hazard Assessment using Actual Data, based on the STATS19 dataset



Source: DfT Analysis of relative personal injury collision rates for the top 21 hazards (covering around 90% of the risk) based on Highways England, Smart Motorway All Lane Running Overarching Safety Report

4.26 In addition to looking at this overarching result, the rest of this section will focus on outturn collisions involving vehicles that have stopped in places of relative safety, and breakdowns or collisions in a live lane, as these have been highlighted as forms of risk of particular interest. When considering the evidence on these elements of overall risk, the above finding of an overall reduction in risk should be kept in mind.

Collisions in Places of Relative Safety

4.27 Although the hard shoulder is a place to stop in an emergency, there remains a risk to personal safety from doing so, with a hundred casualties on the hard shoulder in 2017.[23] On average, 1 in 12 (8%) fatalities on motorways occur on the hard shoulder.[24] And, between 2014 and 2017 there were 27 fatalities on hard shoulders.[25]

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[23] https://www.gov.uk/government/publications/highways-england-reported-road-casualties-on-the-strategic-road-network-srn-2014-and-2015.

[24] https://www.parliament.uk/documents/commons-committees/transport/jim-osullivan-ceo-highways-england-to-lilian-greenwood-all-lane-running-25092019.pdf

[25] This figure comes from an appendix to Highways England's SRN Casualty Report 2017. This appendix is available on request from Highways England.

4.28 Smart motorways have emergency areas to stop in (see picture) if drivers cannot make it to the nearest motorway service areas or exit the motorway. Emergency areas are wider than hard shoulders, set further away from traffic and at regular intervals – and so a vehicle in one is less likely to be struck by traffic.

4.29 Highways England’s 'Smart Motorway All Lane Running Overarching Report' analysis shows that there has been a reduction in the average annual number of personal injury collisions involving vehicles in places of relative safety, following conversion to ALR. Looking at the first nine ALR schemes before and after their introduction, total personal injury collisions involving vehicles in places of relative safety have fallen from an average of 2.7 per year before the ALR was introduced to an average of 1.4 per year after the motorway had been converted to ALR. Looking at this in more detail, there is a varied picture of risk change: 2 slights, 0.3 serious and 0.3 fatal collisions on average before; and 0.7 slights, 0.7 serious and zero fatal collisions on average afterwards. But this is consistent with the expectation in the risk modelling that there would be a reduced overall risk with stopping in emergency areas compared to the hard shoulder.

Collisions Involving Vehicles Stopped in a Live Lane

4.30 The table below sets out the average annual number of live lane breakdowns on the SRN over two years (2017 and 2018). This suggests that, when compared to the volume of traffic, breaking down and stopping in a live lane is an infrequent experience for road users. When a vehicle breakdown occurs, it is more likely to occur in a place of relative safety on a conventional motorway than it is on DHS or ALR. Should a vehicle break down in a live lane, the smart motorway technology gives Highways England a greater ability to close the lane, reduce vehicle speeds, and warn other drivers of a hazard.

Table 3: Number of Breakdown Incidents, by SRN Road Type (Average Annual Over 2017-2018 - Highways England, 2019)

Breakdown Type	A-Road	Conventional motorway	Controlled motorway	Dynamic hard shoulder running	All lane running
Breakdown – in a live lane	10,656 (52%)	25,663 (20%)	2,361 (14%)	3,837 (27%)	9,206 (40%)
Breakdown - not in live lane	8,379 (41%)	96,097 (74%)	14,118 (81%)	9,012 (63%)	12,112 (53%)
Breakdown - not specified	1,532 (7%)	8,250 (6%)	930 (5%)	1,367 (10%)	1,536 (7%)
Total	20,567 (100%)	129,991 (100%)	17,409 (100%)	14,215 (100%)	22,963 (100%)

Source: Highways England estimates.

4.31 Turning to personal injury collisions involving a vehicle stopped in a live lane, as expected in the risk modelling, the likelihood of collisions involving a vehicle stopped in a live lane has increased. Looking at the first nine ALR schemes before and after their introduction, total live lane collisions have increased from an average of 3 per year before the ALR was introduced to an average of 19 per year after the motorway had been converted to ALR. This is broken down into: 2.3 slight, 0.3 serious and zero fatal live lane collisions on average before; and 9.1 slight, 7 serious and 2.8 fatal live lane collisions on average afterwards. This confirms the expectation in the risk modelling that there would be increased risks associated with vehicles stopping in a live lane.

4.32 However, these collisions continue to be very infrequent, with an average of 19 collisions per year across nine of the twelve ALR schemes being far lower than the 9,206 live lane breakdowns per year across all ALR schemes illustrated in table 3 above.

4.33 This suggests that converting from conventional motorway to ALR leads to mixed impacts on the risks faced by road users breaking down on a motorway. A vehicle which breaks down is more likely to stop in a live lane on ALR than on conventional motorways, which is reflected in the increased likelihood of personal injury collisions involving a vehicle stopped in a live lane. However, vehicles which reach a place of relative safety on ALR are less likely to be involved in a personal injury collision. And as mentioned earlier, the outturn risk analysis demonstrated that exposure to some hazards falls when a road is converted to ALR, while exposure to other hazards increases, including the risk of collisions involving a vehicle stopped in a live lane. The risk of a collision involving a vehicle stopped in a live lane remains relatively small, and overall collision risks decline following conversion to ALR.

4.34 The next section uses before and after studies to examine the resulting overall change in safety outcomes attributable to the conversion of motorways to ALR and DHS.

d) Before and After Studies of Smart Motorway Schemes

4.35 This section considers the evaluation evidence on the scale of collision and casualty risks before and after the introduction of DHS or ALR. Before and after studies, with a 'counterfactual' scenario to estimate what might have happened in the absence of the road scheme, is the strongest standard of evidence considered in this stocktake. Combined with statistical significance testing, it is the most reliable basis for forming conclusions on the relative safety of smart motorways on a like for like basis, and is in line with best practice and HMT guidance on policy evaluation, as set out in the Green Book[26] and Magenta Book[27].

4.36 For this section, the evidence stocktake has considered:

- Highways England's Post Opening Project Evaluation (POPE) and safety reports
- Highways England's 'Smart Motorway All Lane Running Overarching Safety Report'
- Collision data before and after the introduction of Dynamic Hard Shoulder Running

4.37 Reflecting the nature of evidence in these documents, this section provides summaries of findings for some individual schemes, and by scheme type. To assess whether the roads converted to DHS or ALR are as safe as the roads they replaced, analysis needs to estimate what might have happened had there been no intervention.

4.38 The best source of a such a 'counterfactual' would be to find a set of similar roads and observe what happened to collisions/casualties in this group, as a comparator group. Highways England's analysis identified all motorways as the comparator group. Hence the reports reviewed in this analysis assume that, if the scheme had not been built, the collision rate on each road would have changed at the rate observed across the motorway network between the before and after periods.

4.39 In addition to the counterfactual, many of these reports make use of 'statistical significance' testing. This is a standard statistical technique which helps to establish whether a difference in two casualty rates reflects a variation in the underlying casualty risks, or is within the statistical margin of error which results from natural variability in the figures over time. The use of this statistical term is not intended to imply any judgement about the importance of the events recorded by these statistics.

4.40 This form of evidence is still evolving, with more outturn data naturally becoming available over time and analytical methods developing.

[26] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent
[27] https://www.gov.uk/government/publications/the-magenta-book

All Lane Running

POPE and Safety Reports

4.41 Highways England has completed four POPE or three-year monitoring reports across the twelve ALR schemes that have been introduced:

- **Both the M25 schemes** three-year studies showed a decline in personal injury collision rates (per hundred million vehicle miles travelled, hmvm). For the M25 J5-7 this was a statistically significant reduction compared to the counterfactual informed by background trends, from 11.7 per hmvm (compared to 13.2 per hmvm before) to 9.3 per hmvm. For the M25 J23-27 the decline in PICs from a counterfactual of 11.4 per hmvm (compared to 12.9 per hmvm before) to 11.2 per hmvm was found to be within the statistical margin of error.
- The **M1 J39-42** one-year after POPE report showed an increase in personal injury collisions rates in the first year, from a counterfactual of 2.2 per hmvm (compared to 2.4 per hmvm before) to 3.0 per hmvm, though this change was found to be within the statistical margin of error.
- The **M6 J10a-13** interim evaluation showed a reduction in the average annual number of personal injury collisions, from a counterfactual of 30 per year (based on an average of 31 per year before) to 18 per year, a statistically significant reduction compared to the counterfactual informed by background trends. The collision rates could not be assessed and further data is being collected for the full evaluation.

4.42 Three of the four reports presented a reduction in personal injury collisions and/or collision rates. All schemes showed a reduction in the FWI, though these were not compared to background national trends.

Analysis of casualties following introduction of All Lane Running

4.43 Highways England's 'Smart Motorway All Lane Running Overarching Safety Report' analysis included an estimate of what would have happened to casualties along these roads given background trends on the motorway network (the counterfactual scenario.

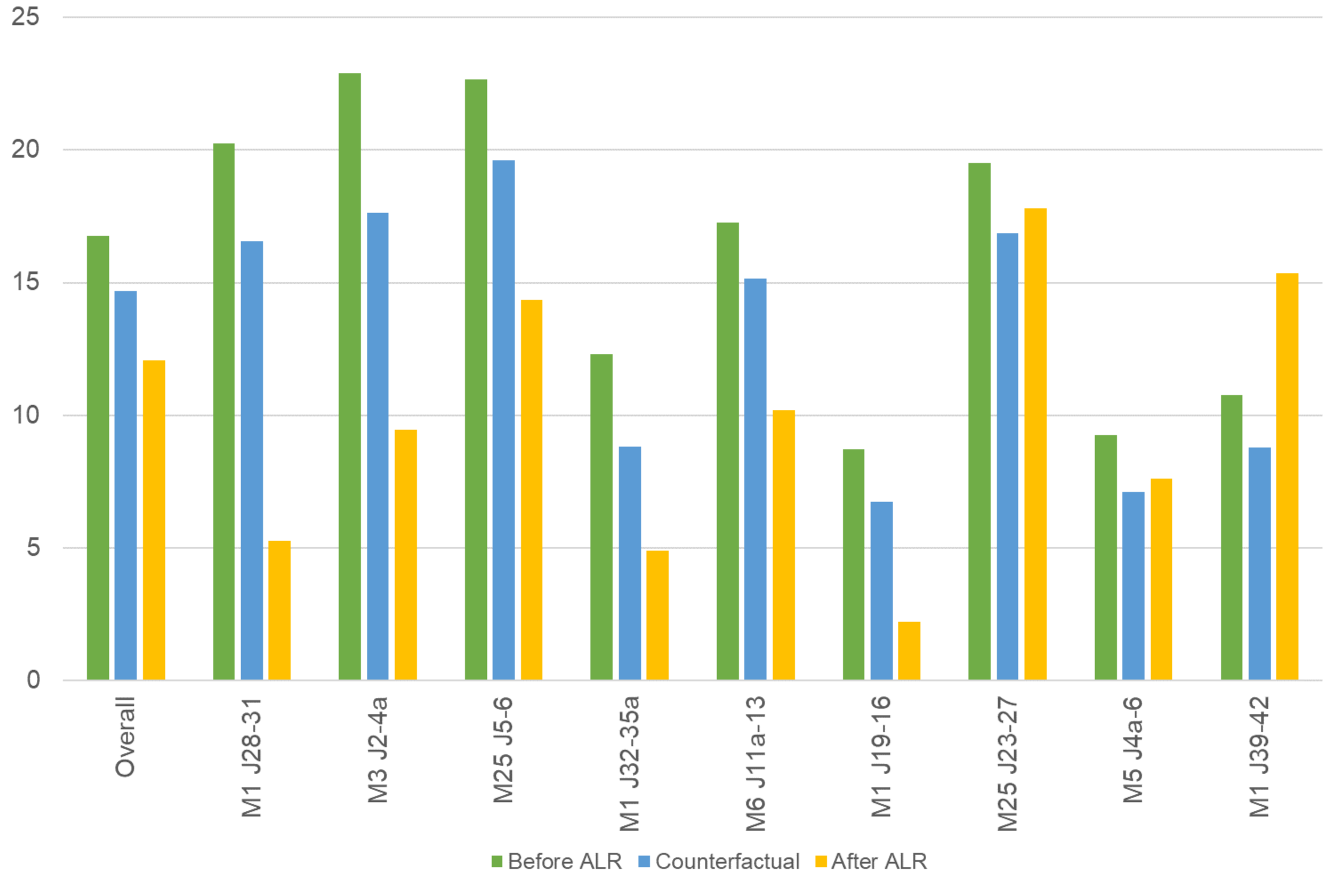
4.44 The analysis Highways England conducted took three years of data before and compared this to available data after ALR opened on each of these schemes (for two of the schemes this meant three years after, for the other seven this was based on one year's data).

4.45 The background trends used to calculate the counterfactual were estimated using national casualty data for motorway class roads in the middle year of the 'After' period (2015) and for the middle year in the 'Before' period (2011). During this period there was a slight increase in the killed and seriously injured (KSI) rate.[28] This is partially explained by a change in 'injury based' reporting methods (as explained in section 5a). The casualty data used for this analysis has not been adjusted to account for the change in reporting methods. As such, this analysis might evolve in

[28] The KSI rate has been broadly stable over the past decade.

the future in line with relevant developments in methodology relating to the effects of injury-based reporting.

Figure 24 – All Casualties per Hundred Million Vehicle Miles Travelled, Before and After Introduction of All Lane Running



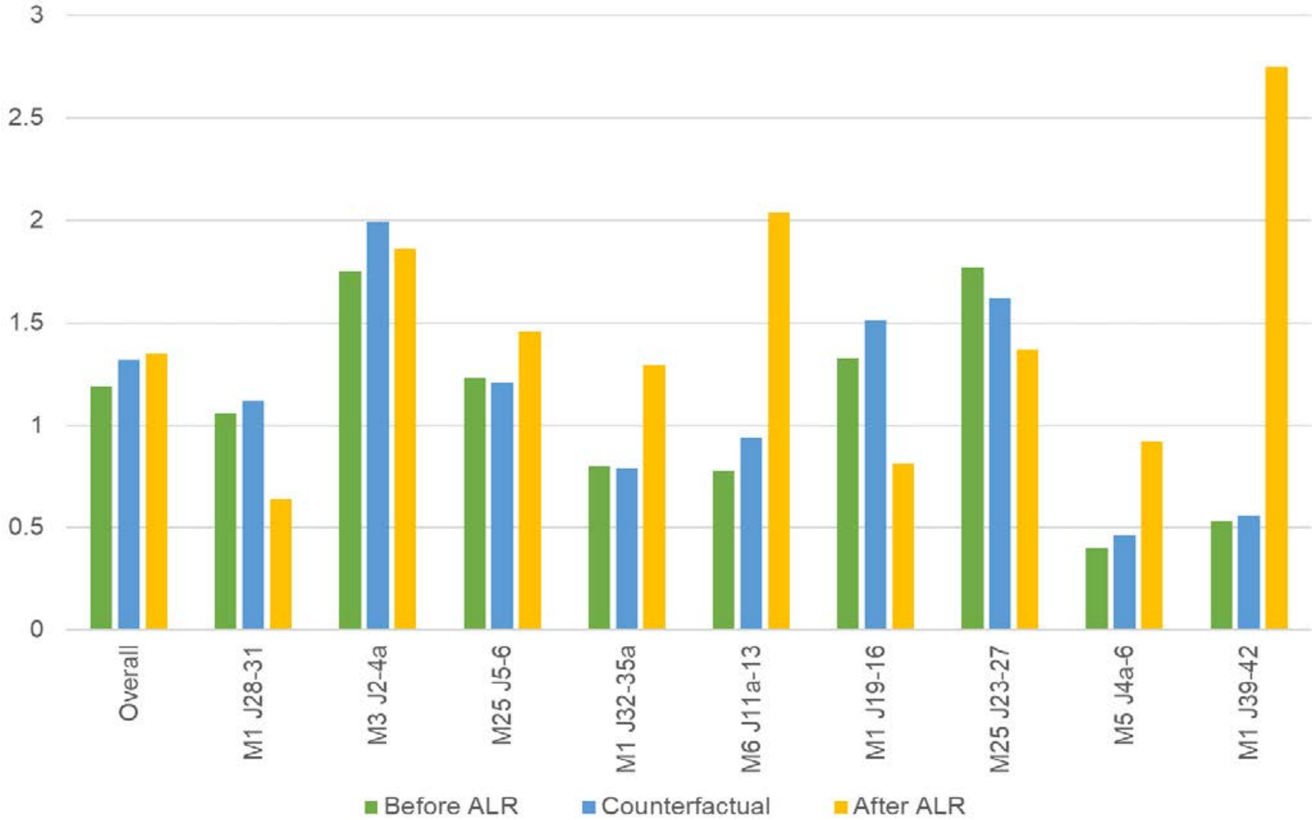
Source: Highways England, Smart Motorway All Lane Running Overarching Safety Report

4.46 Figure 24 shows that, overall[29], there has been a 28% reduction in the all casualty rate from 16.8 per hmvm to 12.1 per hmvm when simply comparing the 'Before' and 'After' period. The counterfactual scenario indicates that a 12% reduction in the casualty rate from 16.8 per hmvm to 14.7 per hmvm might otherwise have been expected. Overall, there has been a statistically significant reduction of 18% in the all casualty rate[30] from 14.7 per hmvm to 12.1 per hmvm when compared to what might otherwise have been expected. Of the nine schemes, a reduction in casualties was seen in six and an increase was seen in three. Of the three schemes that saw an increase – both the M25 J23-27 and M5 J4a-6 found to be within the statistical margin of error. For the M1 J39-42, although the number of casualties per annum in the after period was comparable to the other schemes evaluated, the number of casualties in the before period was the lowest among all the schemes.

[29] The ‘Overall’ figure for each of these metrics is calculated by aggregating casualties across the set of schemes and dividing by total road traffic.

[30] The casualty rate is the number of casualties per million vehicle miles travelled. This represents risk in a consistent way across schemes with different traffic levels.

Figure 25 – Fatal and Serious Casualties per Hundred Million Vehicle Miles Travelled, Before and After Introduction of All Lane Running



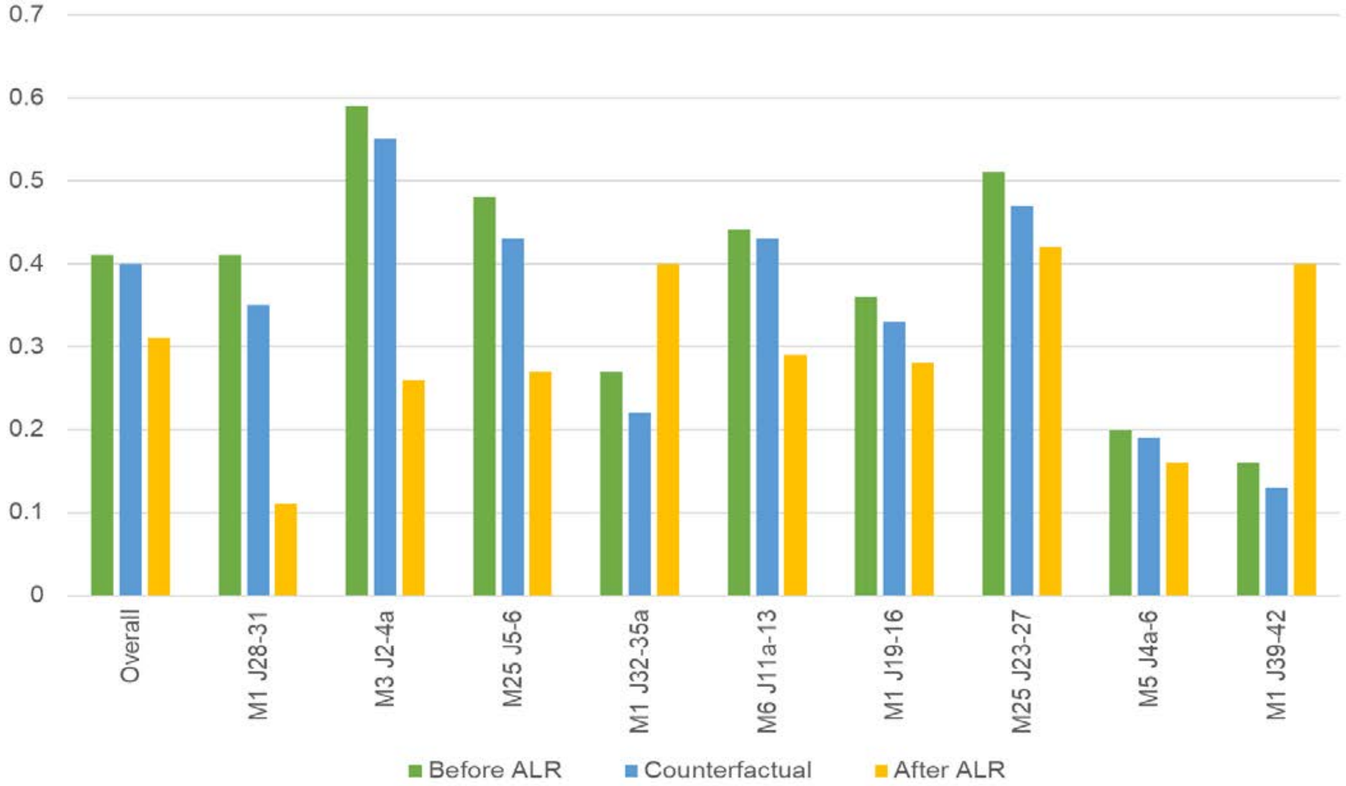
Source: Highways England, Smart Motorway All Lane Running Overarching Safety Report

4.47 Figure 25 shows that the fatal and serious casualty rate across the nine schemes has increased by 14% from 1.19 per hmvm to 1.35 per hmvm when simply comparing the 'Before' and 'After' period[31], this is line with what might otherwise have been expected (a 12% increase from 1.19 per hmvm to 1.32 per hmvm). Overall, there has been an increase (2%) in the fatal and serious casualty rate from 1.32 per hmvm to 1.35 per hmvm when compared to what might otherwise have been expected (though this is within the statistical margin of error). Of the nine schemes evaluated, three showed a reduction, while six showed an increase. However, these changes were either within the statistical margin of error when accounting for the background trends in casualty rate, or the sample sizes were too small for statistical analyses to be carried out.

4.48 Figure 26 shows that the FWI rate across the nine schemes has decreased by 25% from 0.41 per hmvm to 0.31 per hmvm when simply comparing the 'Before' and 'After' period. The counterfactual scenario indicates that a 2% reduction in the FWI rate from 0.41 per hmvm to 0.4 per hmvm might otherwise have been expected. Overall, there has been a reduction of 23% in the FWI rate from 0.4 per hmvm to 0.31 per hmvm when compared to the counterfactual informed by background trends. Of the nine schemes evaluated, seven showed a reduction in the FWI rate. The two schemes that showed an increase in the FWI rate were the M1 J39-42 and M1 J32-35a schemes. The statistical significance of these results could not be ascertained.

[31] This reflects an increase in the serious casualty rate and a decrease in the fatal casualty rate from ‘Before’ to ‘After’.

Figure 26 – Fatal and Weighted Injuries per Hundred Million Vehicle Miles Travelled, Before and After Introduction of All Lane Running



Source: Highways England, Smart Motorway All Lane Running Overarching Safety Report

4.49 Overall, this analysis (as shown in Figures 24-26) illustrates that:

- The casualty rate has fallen for the majority of schemes and as a group, following introduction of All Lane Running. This indicates a fall of 18% from 14.7 per hmvm to 12.1 per hmvm when compared to the counterfactual informed by background trends, which was statistically significant.
- The fatal and serious casualty rate has increased across the group of schemes by 2% from 1.32 per hmvm to 1.35 per hmvm when compared to the counterfactual informed by background trends, which was within the statistical margin of error.
- The Fatal and Weighted Injuries (FWI) rate fell following introduction of ALR for all but two of the schemes, and fell as a group from 0.4 per hmvm to 0.31 per hmvm compared to the counterfactual informed by background trends (by 23%). The statistical significance of these results could not be ascertained.

4.50 In summary, the ‘Overarching’ ALR report assessed a range of metrics around the collisions and casualties of the majority of ALR schemes in operation, using the latest data available and comparing actual changes to the counterfactual. This is a strong method, although seven of the nine schemes assessed only had data available for one year after scheme opening. Nonetheless, the set of ALR schemes considered had a statistically significant reduction in casualty rates, with an increase in serious and fatal casualties in line with the counterfactual and a fall in the FWI.

Dynamic Hard Shoulder Running

POPE and Safety Reports

4.51 Highways England has completed five POPE reports and one three-year safety report for DHS schemes. Overall these find that:

- **M42 J3a-7** – there was a reduction in the personal injury collision rate. As this was from a 3 year safety report, the analysis did not take into account background trends in collisions and did not test for statistical significance.
- **M1 J10-13** - there was an increase in collision rates of 19% on the main carriageway, after accounting for background trends - from 3.0 per hundred million vehicle miles to 3.7 per hmvm. However, this change was found to be within the statistical margin of error. For Junction 11 there was an 11% increase in the number of collisions, but for Junction 12 a 14% fall in collisions when compared to background trends – both were found to be within the statistical margin of error.
- **M62 J25-30** - there was a statistically significant reduction of 34% in the average annual number of collisions, from 67 to 44, after accounting for the background trend.
- **M4 J19-20 & M5 J15-17** - there was a statistically significant decrease in the collision rates, after accounting for background trends – 55% for the M4 and 52% for the M5.
- **M6 J5-8** - there was an increase in the personal injury collision rate of 15%, after taking in account background trends, from 3.8 per hmvm to 4.4 per hmvm. This change was found to be within the statistical margin of error.
- **M6 Junction 8-10a** - there was an increase in the collision rate of 26%, after taking in account background trends, from 4.0 per hmvm to 5.1 per hmvm. This change was found to be only just statistically significant.

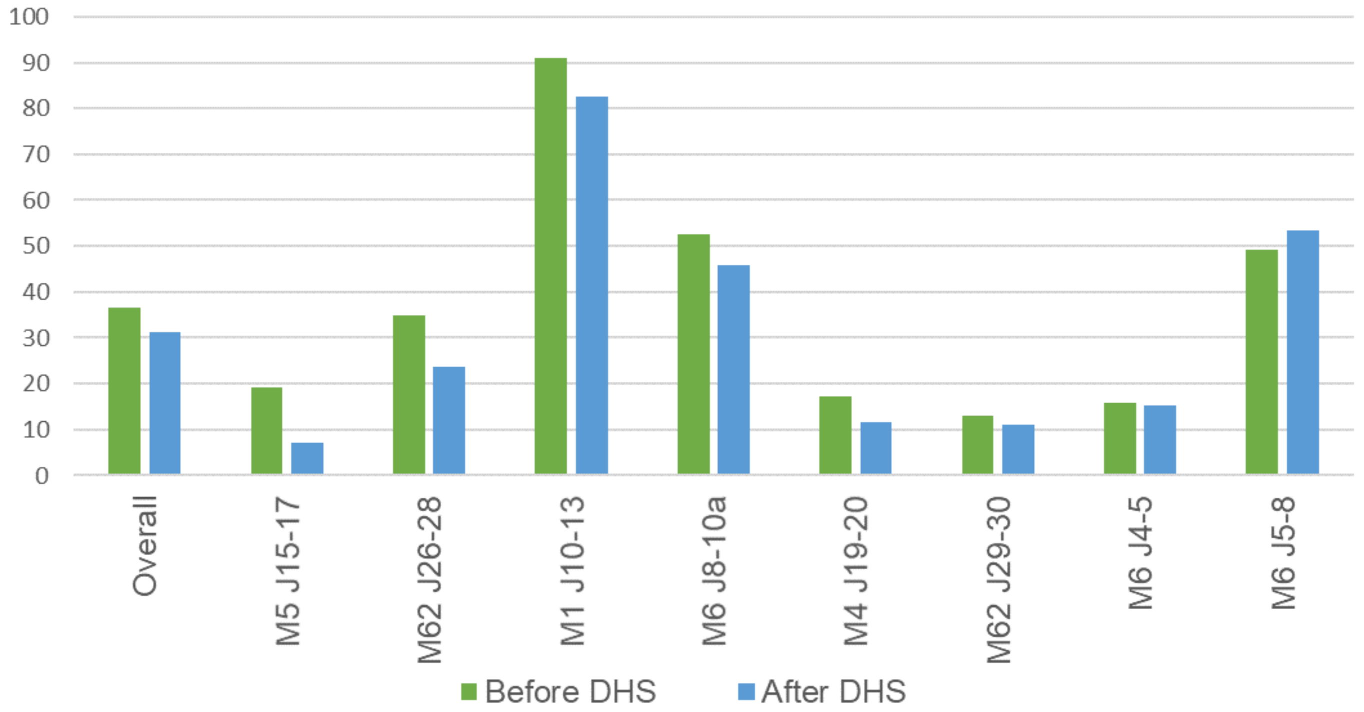
4.52 The individual DHS POPE and three-year safety reports show a varied picture of the change in the personal collision rates across the schemes, although increases in collision rates were in most cases found not to be statistically significant. The FWI measure fell for all of the schemes considered.

Analysis of Collisions Following Introduction of Dynamic Hard Shoulder Running

4.53 An overarching analysis of the DHS schemes as a whole, akin to that for ALR schemes, has not been produced. Therefore, using additional data provided by Highways England this analysis considers the annual average number of slight, serious and fatal collisions on a selection of roads that have been converted to Dynamic Hard Shoulder Running.

4.54 The analysis considered annual collisions 3-6 years before construction started and 3-9 years after the scheme opened, depending on how much data was available – but has not been able to consider how these changes in collisions compare to a counterfactual or test for statistical significance.[32] However, this analysis can add some insight into what has happened following introduction of DHS on the SRN (Figures 27-29 below) and suggests that the number of personal injury collisions has reduced across the DHS schemes.

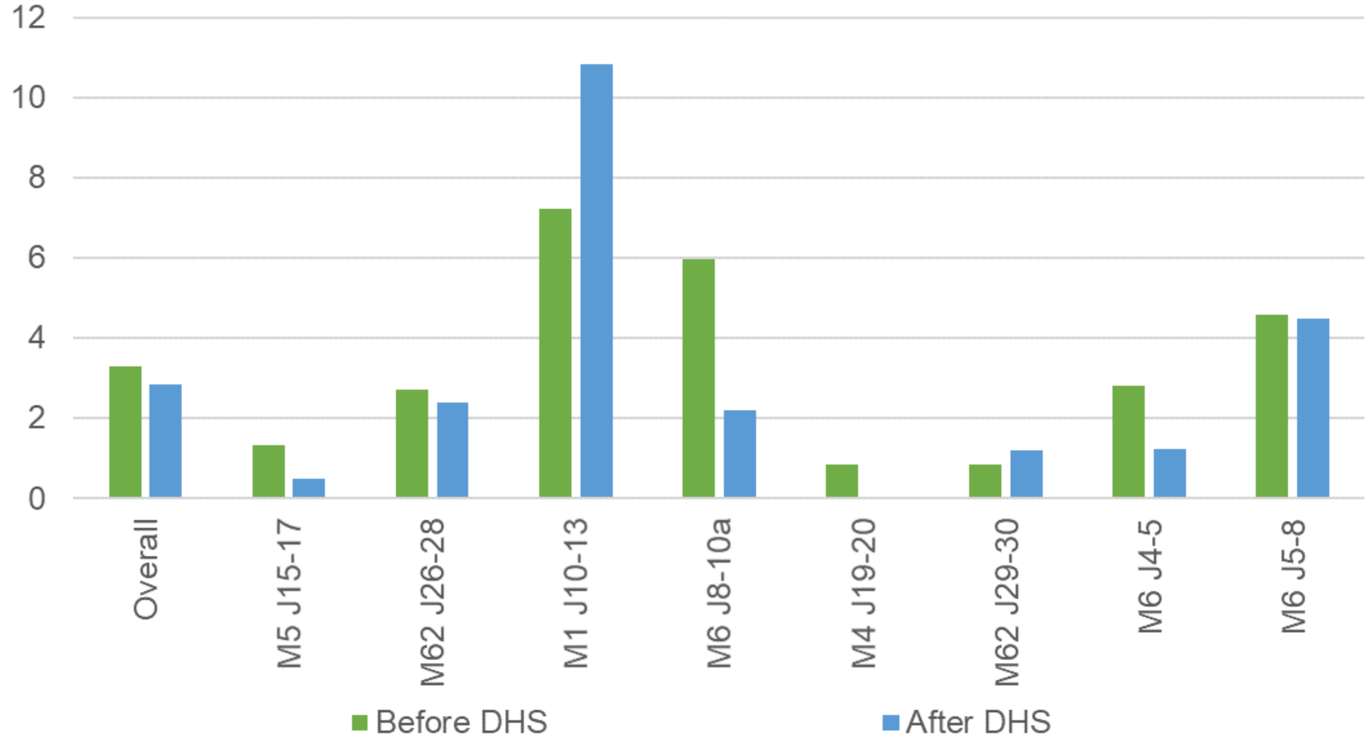
Figure 27 – Slight Collisions Before and After Introduction of Dynamic Hard Shoulder Running (Annual Average)



Source: DfT analysis based on collision data provided by Highways England. Simple average is estimated by aggregating collisions across all the of the schemes and dividing by number of schemes.

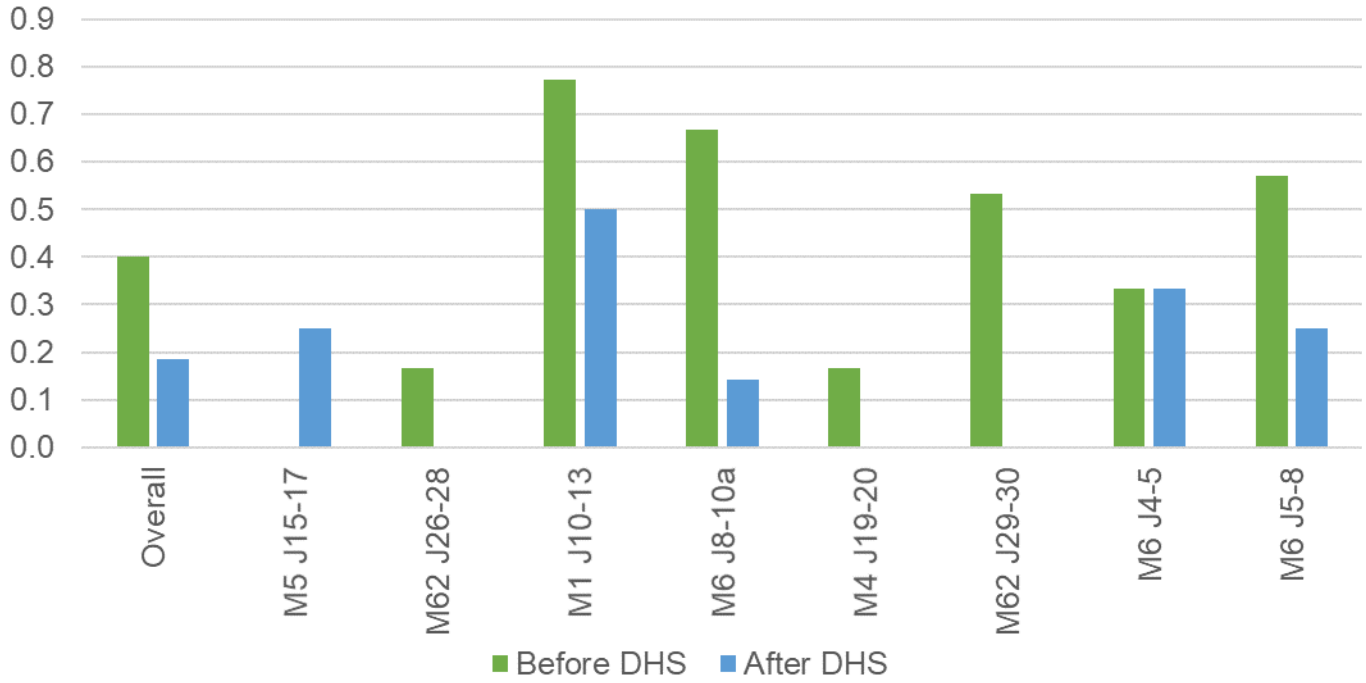
[32] Where there was partial year data before-construction or post-opening, the analysis 'annualised' the data by factoring up the number of collisions by months in the year.

Figure 28 – Serious Collisions Before and After Introduction of Dynamic Hard Shoulder Running (Annual Average)



Source: DfT analysis based on collision data provided by Highways England. Simple average is estimated by aggregating collisions across all the of the schemes and dividing by number of schemes.

Figure 29 – Fatal Collisions Before and After Introduction of Dynamic Hard Shoulder Running (Annual Average)



Source: DfT analysis based on collision data provided by Highways England. Simple average is estimated by aggregating collisions across all the of the schemes and dividing by number of schemes.

5. Conclusion

5.1 Understanding the relative safety of smart motorways involves considering several factors. It involves both comparing the safety performance of the motorway types as the network stands, and considering the safety effects of converting a conventional motorway to a smart motorway on a like-for-like basis. It also involves understanding not just differences in the scale of casualty risk, but also how the nature of the underlying risks varies.

5.2 Substantial effort has been made to build the evidence base on the relative safety of smart motorways, over many years. The high level statistics are helpful in understanding safety performance as the network stands. The before and after studies are better suited to considering the effect of converting a section of motorway, like-for-like; as is the risk modelling, which additionally is useful for looking at the nature of risks. This evidence base has the potential to evolve, as more years of data become available and analytical methods develop.

5.3 The high level statistics suggest that fatal casualty rates on the ALR network as it stands are lower, while injury rates are slightly higher. The risk modelling suggests that when converting conventional motorways to ALR, many risks decrease, while some increase. For example, the risks of a vehicle being driven too fast, and of a vehicle drifting off the carriageway, reduce whilst the risks of unsafe lane changing and of a vehicle stopping in a live lane increase. Looking at like-for-like studies of specific roads which have been converted to ALR: the overall casualty rate declines significantly; the fatal and serious casualty rate increases slightly, but within the statistical margin of error; and the FWI rate declines. The same studies further indicate that the motorway types differ in terms of the underlying risks.

5.4 The high level statistics show that DHS motorways, compared to conventional motorways, have a lower rate of fatal casualties and a higher rate of slight casualties, while serious casualty rates are slightly higher. Before and after collision data for DHS schemes suggested that personal injury collisions reduced.

5.5 Overall, the evidence shows that in most ways, smart motorways are as safe as, or safer than, conventional motorways, but not in every way. Part B of this report sets out our Action Plan, which includes continuing to monitor the evidence as it evolves.

PART B - ACTION PLAN

1. Stocktake findings and recommendations

1.1 The Department has completed the evidence stocktake and the findings are described in detail in Part A of this document. Overall, what the evidence shows is that in most ways, smart motorways are as safe as, or safer than, the conventional ones, but not in every way. The statistics suggest that fatal casualty rates are lower while injury rates may be slightly higher. Within this overall picture, the specific risk related to live lane breakdowns has increased and there is confusion over the different types of smart motorways. This Action Plan seeks to address these issues and not only make smart motorways even safer but provide greater public confidence in their use.

a) Making smart motorways even safer and building public confidence

1.2 This section describes each of the measures the Government is committed to taking and together they form a comprehensive package of investments.

Ending the use of dynamic hard shoulders

1.3 One existing type of smart motorway is known as dynamic hard shoulder running. This is where the hard shoulder is used as a traffic lane to increase capacity temporarily only when it is needed most. Figure 1 shows a section of this type of motorway in operation. We have taken account of Highways England's operational experience with this early version of smart motorway. This type has the potential to cause confusion for motorists because the hard shoulder is sometimes in use for traffic and sometimes not. Also, as time goes on and the motorway becomes busier, the hard shoulder is in use for longer periods of time. The simple solution to end this potential for confusion is to convert the hard shoulder permanently into a traffic lane. This is known as all lane running, and has been the standard for smart motorways since 2012. We are announcing that we will convert all existing dynamic hard shoulder smart motorways into all lane running by the end of March 2025 so there will be only one type without a permanent hard shoulder. This will provide a more consistent experience for motorists.

Figure 1 - Dynamic hard shoulder running - to be brought to an end

Faster rollout of stopped vehicle detection - Highways England asked to deliver this in 36 months, bringing this programme forward by several years

1.4 The evidence stocktake considered how risks differ between conventional motorways and smart motorways, looking at hazard assessments based both on predictions and on actual data. For example, the risk of collisions involving speeding or tailgating was expected to reduce and it did. While a reduction in risk was expected overall with smart motorways, the specific risk of collisions involving vehicles stopped in a live lane was predicted to increase. We have considered and are implementing a wide range of measures to reduce this risk.

1.5 All smart motorways already include a system called MIDAS (Motorway Incident Detection and Automatic Signalling) which uses sensors to monitor traffic volumes and automatically set signs and signals as the motorway becomes more congested. This system is just one of a suite of technology enhancements, which also includes red X signs, CCTV, enforcement cameras and roadside telephones in emergency areas, that are built into smart motorways as standard and which are there to ensure the motorways are as safe as, or safer than, conventional ones.

1.6 Though not essential for achieving the safety objective for smart motorways to be as safe as, or safer than, the road they replace Highways England has also trialled and implemented a separate radar-based stopped vehicle detection (SVD) system on two smart motorway sections of the M25 and is in the process of installing it on a smart motorway section of the M3. The advantage of the SVD system is it is specifically designed to detect a stationary vehicle, typically in 20 seconds, set a message automatically on electronic signs, and alert a control room operator who can see the incident on camera, close lanes and dispatch an on-road Highways England traffic officer to attend to the stopped vehicle.

1.7 Smart motorway schemes completing design in 2020 will be the first to have the SVD technology as standard. But most sections of smart motorway are without it. While

Highways England is committed to rolling out SVD to every existing all lane running smart motorway, until now there has not been a public timetable for this work. As a result of this evidence stocktake, Highways England has been asked to accelerate its plans and install the technology on all lane running smart motorways within the next 36 months, setting a clear public timetable for the first time.

1.8 Highways England has been investigating other technologies for detecting stopped vehicles and has run a small-scale trial of a system that analyses CCTV images. As a result of this evidence stocktake, Highways England will launch a large-scale trial of this technology. This will make greater use of the full CCTV coverage on smart motorways, providing another option alongside current radar technology.

Faster attendance by more Highways England traffic officer patrols

1.9 Detecting a stopped vehicle quickly and warning other drivers is the first response. A stranded motorist also wants to know that help will be at hand fast. We are committing to introduce additional traffic officer patrols on smart motorways where the existing spacing between safe places to stop in an emergency is more than one mile. We aim to reduce the attendance time from an average of 17 minutes to 10 minutes. This will mean reaching those who need assistance quicker and making them safer. This average response time compares favourably with the Police 15-minute target for response time.

Committing to a new standard for spacing of places to stop in an emergency

1.10 In an emergency, it is recommended you leave the smart motorway to find a place to stop. If this is not possible, other places to stop in an emergency include motorway services, emergency areas and remaining sections of hard shoulder, such as on slip roads. Emergency areas are safer places to stop in an emergency than a hard shoulder because they are set back from the edge of the road and are wider than a hard shoulder.

1.11 Design standards have been amended to reduce the distance between safe places to stop in an emergency to a maximum of 1 mile. This applies to new schemes and means motorists will reach a safe place to stop every minute when travelling at 60mph. This year, Highways England is completing the design of the first smart motorways to this latest specification. In practice, across the first four schemes for which designs have been prepared to this 1-mile maximum spacing standard, the average distance between places to stop in an emergency is 0.75 miles, which means drivers will on average reach one every 45 seconds at 60mph. Going forward, we will commit to a maximum spacing of 1 mile apart and look to, where feasible, provide them every ¾ of a mile apart – as a new design standard for all future schemes when they enter the design stage.

Delivering ten additional emergency areas on the M25

1.12 We have heard the calls for something to be done on existing smart motorways where places to stop in an emergency are furthest apart. We are re-confirming the commitment to install ten extra emergency areas on the M25 on the section of smart motorway with a higher rate of live lane stops and where places to stop in an emergency are furthest apart. These will be evaluated to establish if they have reduced the level of live lane stops.

Considering a national programme to install more emergency areas on existing smart motorways

1.13 We will also consider a national programme of retrofitting additional emergency areas on existing smart motorways where places to stop in an emergency are more than one mile apart, drawing on evidence from the programme to deliver additional emergency areas on the M25. There will be a thorough evaluation of the M25 programme, collecting data on live lane stops before and after the extra emergency areas are installed. We will also learn from the M25 programme about the practicalities of constructing additional emergency areas on an operational smart motorway. The roadworks for the M25 programme have involved closure of the left-hand lane which has caused congestion and delays. Consideration of a national programme needs to look in detail at how to minimise the impact on motorists during construction, such as coordinating the work with other planned improvements and maintenance activity.

1.14 In addition to considering a national programme, where there have been clusters of incidents we will not wait for this work to conclude but will act urgently to investigate and take action where necessary.

Investigate M6 Bromford viaduct and sections of the M1

1.15 We have heard the concerns about clusters of incidents on specific sections of the M6 and M1 smart motorway. This includes the M6 Bromford viaduct between Junctions 5 and 6, where places to stop in an emergency are furthest apart. Though Highways England traffic officers are stationed at each end of the viaduct so they are close by, we know that some people remain worried. Concerns have also been raised about sections of the M1 where multiple collisions have occurred. These include M1 Junctions 10 to 13 (Luton) and Junctions 30 to 35 (Sheffield). We have also seen evidence of multiple incidents on the M1 Junctions 39 to 42 (Wakefield).

1.16 We are committing to investigate urgently what more could be done on the M6 Bromford viaduct and on these sections of the M1. Where an intervention is considered likely to make a difference, we will look to make changes to the motorway at these locations.

1.17 We will also commit to monitor existing smart motorways and new ones after they become operational to review safety data and evaluate whether they are meeting the safety objective of being as safe as, or safer than, the conventional motorways they replaced.

Making emergency areas more visible

1.18 Emergency areas provide a safer place to stop in an emergency than a traffic lane or hard shoulder. The hard shoulder of a motorway is often seen as a safe place to stop but 1 in 12 fatalities on a conventional motorway occurs there. The latest standard for smart motorways - all lane running - removes the hard shoulder and provides emergency areas instead. These 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. They are approximately 110-yard-long bays (the average length of a football pitch) set back from the left-hand side of the motorway with an emergency telephone from which to alert Highways England of an issue and call for help. The stocktake found that these emergency areas are safer than the hard shoulder. We are committing to ensuring that all existing emergency areas will have a bright orange road surface, dotted lines on the surfacing showing where to stop, better and more frequent signs on approach to the emergency area showing where it is and new signs inside giving information on what to do in an emergency. These improvements will be installed by the end of spring 2020 on existing smart motorways and are being designed into new smart motorways as standard. Figure 2 shows an emergency area with the new orange surfacing.

Figure 2 - Making emergency areas more visible

More traffic signs giving the distance to the next place to stop in an emergency

1.19 In addition to making emergency areas more visible, we are committing to install more traffic signs in between places to stop in an emergency so you should almost always be able to see a sign wherever you are on the motorway. Typically, these will be between approximately 330 and 440 yards apart and will show how far it is to the next place to stop in an emergency, to help motorists reach one and avoid stopping in a live lane. Figure 3 shows the existing signs on approach to an emergency area. We are committing to 'filling in the gaps' between these signs so you will almost always be able to see one.

Figure 3 - Traffic signs showing the distance to the next emergency area

More communication with drivers

1.20 Many motorists do not know exactly what a smart motorway is and are not aware of whether they are on one or not. We need to tackle the public perception of, and public confidence in, the safety of smart motorways as much as the reality. We recognise that we could do more. We are therefore committing to an additional £5 million on national and targeted communications campaigns to further increase awareness and understanding of smart motorways, how they work and how to use them confidently. We will ensure drivers receive advice to help them keep safe on smart motorways including advice on what to do in a breakdown. We will run these campaigns using the most effective and accessible media based on market research and insight to ensure it has the desired impact.

Displaying 'report of obstruction' messages

1.21 The stopped vehicle detection system sends an alert to a control room. It can also automatically display a message on an electronic overhead sign. We are committing to rolling out the automatic display of a 'report of obstruction' message on overhead signs to warn oncoming drivers of a stopped vehicle ahead, which has begun being trialled on the M25 Junctions 23 to 27 and Junctions 5 to 7 - and then to begin on the M3 Junctions 2 to 4a.

Places to stop in an emergency shown on your satnav

1.22 Many motorists use a satnav (satellite navigation) device to follow a route to their destination and we want information on where to stop in an emergency to be easily available. In addition to the new signs, we are committing to work with satnav providers to ensure that places to stop in an emergency, such as motorway services, emergency areas and remaining areas of hard shoulder such as on slip roads, are shown on the screen of the device when needed.

Making it easier to call for help if broken down

1.23 Increasing numbers of new cars come with an eCall or 'SOS' button which can be used to call for help. We are committing to work with car manufacturers to build greater awareness and understanding of this function in newer cars. Figure 4 shows an example of this type of feature in a car. For those whose cars do not have this feature, there is guidance over the page on how to call for help which is based on the Highways England website on 'what to do in an emergency or breakdown on a Smart Motorway'.

Figure 4 - Increasing awareness of eCall or 'SOS' buttons in newer cars

We have changed the law to enable automatic detection of red 'X' violations and enforcement (3 points, £100 fine) using cameras

1.24 Sometimes a vehicle will stop in a live lane despite the best efforts of the driver to reach a safer place. This is true for conventional motorways as well as for smart motorways, though it happens at a higher rate with the latter. However, smart motorways have technology that can help to protect a vehicle stopped in a live lane and this is not installed on conventional motorways. Smart motorways have overhead signs that can display a 'red X'. A 'red X' means the lane is closed to traffic and vehicles must not continue in that lane beyond the 'red X' sign. Where a vehicle has broken down, a control room operator can switch on the 'red X' sign to close the lane behind, reducing the risk of a collision between the stopped vehicle and oncoming traffic. The vast majority of drivers comply with 'red X' signs but for the very small minority who do not, the police have the powers to prosecute. The penalty is 3 points on the driver's licence and a £100 fine, or the driver can be referred to an awareness course.

1.25 To help the police bring compliance closer to 100%, we have changed the law to enable automatic detection of red X violations and enforcement using cameras. Auto-detection uses the same cameras that are installed as standard on smart motorways to help ensure variable speed limits deliver smoother journeys for all motorists. We are committing to expanding the upgrade of smart motorway cameras (known as HADECS); discouraging those who currently ignore the signs and therefore reducing the risk of a collision with a vehicle stopped in a live lane. Figure 5 shows a 'red X' displayed above a lane on an overhead gantry to close that lane.

Highways England advice on what to do in an emergency or breakdown

If your vehicle is damaged or appears to have problems, always try to turn off the motorway at the next exit. If that's not possible, you should follow these steps:

1 Use an emergency area if you can reach one safely. These are marked with blue signs featuring an orange SOS telephone symbol.

2 When in the emergency area, if you can leave your vehicle safely, contact Highways England via the roadside free emergency telephone provided in all emergency areas. If you can't get to the emergency telephone but have a mobile phone with you, call us on 0300 123 5000.

3 If you can't get to an emergency area but your vehicle can be driven, move it to the hard shoulder (where available) or as close as possible to the nearside (left hand) verge or other nearside boundary or slip road. Do not put out a warning triangle.

4 Switch on your hazard warning lights and any other lights such as rear fog lights or side lights, to increase your visibility especially if it's dark or foggy.

5 If you feel you can exit your vehicle safely with any occupants, consider exiting via the nearside (left hand) door, and wait behind the safety barrier, if there is one and it's safe to do so. Keep clear of your vehicle and moving traffic at all times (for example if your vehicle gets hit, you're out of the way).

If it's not possible to exit your vehicle safely, there's no safe place to wait, or you feel your life is in danger, put your hazard warning lights on and stay in your vehicle with your seat belt on. If you have a mobile phone, dial '999' immediately.

Our regional control centres use CCTV cameras to monitor and manage our motorways. Once they're aware of your situation (via CCTV or the police), they can set overhead signs and close the lane to help keep traffic away from you.

The control centre can also send a traffic officer or the police to help you, and assist you to re-join the motorway when appropriate.

Please note that if you break down or are in an emergency, you must call for help as soon as possible. Keep the following items in your vehicle in case you break down:

- warm clothes,
- water and food, hi-vis jacket, a torch,
- charged mobile phone,
- access to a route planner either via your smart phone or an atlas,
- breakdown cover details, and
- any medication you need

Figure 5 - Auto-enforcement of Red 'X' signs

An update of the Highway Code

1.26 The Highway Code already includes information about smart motorways, such as 'red X' and variable speed limits, but we recognise it could provide more guidance. We are committing to an update of the Highway Code to provide more guidance for motorists on smart motorway driving. For example, this will include emergency area signage for the first time. Figure 6 shows the cover of the hard copy Highway Code and it is also available at www.gov.uk/guidance/the-highway-code.

Figure 6 - The cover of the official Highway Code

<u>Specific measures for the breakdown recovery industry</u>

1.27 We have heard the concerns of the breakdown recovery industry. While the measures set out above aim to address many of those concerns, we are also taking action on issues specific to the industry.

Closer working with the recovery industry

1.28 Much work has been done already to develop and test operational processes to ensure the safe recovery of broken down vehicles on smart motorways. Recovery vehicle operators are never required to recover a broken-down vehicle from a live lane on a smart motorway, unlike on other types of road. On a smart motorway, Highways England traffic officers or the police either close the lane first before recovery takes place, or they tow the vehicle to an emergency area or another place to stop in an emergency before the recovery operator begins work. Despite this existing work, we recognise that there is more we could do. We are therefore committing to closer working with the recovery industry on improving training and procedures.

Reviewing existing emergency areas where the width is less than the current standard

1.29 We have heard concerns about the width of some existing emergency areas where it is less than the current 15-foot-wide standard when measured from the edge of the carriageway. Though these slightly narrower emergency areas are still significantly wider than an 11-foot-wide traditional hard shoulder, we are committing to review these and if feasible and appropriate we will widen to the current standard.

Review of use of red flashing lights to commence immediately

1.30 We have listened to the calls for recovery vehicles to be allowed to use red flashing lights. We will commence work immediately on a review.

b) Existing measures

1.31 These measures build on the existing operational procedures and technology to improve road users' safety and instil more confidence in the use of smart motorways. Existing resources and systems include traffic officer patrols, full CCTV coverage of the road and emergency areas, automatic incident detection system (MIDAS), variable speed limits to smooth traffic flow and electronic message signs to warn drivers of incidents ahead.

2. Conclusions and next steps

2.1 Overall, what the evidence shows is that in most ways, smart motorways are as safe as, or safer than, the conventional ones. But not in every way. The statistics suggest that fatal casualty rates are lower while injury rates are slightly higher. Within this overall picture, the specific risk related to live lane breakdowns has increased and there is confusion over the different types of smart motorways. Also, many motorists do not know exactly what a smart motorway is, and are not aware of when they are on one or not. We need to tackle the public perception of, and public confidence in, the safety of smart motorways as much as the reality

2.2 This Action Plan seeks to address these issues. We are taking action to improve safety further and give motorists more confidence in the use of this type of road. We will also continue to listen to feedback on motorists' experience of smart motorways, we will monitor future evidence on smart motorway safety and we will seek regular updates from Highways England on delivery of the measures in this Action Plan.

2.3 On the basis of the improvements outlined in the Action Plan to help ensure that smart motorways outperform conventional motorways, the schemes currently under construction may now proceed to open for traffic. We will pay particularly close attention to their post-implementation performance.

Annex A: Road Length and Road Traffic Data 2010-2018

Table 4

Road Class	Road Length (Miles)								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Conventional Motorway	1,778	1,755	1,700	1,697	1,651	1,657	1,617	1,583	1,576
Controlled Motorway	51.0	73.3	115	117	121	121	124	135	137
Dynamic Hard Shoulder	15.8	22.4	37.6	50.7	66.5	66.5	66.5	66.5	66.5
All Lane Running	-	-	-	-	28.6	28.6	62.4	105	123
All SRN 'A' Roads	2,570	2,582	2,583	2,571	2,574	2,570	2,563	2,578	2,611

Source: DfT Road Length Statistics on the Strategic Road Network in England from 2010-18.

Table 5

Road Class	Motor Vehicle Traffic (Billion Vehicle Miles)								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Conventional Motorway	51.3	50.8	49.1	48.4	47.8	48.1	47.6	47.0	45.2
Controlled Motorway	2.4	3.3	5.1	5.9	6.1	6.4	6.6	6.6	7.2
Dynamic Hard Shoulder	0.7	1.0	1.1	1.8	2.9	3.0	3.1	3.2	3.3
All Lane Running	-	-	-	-	0.6	1.4	2.7	3.9	5.1
All SRN 'A' Roads	29.1	29.3	29.4	29.3	30.0	30.8	32.2	33.4	34.0

Source: DfT Road Traffic Statistics on the Strategic Road Network in England from 2010-18.

Table 4 above shows the road length of the Strategic Road Network from 2010-2018, split by road class. This is taken from DfT road length data, which are National Statistics and can be found here https://www.gov.uk/government/collections/road-network-size-and-condition.

Table 5 shows the road traffic levels on the Strategic Road Network from 2010-2018, split by road class. This is taken from DfT road traffic data, which are National Statistics and can be found here https://www.gov.uk/government/collections/road-traffic-statistics.

Annexes B-D, England SRN Casualty Data by Severity, 2015-2018

The tables in Annexes B, C and D show the number of reported casualties by road class on England's SRN for slight, serious and fatal casualties. The analysis in this report draws upon these figures to illustrate how casualty rates vary across motorway types taking into account the growth of the smart motorway network. The conclusions of this report draw upon a wider range of evidence, which includes risk modelling as well as before and after studies.

These tables show the casualty split on different types of motorway. This data was provided by Highways England and is based on STATS19. The number of reported casualties on Strategic Road Network A Roads from 2015-2018 is taken from DfT statistics based on STATS19 data, which are national statistics, and can be found at https://www.gov.uk/government/statistics/reported-road-casualties-in-great-britain-annual-report-2018.

For context and ease of reference, the traffic from Table 4 for 2015-2018 is repeated in each annex.

Annex B: England SRN Slight Casualty Data 2015-2018

Table 6

Road Class	Number of Reported Slight Casualties			
	2015	2016	2017	2018
Conventional Motorway[1]	5,539	5,102	4,398	3,973
Controlled Motorway[1]	947	1,052	921	871
Dynamic Hard Shoulder[1]	521	459	461	413
All Lane Running[1]	245	373	398	443
All SRN 'A' Roads[2]	7,335	7,242	6,194	5,693

Sources: 1 - STATS19, Highways England Statistics on motorway slight casualties in England from 2015-18. 2 - STATS19, DfT Statistics on slight casualties on the Strategic Road Network in England from 2015-18

Table 7

Road Class	Motor Vehicle Traffic (Billion Vehicle Miles)			
	2015	2016	2017	2018
Conventional Motorway	48.1	47.6	47.0	45.2
Controlled Motorway	6.4	6.6	6.6	7.2
Dynamic Hard Shoulder	3.0	3.1	3.2	3.3
All Lane Running	1.4	2.7	3.9	5.1
All SRN 'A' Roads	30.8	32.2	33.4	34.0

Source: DfT Road Traffic Statistics on the Strategic Road Network in England from 2010-18.

Annex C: England SRN Serious Casualty Data 2015-2018

Table 8

Road Class	Number of Reported Serious Casualties			
	2015	2016	2017	2018
Conventional Motorway[1]	516	585	502	519
Controlled Motorway[1]	63	68	73	108
Dynamic Hard Shoulder[1]	44	34	45	23
All Lane Running[1]	14	42	41	72
All SRN 'A' Roads[2]	923	1,045	956	1,015

Sources: 1 - STATS19, Highways England Statistics on motorway serious casualties in England from 2015-18. 2 - STATS19, DfT Statistics on serious casualties on the Strategic Road Network in England from 2015-18

Table 9

Road Class	Motor Vehicle Traffic (Billion Vehicle Miles)			
	2015	2016	2017	2018
Conventional Motorway	48.1	47.6	47.0	45.2
Controlled Motorway	6.4	6.6	6.6	7.2
Dynamic Hard Shoulder	3.0	3.1	3.2	3.3
All Lane Running	1.4	2.7	3.9	5.1
All SRN 'A' Roads	30.8	32.2	33.4	34.0

Source: DfT Road Traffic Statistics on the Strategic Road Network in England from 2010-18.

Annex D: England SRN Fatality Data 2015-2018

Table 10

Road Class	Number of Reported Fatal Casualties			
	2015	2016	2017	2018
Conventional Motorway[1]	81	72	83	67
Controlled Motorway[1]	6	2	3	8
Dynamic Hard Shoulder[1]	5	2	1	1
All Lane Running[1]	0	1	4	10
All SRN 'A' Roads[2]	132	154	145	165

Sources: 1 - STATS19, Highways England Statistics on motorway fatal casualties in England from 2015-18. 2 - STATS19, DfT Statistics on fatal casualties on the Strategic Road Network in England from 2015-18

Table 11

Road Class	Motor Vehicle Traffic (Billion Vehicle Miles)			
	2015	2016	2017	2018
Conventional Motorway	48.1	47.6	47.0	45.2
Controlled Motorway	6.4	6.6	6.6	7.2
Dynamic Hard Shoulder	3.0	3.1	3.2	3.3
All Lane Running	1.4	2.7	3.9	5.1
All SRN 'A' Roads	30.8	32.2	33.4	34.0

Source: DfT Road Traffic Statistics on the Strategic Road Network in England from 2010-18.

Annex E: Glossary of Terms

Term	Explanation
All Lane Running (ALR) Motorways	All Lane Running (ALR) motorways apply the controlled motorway technology, permanently converts the hard shoulder as a running lane, and feature emergency areas.
Casualty Rate	The casualty rate takes the number of casualties and controls for the volume of traffic on the road, more specifically it is defined as the number of casualties per million vehicle miles travelled.
Controlled Motorways (CM)	Controlled Motorways apply technology to a conventional motorway to control the speed of traffic retaining a permanent hard shoulder.
Counterfactual	A counterfactual scenario is used to estimate what would have happened had a policy intervention, such as a smart motorway scheme, not taken place.
Dynamic Hard Shoulder Running (DHS) Motorways	Dynamic Hard Shoulder Running (DHS) Motorways apply the controlled motorway technology, and temporarily increase capacity by utilising the hard shoulder, and feature emergency areas.
Fatal and Weighted Injuries (FWI)	This gives a fatality ten times the weight of a serious casualty, and a serious casualty ten times the weight of a slight casualty. Specifically, it is calculated as: *Fatal and Weighted Injuries = Fatal casualties + Serious Casualties * 0.1 + Slight Casualties * 0.01*
Fatal Casualties	When a person has died from their injuries up to 30 days after the accident.
Outturn	The actual, observed amounts, results etc. rather than those that were expected.
Personal Injury Collisions (PIC)	Collisions involving at least one vehicle where there was a personal injury. The severity classification applied to the collision is based on the most severe casualty resulting from the collision.
Post Opening Project Evaluation (POPE) Reports	Highways England undertakes reviews on major road schemes to measure impact against forecast. The main mechanism for evaluating a new scheme is the Post Opening Project Evaluation (POPE), which evaluates the realisation of scheme benefits once they have been open to traffic for one and five years.
Serious Casualties	Injuries requiring hospitalisation, or any of the following injuries whether or not the individual went to hospital: fractures, concussion, internal injuries, crushing's, burns (excluding friction burns), severe cuts, severe general shock requiring medical treatment and injuries causing death 30 or more days after the accident.
Slight Casualties	A minor injury such as a sprain (including neck whiplash), bruise or cut which are not judged to be severe, or slight shock requiring roadside attention. This definition includes injuries not requiring medical treatment.
Smart Motorway	A smart motorway is 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.
Strategic Road Network (SRN)	In England, the Strategic Road Network is made up of motorways and trunk roads (the most significant 'A' roads). They are administered by Highways England, a government-owned company.