national highways

M25 junctions 23 to 27 all lane running

Five-year post-opening project evaluation

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Foreword

As Chief Customer and Strategy Officer, I want to know whether developments on our network are meeting their objectives and making a difference for our customers – the four million people that use the Strategic Road Network every day.

Evaluation is a key function in the safe running of the Strategic Road Network (SRN) and we carry out POPE[1] evaluations at set points during a major enhancement scheme's lifetime to enable us to take stock and make any necessary interventions. POPEs provide an early indication if the scheme is on track to deliver the benefits over 60 years as set out in the business case appraisal.

This report evaluates the M25 junctions 23 to 27 all lane running (ALR) smart motorway scheme within five years of operation following its conversion from a conventional three lane motorway.

An initial study was conducted one year after the M25 junctions 23 to 27 project which opened in 2014, followed by this report after five years which provides more robust data and analysis. The report includes an understanding of the safety and environmental impacts of a scheme, as well as how traffic has changed due to a scheme being in place and how the scheme supports the economy.

There are three types of smart motorway, all lane running (ALR), dynamic hard shoulder (DHS) and controlled motorway. ALR and DHS motorways create more space on some of the most congested sections of the SRN by using hard shoulder as a running lane either permanently or only at busy times. They create extra capacity with less disruption to road users and fewer environmental impacts than physically widening the road, along with reduced carbon emissions associated with construction.

Although the performance of individual scheme is important at a local level, drawing together findings at a programme level helps us to understand patterns and trends across our network.

Safety remains our number one priority and the five-year POPEs published to date (representing approximately a quarter of those in operation) demonstrate that smart motorways are delivering safety benefits in line with or above those originally forecast, with most schemes evaluated having lower collision rates than would have been expected on the conventional motorways they replaced. Where it has been possible to assess changes to the severity of such collisions, the evidence shows those collisions have been less severe.

The published five-year POPEs show that smart motorways are broadly on track to realise their envisaged environmental objectives. With further planned mitigation these will be fully met.

The five-year ALR and DHS POPEs published to date for smart motorways also show that the schemes are delivering much needed capacity with schemes accommodating up to almost a quarter (22%) more traffic than before they were converted into smart motorways. The reports indicate that many of the motorway

[1] Post Opening Project Evaluation (POPE)

sections would have been unable to cater for today's traffic (at the busiest times) if they had not been converted into smart motorways.

According the to the reports, the schemes are currently on course to deliver benefits, but will not deliver all the originally expected benefits within the 60-year appraisal period. There has been lower traffic growth than was expected when these schemes were appraised, due to the 2008 financial crisis and lower population growth than originally forecast (this will impact all transport schemes, built around this time). This means fewer drivers are benefiting today from smart motorway schemes than original anticipated. Five-year POPEs also show that traffic on some smart motorway sections is not travelling as quickly as was forecast at the appraisal stage. Together these factors have resulted in the value for money for all schemes with five-year appraisals, over the 60-year appraisal period, currently being lower than anticipated at this stage when compared with the original appraisal. This is, however, a forecast and there is the opportunity to take further action to improve benefits.

We have therefore examined these results in detail and have identified specific actions to further improve the performance of schemes, including:

- Standardised operating procedures for DHS schemes
- Technology improvements
- Optimisation of the algorithms that set speed limits
- Investigating physical constraints off the network that impact performance

We will continue to monitor schemes in operation, enabling us to track their benefits and take further action if required to ensure these schemes deliver an improved experience for our customers.

Elliot Shaw

Chief Customer and Strategy Officer

September 2023

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1. Executive summary

The M25 junctions 23 to 27 smart motorway is a 16-mile stretch of road on the Greater London, Essex and Hertfordshire boundary. The motorway was converted to smart motorway all lane running[2] (ALR). The section between junctions 23 and 25 opened in April 2014, and between junctions 25 and 27 opened in November 2014.

Our smart motorway sections have provided additional road capacity, creating more road space on congested sections of motorway. This has particularly provided more reliable journeys for road users at the busiest and periods of the day. This has allowed people to travel as conveniently, reliably, and safely as possible. This means more traffic can use the strategic road network rather than divert on to the local road network causing further congestion.

This project aimed to provide additional capacity to reduce congestion, better manage traffic conditions and improve journey time reliability while maintaining safety for road users and minimising adverse environmental effects of the project.

The additional lane available to road users at busy periods provided extra capacity and led to improvements in customer journeys. Traffic flows on the route increased by an average of 22%[3] from 2012 to 2019, this was greater than the average growth across the strategic road network (12%). Journey time reliability[4] broadly remained similar or slightly worse compared before, whilst accommodating an increased number of road users.

The increase in the use of the road and the part time speed restrictions meant that journey times tended to be longer after the conversion in the less busy periods. However, journey times on the former motorway layout would have been even longer if the conversion had not been implemented, leading to overall benefits in journey times. When accounting for the observed increase in traffic, if the section of road had remained a 3-lane motorway, it would have been unable to support the additional road users, without experiencing a reduction in speed.

Over the five-year evaluation period following the opening of the project, there was an increase in the number of personal injury collisions[5] on the M25 between junctions 23 and 27. When accounting for the higher flow capacity and the increased volume of motorway users over this period, the rate of personal injury collisions improved. This means that the likelihood of a motorway user incurring a personal injury collision reduced. Road user safety in the wider area improved with fewer personal injury collisions and a reduced severity of collisions observed in the five years after opening.

[2] All lane running (ALR) motorways apply technology to control speeds, and permanently convert the hard shoulder to a running lane. Emergency areas are available at regular intervals providing places to stop in an emergency.
[3] Comparing average weekday traffic (AWT) between 2012 and 2019.
[4] The extent to which journey times vary from the average journey time indicates how reliable a journey is.
[5] A collision that involves at least one vehicle and results in an injury to at least one person.

Slight adverse impacts were expected for some aspects of the environment, including landscape and visual impacts. This was attributed to the gantries, and controlled motorway signage increasing the perception of urbanisation within the countryside surroundings. The five years after evaluation confirmed this impact was as expected. This is attributed to the loss of screening vegetation to accommodate the new motorway infrastructure. Mitigation measures were implemented but requires more time to develop to fully screen the gantries and Controlled Motorway signage. Changes in air quality were likely to be better than expected because the traffic flows using the M25 were lower than forecast. Furthermore, local air quality management area reporting along the project indicated exceedances are not attributed to the project.

Based on the evidence from the first five years, this project is not yet fully realising its anticipated value for money. It is nevertheless delivering some benefits - construction of the project was delivered under budget, it is delivering safety benefits to road users and most of the environmental benefits are as expected, or better.

2. Introduction

What is the project and what was it designed to achieve?

The M25 junctions 23 to 27 smart motorway covers a 16-mile stretch of the M25 in Essex / Hertfordshire. The project was completed in two stages: junctions 23 to 25 opened in April 2014 and junctions 25 to 27 opened in November 2014.

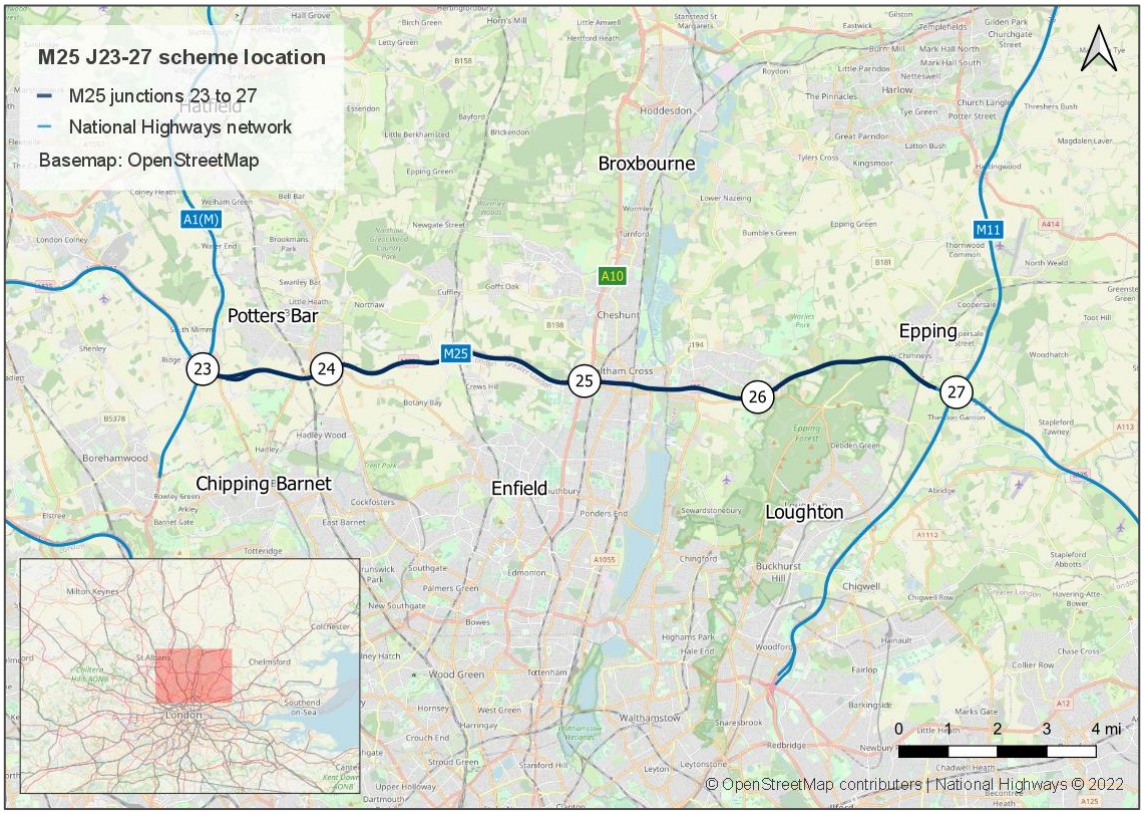
The M25 is part of the strategic road network and one of Europe's busiest motorways. Vehicle demand on the M25 is high, which places pressure on the network and leads to delays and unpredictable journey times, especially during peak hours.

The M25 between junction 23 and junction 27 is an all lane running smart motorway that permanently converted the hard shoulder to a running lane and applied technology to control speeds. Emergency areas are now available at regular intervals, providing places to stop in an emergency.

Project location

The M25 is an orbital route encircling most of Greater London. The 16-mile section between junctions 23 to 27 lies to the north of London in Hertfordshire and Essex. Figure 1 shows the location of the project. Junction 23 is the intersection with the A1(M), while junction 27 is the intersection with the M11. The studied section encompasses two tunnels: Holmesdale between junctions 25 and 26, and Bell Common between junctions 26 and 27.

Figure 1 M25 Junctions 23 to 27 project location



Source: National Highways and OpenStreetMap contributors

How has the project been evaluated?

Post-opening project evaluations are carried out for major projects to validate the accuracy of expected project impacts which were agreed as part of the business case for investment. They seek to determine whether the expected project benefits are likely to be realised and are important for providing transparency and accountability for public expenditure, by assessing whether projects are on track to deliver value for money. They also provide opportunities to learn and improve future project appraisals and business cases.

A post-opening project evaluation compares changes in key impact areas[6] by observing trends on a route before a project is constructed (baseline) and tracking these after it has opened to traffic. The outturn impacts are evaluated against the expected impacts (presented in the forecasts made during the appraisal) to review the project's performance. For more details of the evaluation methods used in this study please refer to the post-opening project evaluation (POPE) methodology manual on our website.[7]

[6] Key impact areas include safety, journey reliability and environmental impacts.
[7] https://nationalhighways.co.uk/media/exypgk11/pope-methodology-note-jan-2022.pdf

3. Delivering against objectives

How has the project performed against objectives?

All our major projects have specific objectives which are defined early in the business case when project options are being identified. This project's objectives primarily related to reducing congestion and improving journey time reliability, while maintaining safety for road users and minimising adverse environmental effects.

These objectives are appraised to be realised over 60 years; a five-year evaluation provides early indication if the project is on track to deliver the benefits.

Table 1 summarises the project's performance against each of the objectives, using evidence gathered for this study.

Table 1 Objectives and evaluation summary

Objective	Five-year evaluation
Reduce congestion and develop solutions that provide additional capacity, increase journey time reliability and ensure the safe and economic operation of the motorway.	The M25 junctions 23 to 27 has been upgraded to a smart motorway all lane running which has provided additional capacity. The journey time reliability and safety performance are considered below.
Improve journey time reliability by improving and better managing traffic flow conditions.	Traffic flow conditions are managed with variable mandatory speed limits (VMSL) technology to smooth the flow of traffic, reducing the stop-start movement. Across time periods, and in both directions, customers experienced a negligible change or worsening of journey time reliability.
"After" collision numbers (per annum) should be no greater than those in the "before" and the severity ratio should not increase.	The evaluation found the number of personal injury collisions increased, however given the upgraded motorway carried larger flows, the rate of collisions decreased. This finding was not statistically significant. The severity ratio improved. For the wider area, the number of personal injury collisions reduced by 10%. The five years after evaluation suggests that the project has improved safety in light of increased traffic but cannot confidently conclude it has met its objective[8].
Make best use of existing infrastructure providing additional capacity within the existing highway boundary, other than in exceptional circumstances.	The M25 has been provided with additional capacity within the highway boundary due to the conversion of the hard shoulder to a permanent running lane.
Minimise detrimental environmental effects of the smart motorway by mitigation measures, taking account of costs, availability of funding and statutory obligations.	Environmental effects five years after opening were as expected or better than expected to those predicted in the appraisal.

[8] Projects are appraised over a 60-year period. This conclusion is based on the findings at five years after the project opened for traffic

Objective	Five-year evaluation
Improve the currency and quality of information provided to drivers about the state of traffic flow on the motorway.	Variable Messaging Signs (VMS) on gantries above the M25 have improved driver information.
Support and enhance the current role of M25 as a major national and inter-urban regional transport artery.	The additional capacity enhanced the motorway's role as a major transport artery – attracting traffic away from less suitable roads. The observed traffic growth on this length of the M25 between 2012 and 2019 was greater than national trends.
Maximise the return on public investment.	The re-forecasted value for money analysis (section 7) identified that, based on the first five years of operation, the project is not on track to deliver the forecast value for money, without further action to optimise benefits.

4. Customer journeys

Summary

The route is now supporting an increased number of road users. Traffic growth on the route had increased by an average of 22%[9] from 2012 to 2019. However, the traffic growth forecasts were found to be too high when compared with the observed data five-years after opening. This was because the modelling and appraisal was undertaken before the impact of the 2008 recession and before the effect of the subsequent austerity measures on traffic growth were fully known. Since then, we have refined the assumptions made when assessing new projects and consider systematic events, such as a recession, with a range of high and low growth forecast scenarios.

Journey reliability[10] and journey times broadly remained similar or slightly worse compared to the three-lane conventional motorway whilst accommodating an increased number of road users. It was particularly notable that journey times for those travelling anti-clockwise on a Friday were longer five-years after the project opened. On most occasions, the observed journey time saving was found to be greater than that forecast.

The operation of the variable mandatory speed limit (VMSL) technology was reflected in the observed journey times. During periods of the week when VMSL is operated frequently – for example on weekday mornings in the anti-clockwise direction – the journey times were longer, and the reliability statistics deteriorated – for example on Friday afternoons in the clockwise direction.

Without the additional capacity of the fourth lane, it is unlikely that the former three-lane motorway would have been able to support the increased demands of road users, leading to even slower journeys and congestion as drivers would have to frequently brake, which would lead to flow-breakdown, the forming of queues and more unreliable journeys.

How have traffic levels changed?

Smart motorways are built on stretches of motorway that experience high levels of congestion and are expected to see traffic levels increase in future years. The following sections examine how the traffic levels changed over the evaluation period and to what extent the forecast traffic levels were realised.

National and regional

To assess the impact of the project on traffic levels, it is helpful to understand the changes within the context of national and regional traffic. To do this, we use the Department for Transport annual statistics. The data is reported by local authority and road type, recording the total number of million vehicle kilometres travelled[11]. This data is used as a baseline, and we attribute any growth observed on roads in the project area which is above national and regional trends to the project.

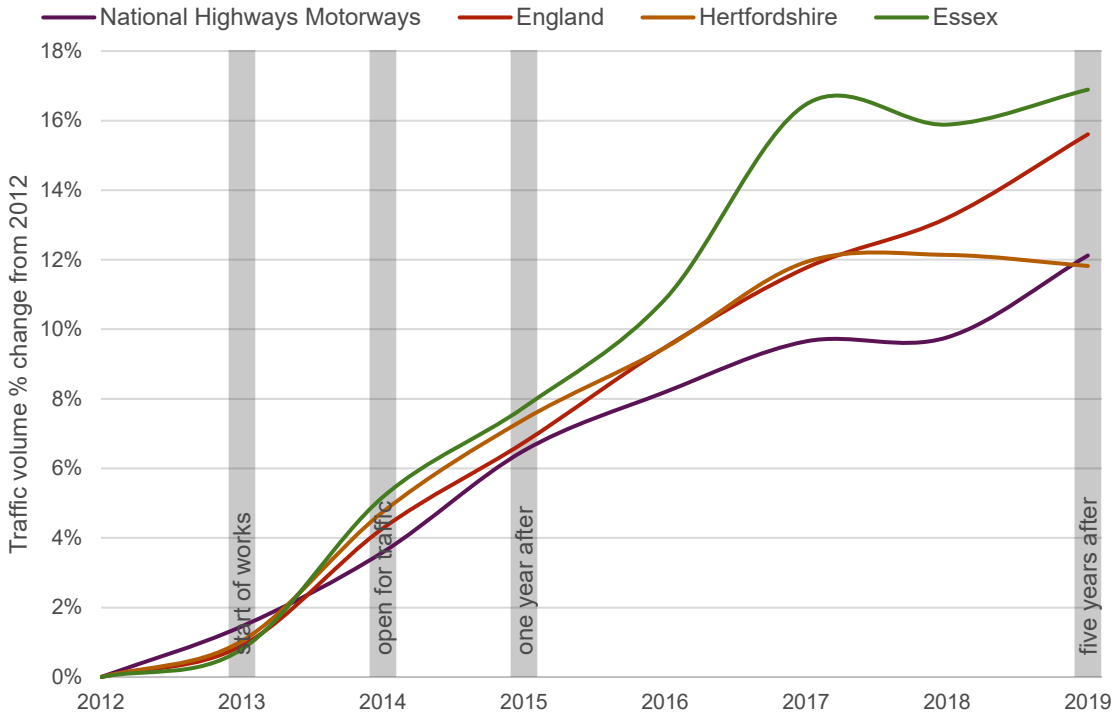
[9] Comparing average weekday traffic (AWT) between 2012 and 2019.
[10] The extent to which journey times vary from the average journey time indicates how reliable a journey is.
[11] Motor vehicle traffic (vehicle kilometres) by region in Great Britain, annual from 1993 to 2019, Table TRA 8904, Department for Transport

Figure 2 shows traffic growth in England and the local counties between 2012 (before construction) and 2019 (five year after project opened). Traffic increased by 12% in Hertfordshire and National Highways motorways, with Essex experiencing slightly more growth at 17%.

Considering local, regional and motorway traffic trends, growth of 12-17% might be expected to have occurred between 2012 and 2019 regardless of the project being implemented. The evaluation observed traffic growth on the M25 junctions 23 to 27 during the same period, had increased by an average of 22%[12].

The analysis in the following sections should be considered in this context as no adjustments have been made to take account of background traffic growth.

Figure 2 National and regional traffic volume changes (2012-2019)



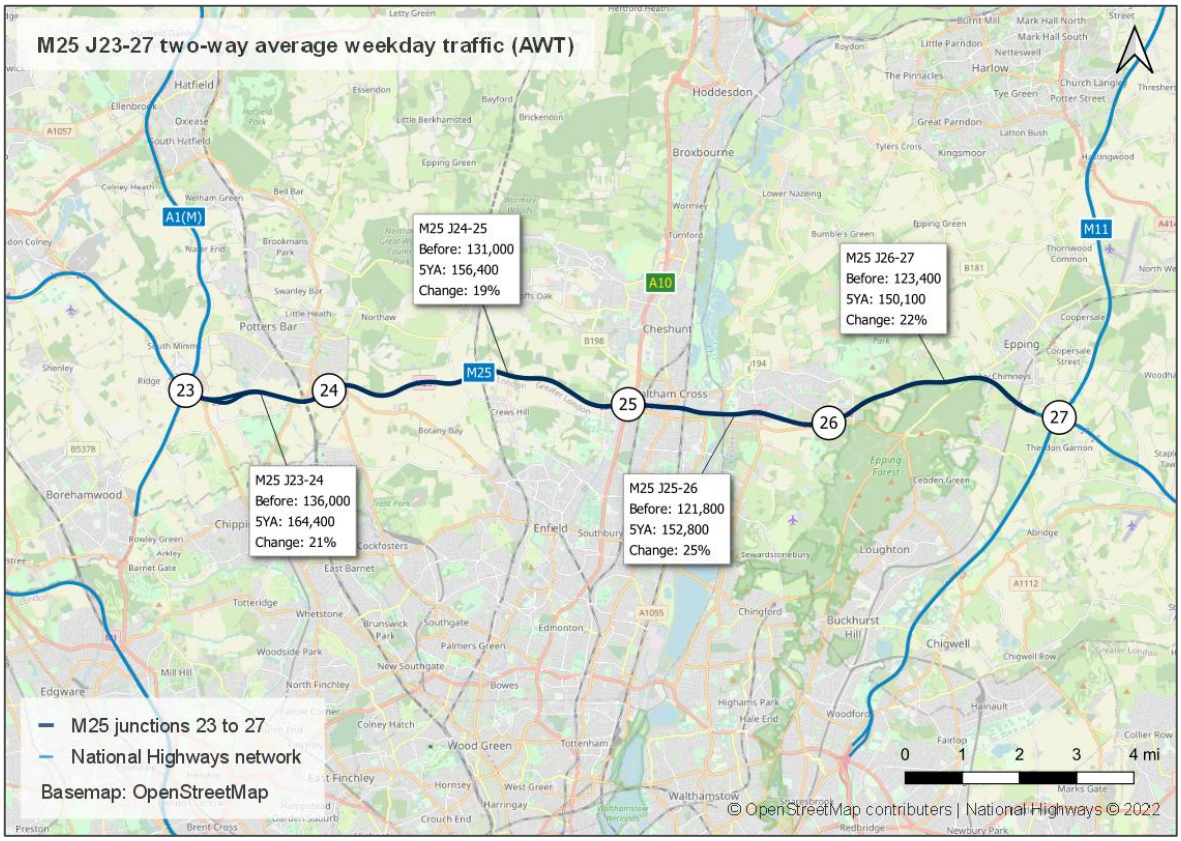
Source: Department for Transport Road Traffic Statistics Table TRA 8904
https://www.gov.uk/government/statistical-data-sets/road-traffic-statistics-tra

[12] Comparing average weekday traffic (AWT) between 2012 and 2019.

How did traffic volumes change?

Figure 3 shows the observed average weekday traffic (AWT) flows at strategic locations before and five-years after the opening of the project. The evaluation found that traffic flows on the route had increased by an average of 22%[12] from 2012 to 2019. This was higher than the average growth across the strategic road network. The largest two-way growth (25%) was seen between junctions 25 and 26.

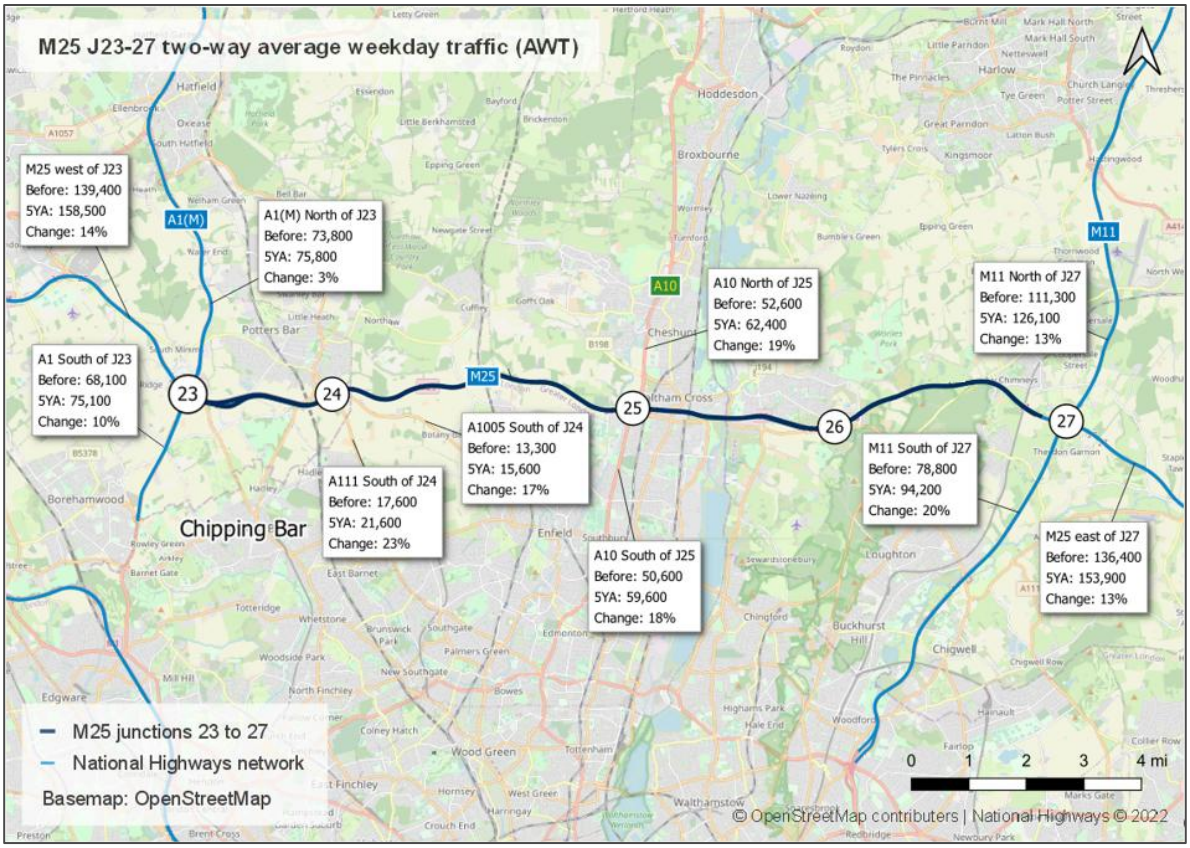
Figure 3 Changes in traffic volumes for strategic locations



Sources: National Highways WebTRIS, commissioned counts 2012 and 2019. OpenStreetMap contributors.

Figure 4 shows the change in traffic volumes on local roads connected to the M25, generally those local roads to the south have seen larger flow increases compared to those to the north. This flow increase on perpendicular routes indicates that trips are being drawn into the M25 corridor.

Figure 4 Changes in traffic volumes on connected roads



Sources: National Highways WebTRIS, commissioned counts 2012 and 2019. OpenStreetMap contributors.

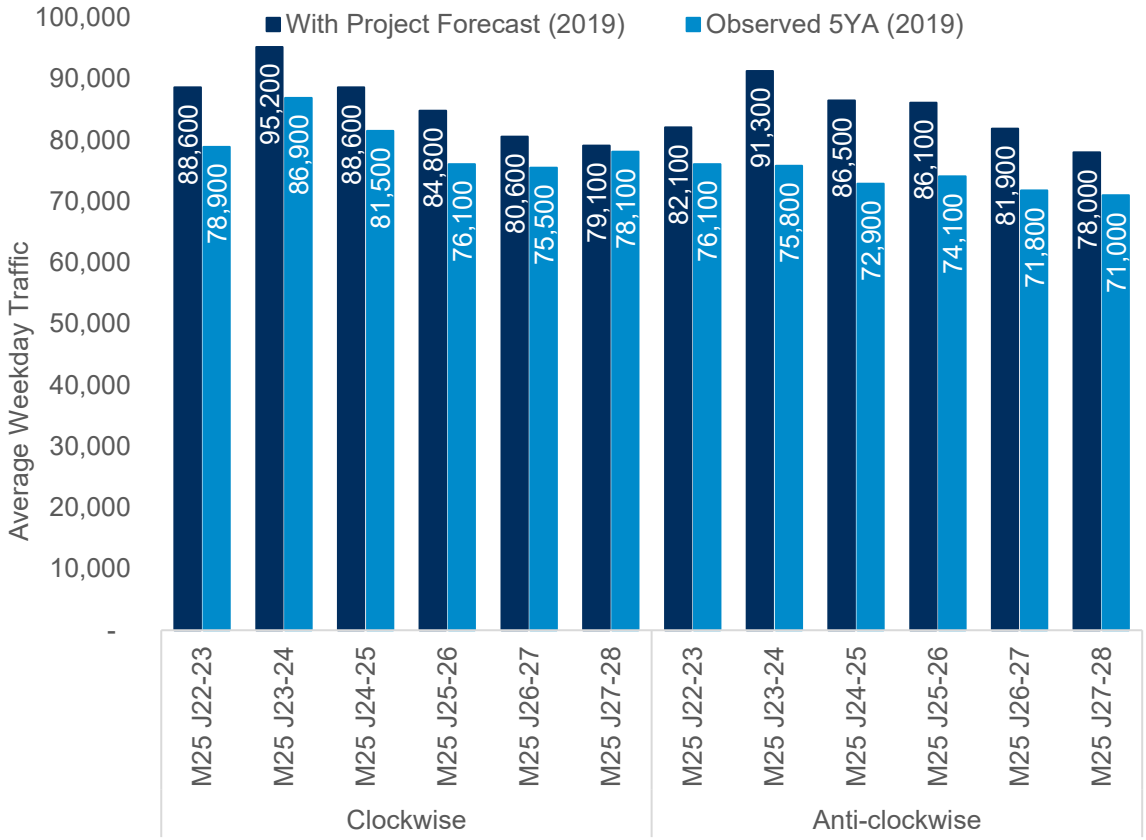
Was traffic growth as expected?

The modelling and appraisal were completed before the impact of the 2008 recession and the effects of the subsequent austerity measures were fully known. The same travel demand forecasting inaccuracy would have had the same impact on both the without and with project forecasts. The 2019 forecast flow attracted to the motorway by the improvement varied by section and direction and ranged from 10,400 vehicles per day (15%) for the project length from J26 to J27 clockwise up to 14,500 vehicles per day (19%) for the project length from J23 to J24 clockwise.

These traffic forecasts for 2019 (prepared before construction commenced) of the ‘with project’ case were higher than observed five years after (5YA), as shown in Figure 5. The difference varied by section and direction and ranged from 1,000 vehicles per day (1%) to 15,500 vehicles per day (20%).

We have refined the assumptions made when assessing new projects. The method for forecasting traffic growth includes adjustments for a range of high and low growth forecasting scenarios to account for external systemic events, for example a financial crisis, or other scenario that could adversely impact the demand for travel.

Figure 5 Forecast and observed traffic volume



Note: The 2019 with project forecast is interpolated between the 2015 opening year and 2030 design year traffic model. Observed data from National Highways count data, October 2019.

Relieving congestion and making journeys more reliable

We implement smart motorways on the busiest routes to ease congestion and ensure journey times are more predictable. Often these routes are where we anticipate congestion will increase in the future and our actions seek to limit this.

Analysis of journey times and speeds can indicate the impact of the smart motorway on congestion[13]. The extent to which journey times vary from the expected average journey time indicates how reliable a journey is.

Did the project deliver journey time savings?

Journey time data was obtained before construction started and five years after the project opened[14]. This data was obtained for the weekday AM peak, inter-peak (IP) and PM peak for Monday to Thursday and Friday, as well as a weekend period.

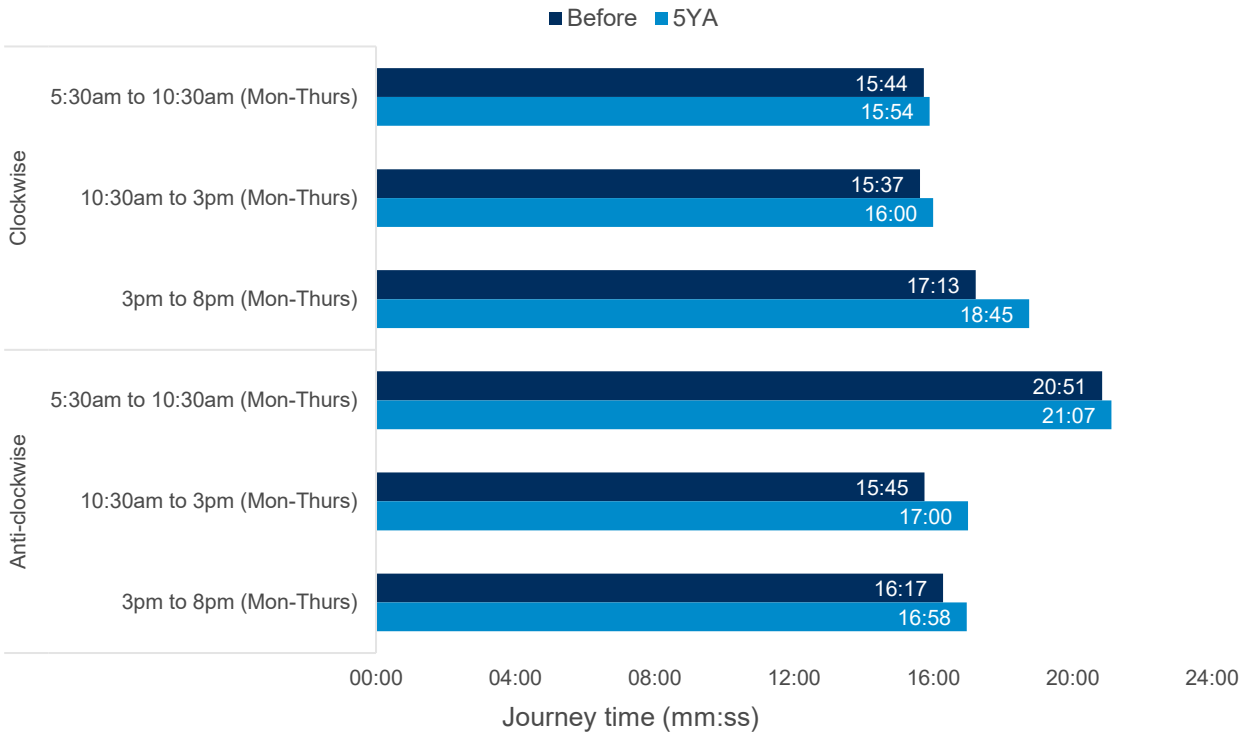
[13] In this section we are presenting before and after journey times unadjusted. For section 7 (value for money) we have compared outturn journey times against a counterfactual estimate of what journey times are likely to have been without the project. This allows for the deterioration in journey times that we would have expected to have happened due to growth in background traffic levels causing additional congestion.

[14] Before: 1st February 2012 to 31st January 2013,
Five years after (5YA): 1st January 2019 to 31st December 2019.

The change in average journey times during Monday to Thursday is shown in Figure 6. The evaluation found that in the AM peak there was little change in the average journey time in both directions. In the inter-peak, there was a small deterioration in the average journey time, while the anti-clockwise average journey time increased by 1 minute 15 seconds. The average journey times in the PM peak increased in both directions, with the greater increase in the clockwise direction (1 minute 32 seconds).

Without the increased capacity that the project provided, we expect the journey times would have continued to deteriorate as the travel demands have increased.[15]

Figure 6 Monday to Thursday observed average journey times by peak period



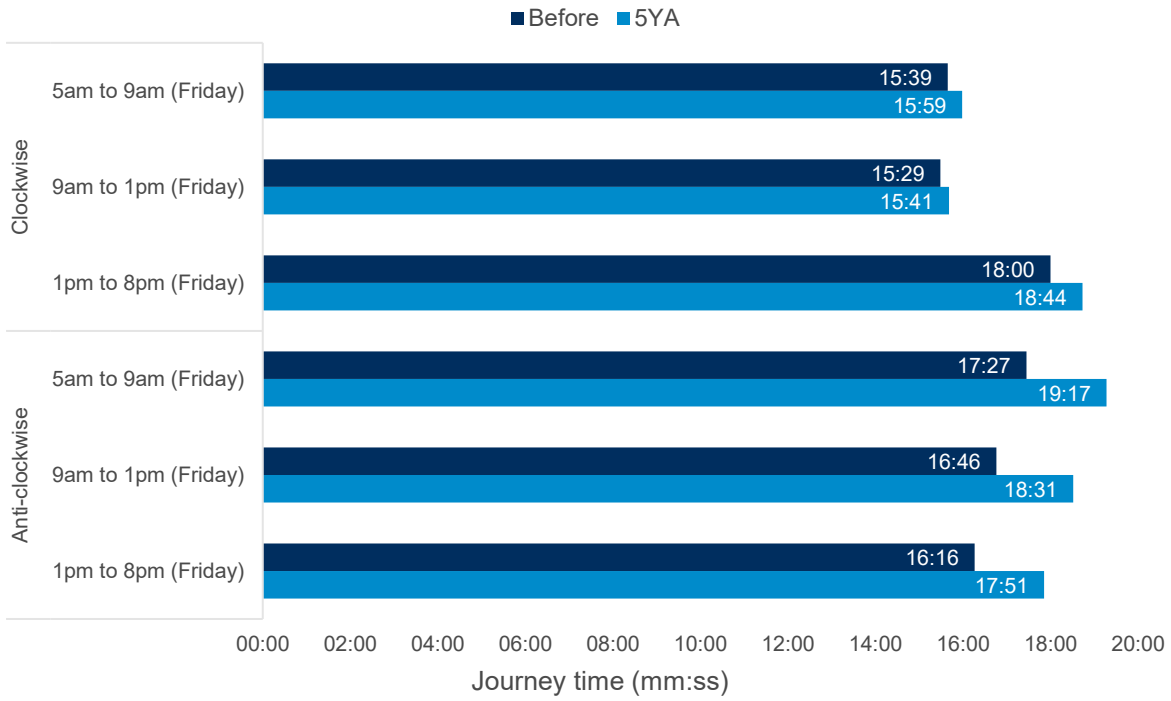
Source: TomTom satnav data. Before: Feb 2012 - Jan 2013, 5YA: Jan 2019 - Dec 2019.

Figure 7 presents the average journey time on a Friday. This shows the clockwise trend is similar to that seen Monday to Thursday, with marginal changes in the AM peak and inter-peak, with an increase in the PM peak. Five years after opening the average PM peak clockwise journey time on a Friday was consistent with that observed on a Monday to Thursday.

In the anti-clockwise direction, Figure 7 shows a worsening of average journey times throughout the day.

[15] In this section we are presenting before and five years after journey times unadjusted.

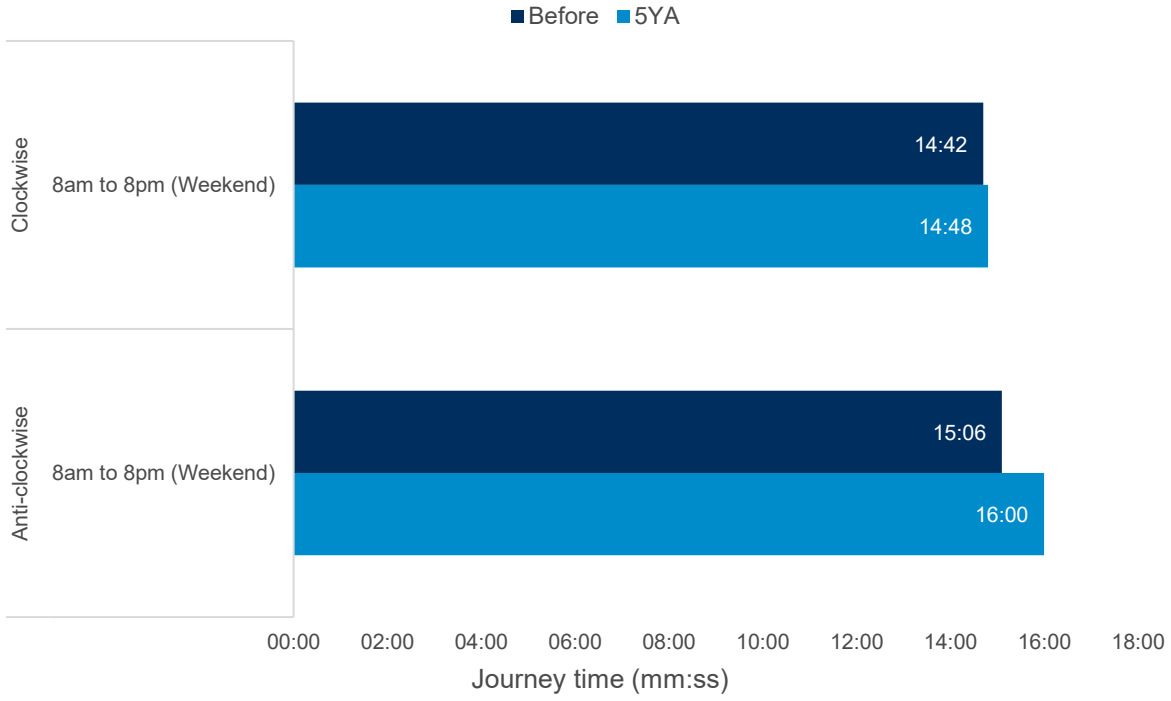
Figure 7 Friday observed average journey times by period



Source: TomTom satnav data. Before: Feb 2012 - Jan 2013, 5YA: Jan 2019 - Dec 2019.

There was little change in the average journey time observed clockwise at the weekend, but there was an increase in the anti-clockwise direction of less than one minute (Figure 8).

Figure 8 Weekend observed average journey times



Source: TomTom satnav data. Before: Feb 2012 - Jan 2013, 5YA: Jan 2019 - Dec 2019.

The increase in journey times is likely to be a combination of increased traffic and deployment of the variable mandatory speed limit (VMSL) technology to smooth the flow of traffic, which reduces the number of stop-start movements when traffic flows are close to the capacity of the motorway.

At five years after, the 2019 journey times have seen little change or are slightly longer compared to the 'before project' conditions in 2012. Journey times tend to increase as traffic levels increase over time. In this case, the five-year after conditions on the M25 are accommodating seven years of traffic growth plus the beneficial effects of attracting journeys away from less appropriate roads. When accounting for the observed traffic growth seen at five years after, if the section of road had remained as a 3-lane motorway they would have been unable to support the additional road users, without experiencing a reduction in speed[16].

The calculations undertaken to support the value for money analysis in section 7 compare the journey times against an estimate of what the 2019 journey times would have been without the project (the 'counterfactual' case). When compared against the counterfactual journey times, the project is delivering a benefit at five years after[17].

Were journey time savings in line with forecast?

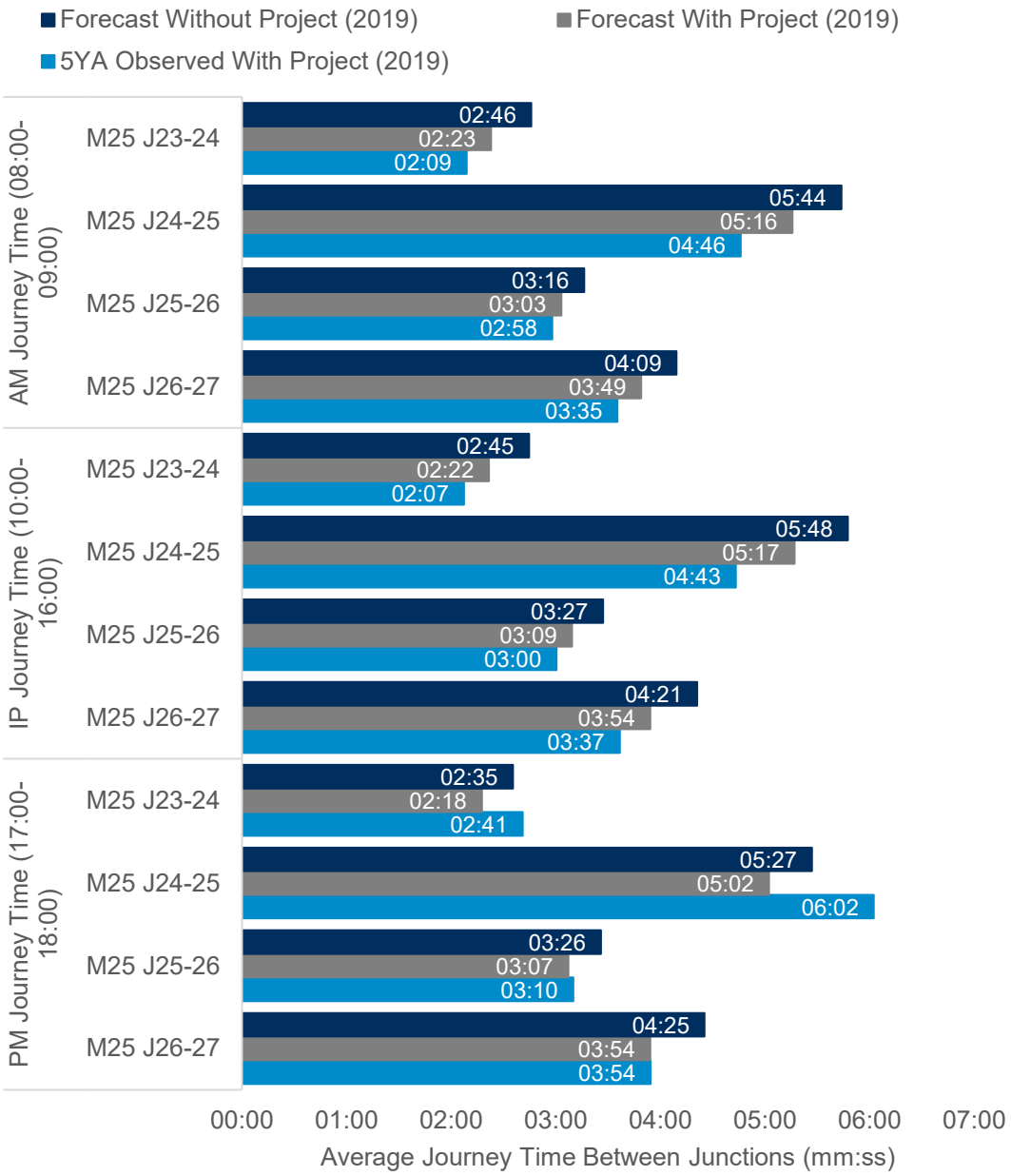
Journey time savings were forecast over the project's extent. It should be noted that the forecasts prepared before construction do not directly align with the weekday time periods of the observed five-year data. The observed five-year data was collated for much wider peak periods and treated Fridays separately from the rest of the week. Therefore, direct comparisons of forecast and observed five-year data for journeys are approximate. A comparison was undertaken using calculated forecast journey times inferred from the forecast speeds.

The observed journey times have been compared to the forecast journey times on each junction-to-junction section for the clockwise and anti-clockwise directions in Figure 9 and Figure 10 respectively. The figures show that, except in the PM peak hour, the observed journey times were quicker than forecast.

[16] Analysis has shown that with observed increased in traffic at five years after, a 3-lane motorway would not be able to support these additional road users without experiencing a reduction in speed, in at least one peak time period.

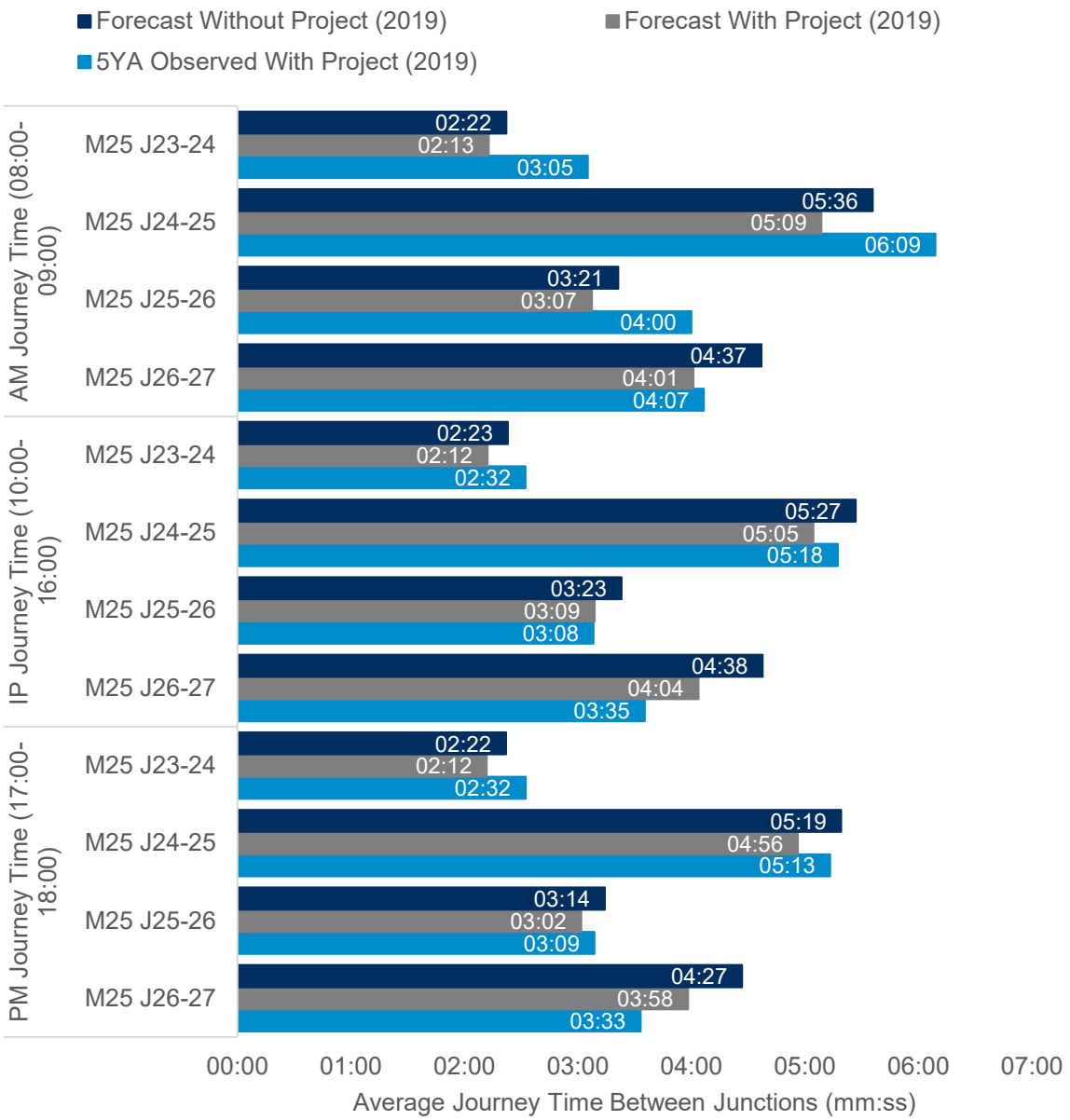
[17] In this section we are presenting before and after journey times unadjusted. For section 7 (value for money) we have compared outturn journey times against a counterfactual estimate of what journey times are likely to have been without the project. This allows for the deterioration in journey times that we would have expected to have happened due to growth in background traffic levels causing additional congestion. The counterfactual calculation along the project length of the M25 estimated that there would have been a benefit of 64 vehicle hours in the fifth year after opening.

Figure 9 Observed journey times compared to forecast - clockwise



Sources: Forecasts from Traffic Forecasting Report. Observed journey times from TomTom satnav data. 5YA: Jan 2019 - Dec 2019.

Figure 10 Observed journey times compared to forecast – anti-clockwise



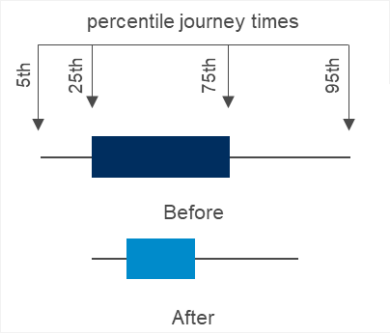
Sources: Forecasts from Traffic Forecasting Report. Observed journey times from TomTom satnav data.
5YA: Jan 2019 - Dec 2019

Did the project make journeys more reliable?

When traffic flow demands approach the capacity of a motorway, the journey times become unreliable. If the time taken to travel the same journey each day varies, the road user is less confident in planning how long their journey will take them. If journey times do not vary, the road user can be more confident in the time their journey will take and allow a smaller window of time to make that journey. If a road user plans a journey and allows for the unreliable journey time but then arrives at a destination earlier than anticipated, then this can result in non-productive time.

The distribution of journey times for the M25 junctions 23 to 27 were analysed and the statistics of variation are presented as box-and-whiskers diagrams for the clockwise and the anti-clockwise journeys. An explanation of what metrics are shown in the box-and-whiskers diagrams is detailed in Figure 11.

Figure 11 What does a box plot show?



The lowest point is the 5th percentile, this means 5% of journeys take less than this amount of time to complete. The highest point is the 95th percentile, this means 95% of journeys take less time than this to complete. This shows the difference between the longest and the shortest journey times observed.

The length of the box shows how the journey times vary between the 25th and 75th percentile (the journey time 25% and 75% of journeys are faster than). The narrower the box the less variable, and hence more reliable, the journey.

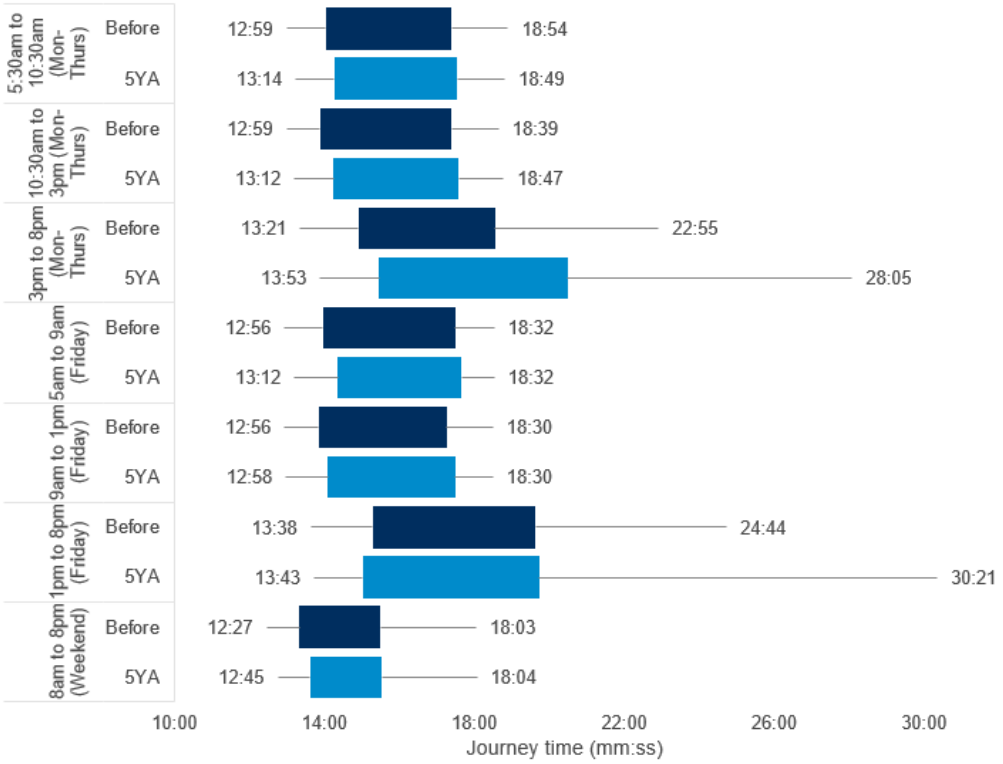
The journey time reliability is depicted by the box-and-whisker plots in Figure 12 (clockwise) and Figure 13 (anti-clockwise).

For most road users travelling in the clockwise direction, the reliability remained broadly the same in all time periods apart from the two bars representing PM weekdays (Mondays to Thursdays and on Fridays) where the average journey has become more unreliable.

For road users in the anti-clockwise direction the reliability in all time periods was slightly worse five years after opening compared to journey times before construction of the smart motorway.

These time periods and directions had the greatest use of VMSL technology, which would have been in operation for some of the observed days. The smart motorway project increased the capacity of the motorway and smoothed the flow of traffic. But for the individual road user, the mandatory speed limit encountered is a variable.

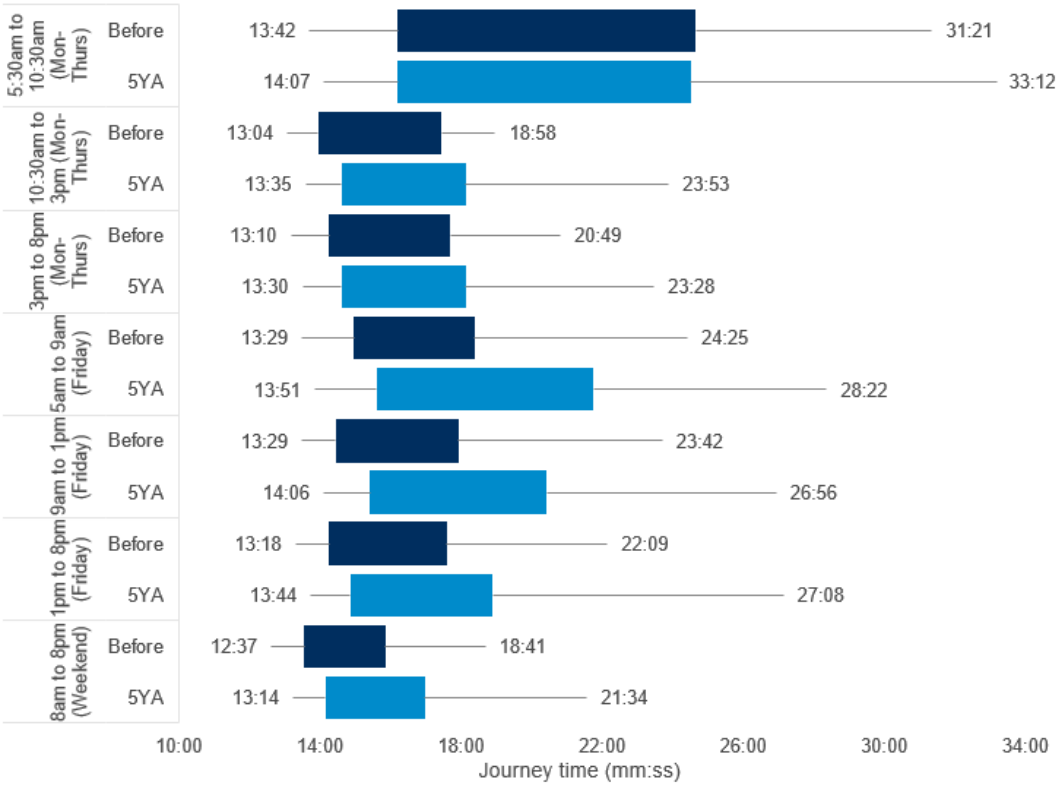
Figure 12 Journey time reliability – clockwise



time taken to drive through the project (mm:ss)

Source: TomTom satnav data. Before: Feb 2012 - Jan 2013, 5YA: Jan 2019 - Dec 2019.

Figure 13 Journey time reliability – anti-clockwise



time taken to drive through the project (mm:ss)

Source: TomTom satnav data. Before: Feb 2012 - Jan 2013, 5YA: Jan 2019 - Dec 2019.

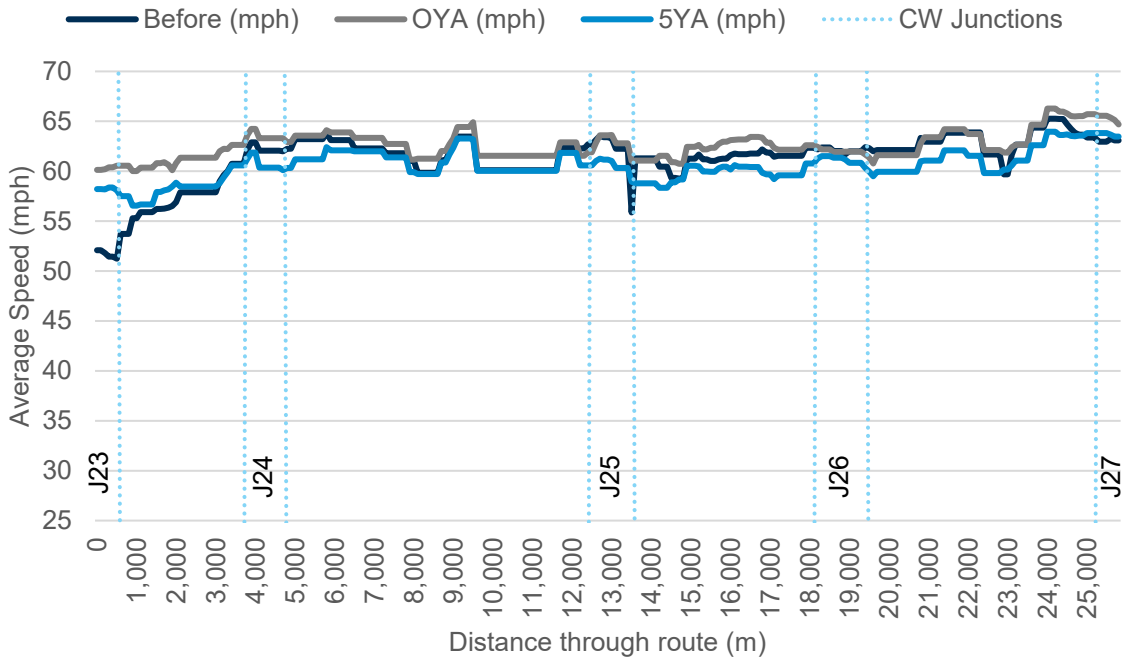
How did the project impact road user's speeds?

In combination with journey time analysis, it is helpful to understand how speeds vary across the route. Average journey speeds are not necessarily quicker as a result of a smart motorway. Smart motorways are often implemented where there is congestion and/or an increase in traffic flow demand is expected in the future years. However, smart motorways aim to make journeys smoother, and therefore speeds should be more consistent, with road users less likely to be accelerating and braking leading to flow breakdown and unnecessary queuing.

The speed comparisons for Monday to Thursday AM peak clockwise and anti-clockwise are shown in Figure 14 and Figure 15 respectively. Meanwhile, the PM peak clockwise and anti-clockwise speed comparisons are presented in Figure 16 and Figure 17 respectively.

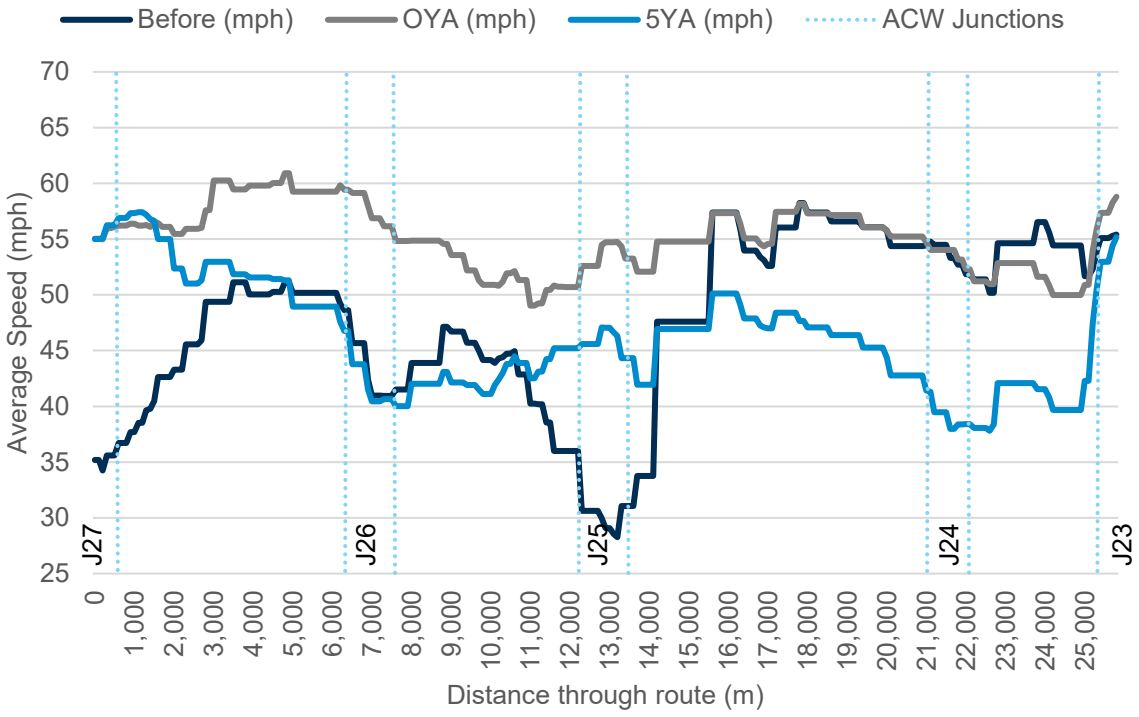
The evaluation observed some periods of improved speed, but on average an overall reduction consistent with the variable speed limits introduced by the project. There was some evidence of traffic flows becoming smoother, suggesting the project eased some of the fluctuations in speeds. For example, in the anti-clockwise direction, the AM peak reduced speeds at the junction 27 and junction 23 merges, which were observed before the project was implemented, were eliminated in the one year after opening and five years after opening observations.

Figure 14 Monday-Thursday AM average spot-speed comparison – clockwise



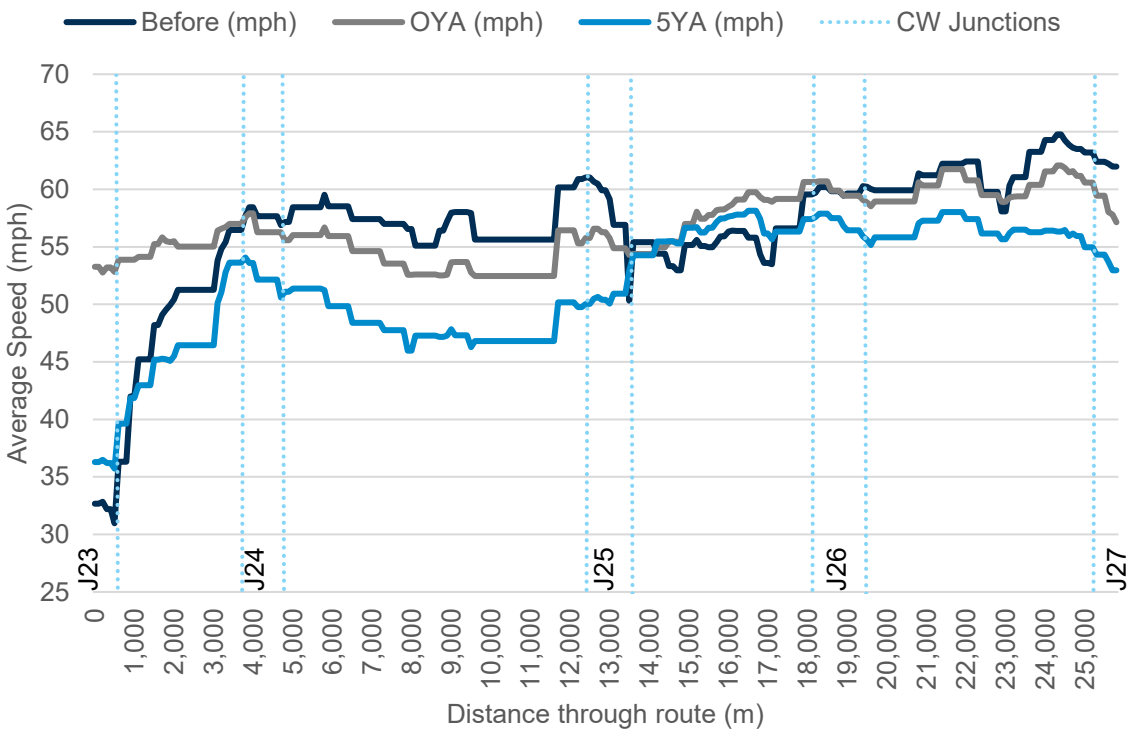
Source: TomTom satnav data. Before: Feb 2012 - Jan 2013, 1YA: Nov 2014 – Apr 2015, 5YA: Jan 2019 - Dec 2019.

Figure 15 Monday-Thursday AM average spot-speed comparison – anti-clockwise



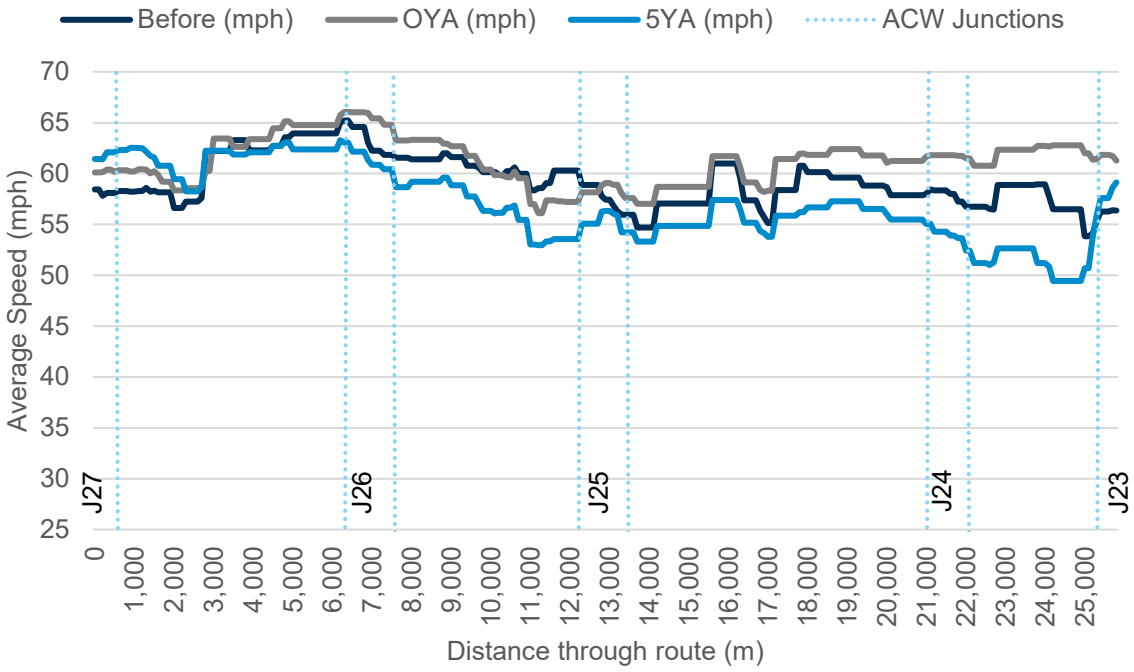
Source: TomTom satnav data. Before: Feb 2012 - Jan 2013, 1YA: Nov 2014 – Apr 2015, 5YA: Jan 2019 - Dec 2019.

Figure 16 Monday-Thursday PM average spot-speed comparison - clockwise



Source: TomTom satnav data. Before: Feb 2012 - Jan 2013, 1YA: Nov 2014 – Apr 2015, 5YA: Jan 2019 - Dec 2019.

Figure 17 Monday-Thursday PM average spot-speed comparison – anti-clockwise



Source: TomTom satnav data. Before: Feb 2012 - Jan 2013, 1YA: Nov 2014 – Apr 2015, 5YA: Jan 2019 - Dec 2019.

5. Safety evaluation

Summary

The safety objective for this project was for the number of collisions to be no greater than those before the project was implemented and for no increase in the severity ratio.

The number of personal injury collisions[18] and the rate of these collisions per hundred million vehicle miles were analysed to track changes over time.

There has been an annual average increase of five personal injury collisions, which is not in line with the appraised business case for the project. This is based on an annual average of 90 personal injury collisions after the project was operational compared with 85 before the project. If the road had remained a conventional motorway, we estimate that the number of personal injury collisions would have been between 70 and 110.

Before the project, the collision rate was 14 per hundred million vehicle miles (hmvm), this equates to traveling seven million vehicle miles before seeing an accident. When accounting for the increased volume of road users over this period, the annual average rate of personal injury collisions per hmvm improved over time. The average collision rate decreased to 13 per hundred million vehicle miles, this equates to travelling eight million vehicle miles before seeing an accident.

When accounting for the increased number of road users over this period, there had been a reduction from 0.7 to 0.6 fatality equivalents[19] per hundred million vehicle miles travelled. Reducing the risk of a fatality equivalent by 0.1 for every hundred million vehicle miles travelled.

The five-year evaluation suggests that the project has improved safety in light of increased traffic but cannot confidently conclude it has met its objective[20].On the surrounding network[21] there was an average reduction of 167 personal injury collisions per year (based on an annual average of 927 personal injury collisions observed after the project had opened compared with 1,094 before the project). If the road had not been converted to a smart motorway, we estimate that the number of personal injury collisions per year would be between 1,207 to 1,361. Against this counterfactual projection, the wider model area has seen savings of 358 personal injury collisions per year.

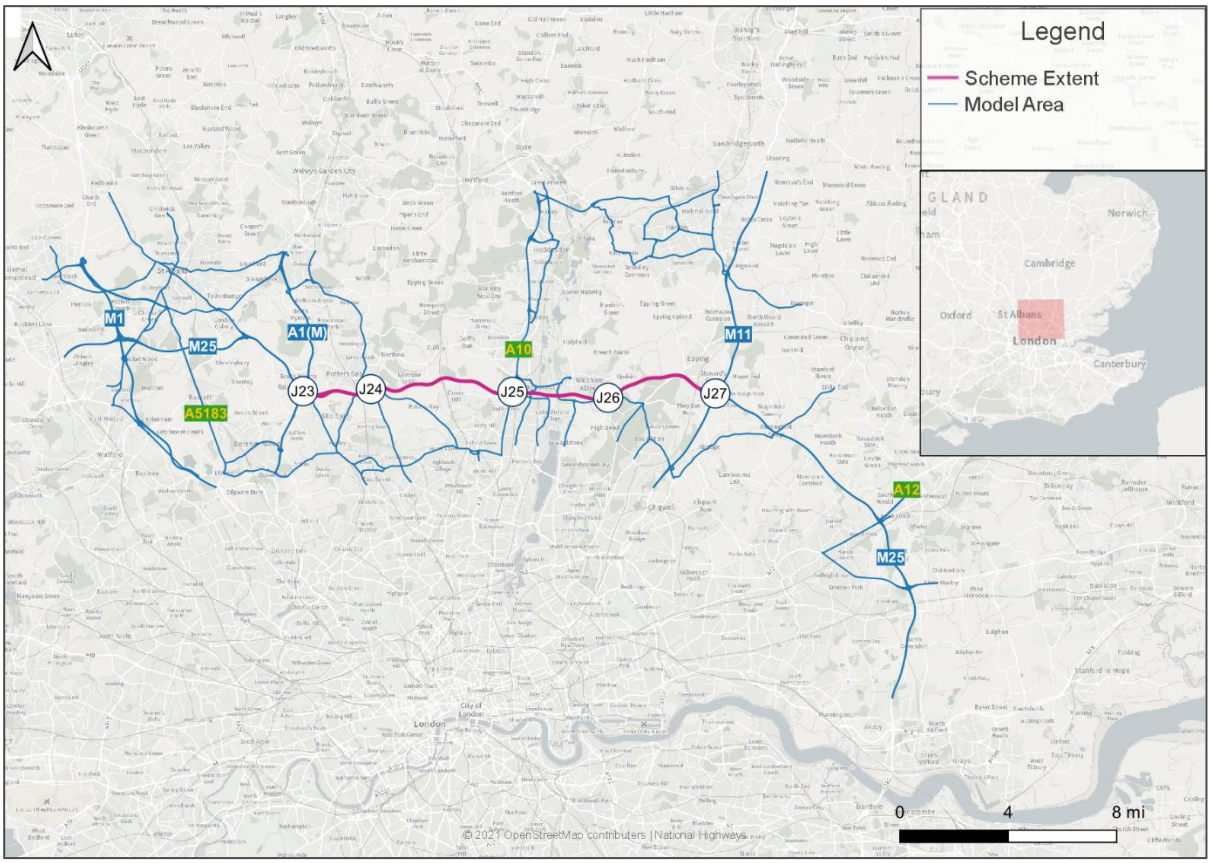
However, we cannot be confident that this improvement in road safety on the wider model area's road network is because the project is reducing traffic flows on surrounding roads and not part of observed wider regional trends for a reduction in collision rates.

[18] A collision that involves at least one vehicle and results in an injury to at least one person.
[19] The FWI weights Collisions based on their severity. A fatal collision is 1, a serious collision is 0.1 and a slight collision is 0.01. The combined measure is added up. A full number is the equivalent to a fatality.
[20] Projects are appraised over a 60-year period. This conclusion is based on the findings at five years after the project opened for traffic
[21] The road network is determined as part of the appraisal process to understand changes to road safety on the project extent and roads which the project may have an impact.

Safety study area

The safety study areas are shown in Figure 18. Two study areas were examined; the project extent, which was the lengths of M25 carriageways between junction 23 and junction 27, and a wider model area. This model area was assessed in the appraisal supporting the business case for the project to check any potential wider implications of the intervention. This information was then used with other predictions around the potential impact of the project such as by how much traffic may grow. We have therefore replicated the appraisal study area to understand the emerging safety trends.

Figure 18 Safety study area



Source: National Highways and OpenStreetMap contributors

Road user safety on the project extent

What impact did the project have on road user safety?

Road safety data was obtained from the Department for Transport[22]. This data contains records of incidents on public roads that are reported to the police. This evaluation only considered collisions that resulted in personal injury via this dataset.

The safety analysis was undertaken to assess changes over time looking at the trends in the five years before the project was operational to provide an annual average. We have then assessed the trends five years after.

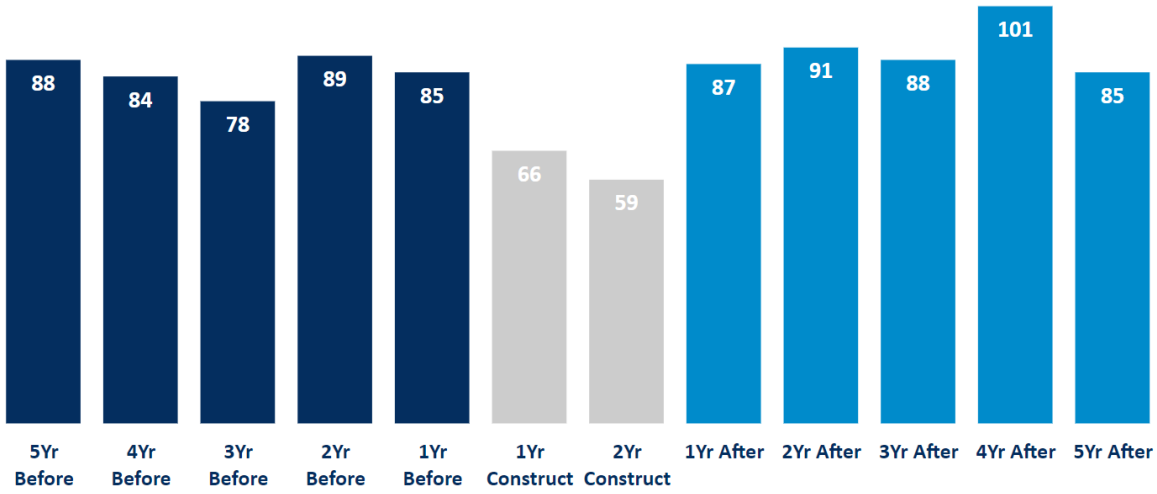
[22] https://data.gov.uk/dataset/cb7ae6f0-4be6-4935-9277-47e5ce24a11f/road-safety-data

The analysis draws on the following data collection periods:

- Pre-construction: 1 February 2008 to 31 January 2013
- Construction: 1 February 2013 to 29 November 2014
- Post-opening: 30 November 2014 to 29 November 2019

The evaluation found the number of personal injury collisions on the project extent had increased (impacts on the wider area are discussed later). Figure 19 shows that over the five years after the project was operational, there was an average of 90 personal injury collisions per year, five more than the average 85 per year over the five years before the project was constructed.

Figure 19 Annual personal injury collisions



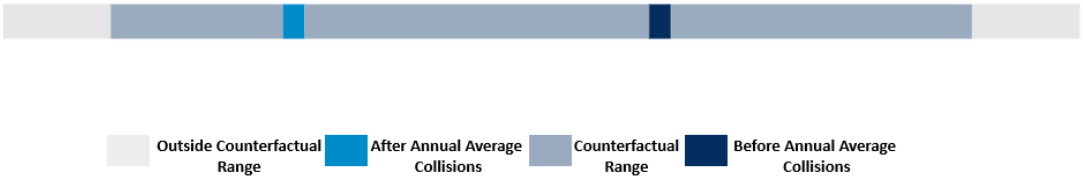
Source: STATS19: 1st February 2008 to 29th November 2019.

As part of the safety evaluation, we look to assess what changes in personal injury collisions might have occurred due to factors external to the project over this timeframe. To do this we estimate the trend in personal injury collisions which might have occurred if the road had remained a conventional motorway (this is referred to as a counterfactual test - see Appendix A.1: “Safety Counterfactual Methodology” and Figure 20 below). This is based on changes in regional safety trends for conventional motorways with a high volume of roads users.

Figure 20 What does the counterfactual show?

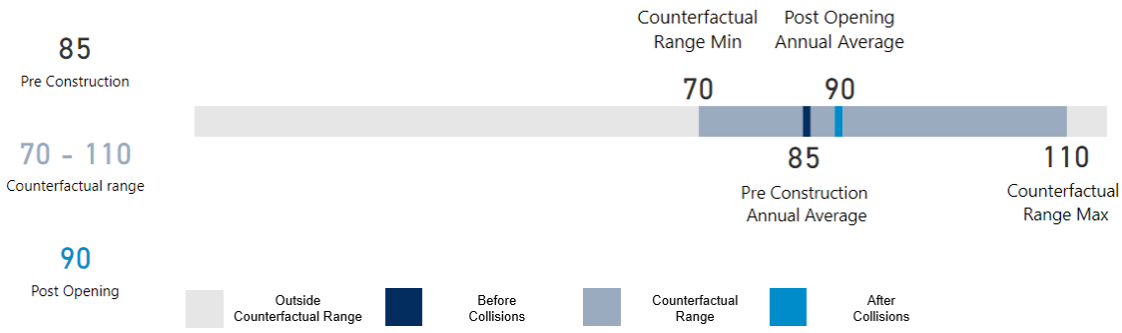
The counterfactual is an estimation of what we think would occur without the project taking place. We estimate a range of collisions that follow regional trends. The chart shows:

1. Annual average number of collisions from before the project
2. Annual average number of collisions after the project
3. Estimated counterfactual range, which comes from a X^2 hypothesis test on one degree of freedom using a significance level of 0.05. More details can be found in the POPE Methodology Manual.
4. National Highways are developing new statistical methods to compare collision and casualty rates. We anticipate adopting these once the methods are finalised.



Based on this counterfactual test, we estimate that if the road had not been converted to a smart motorway, the trend in the number of personal injury collisions would likely have increased, and collision rates would have remained stable, as shown in Figure 21. A range of between 70 and 110 personal injury collisions[23] during the five-year post project period would have been expected.

Figure 21 Observed and expected range of personal injury collisions (annual average)



Source: STATS19: 1st February 2008 to 29th November 2019.

An annual average of 90 personal injury collisions was observed over the five-year post-opening period. This number was within the expected range if the route had remained as a conventional motorway. The pre-construction value of 85 personal injury collisions covered a period when the M25 was carrying less traffic flow. This observation suggests that the personal injury collision rate (accidents per vehicle kilometre travelled) on the M25 was not changed by the project. This suggestion is examined further in the next section.

[23] The safety methodology is different from one year to five-year evaluation. We still have confidence in the accuracy of the previous methodology but have made suitable changes that will ensure a methodology fit for purpose for the future.

How has traffic flow impacted collision rates?

Smart motorways are implemented on some of England's busiest routes. It is, therefore, important to contextualise the number of incidents against the volume of traffic seen on this stretch using a collision rate, the number of collisions per hundred million vehicle miles (hmvm).

The evaluation has identified a decrease in the rate of collisions per hmvm.

Prior to the project, there was an annual average of 14 personal injury collisions per hmvm. After the project improvements were made there was a decrease to 13 personal injury collisions per hmvm. A decrease of one personal injury collision per hmvm.

A counterfactual test was undertaken. It found that the collision rate would likely have been 12 collisions per hundred million vehicle miles in the counterfactual scenario. This indicates we predicted a larger reduction in the rate that personal injury collisions occur. Statistical testing indicates this reduction is not significant and would be similar if the project remained as a conventional motorway.

What changes in the severity of collisions did we see?

Collisions that result in injury are recorded by severity as either fatal, serious, or slight. The way the police record the severity of road safety collisions changed within the timeframes of the evaluation, following the introduction of a standardised reporting tool – Collision Recording and Sharing. This is an injury-based reporting system, whereby the severity of an incident is categorised automatically by the most severe injury. This has led to some disparity when comparing trends with the previous reporting method, where severity was categorised by the attending police officer[24]. As a consequence, the Department for Transport have developed a severity adjustment methodology[25] to enable robust comparisons to be made.

For this evaluation, one reporting mechanism was largely used prior to the smart motorway conversion and another afterwards. The pre-conversion collision severity has been adjusted, using the Department for Transport's severity adjustment factors, to enable comparability with the post-conversion safety trends[26].

Figure 22 shows the severity of personal injury collisions within the project extent. After the project opened, we have observed a total reduction of one collision resulting in fatalities (the total in the five years before construction was seven, compared to six in the five years after). There was an average of two fewer collisions resulting in serious injuries per year (the annual average before construction was 13, compared to 11 after). There was an average of eight more collisions resulting in slight injuries per year (the annual average before construction was 70, compared to 78 after).

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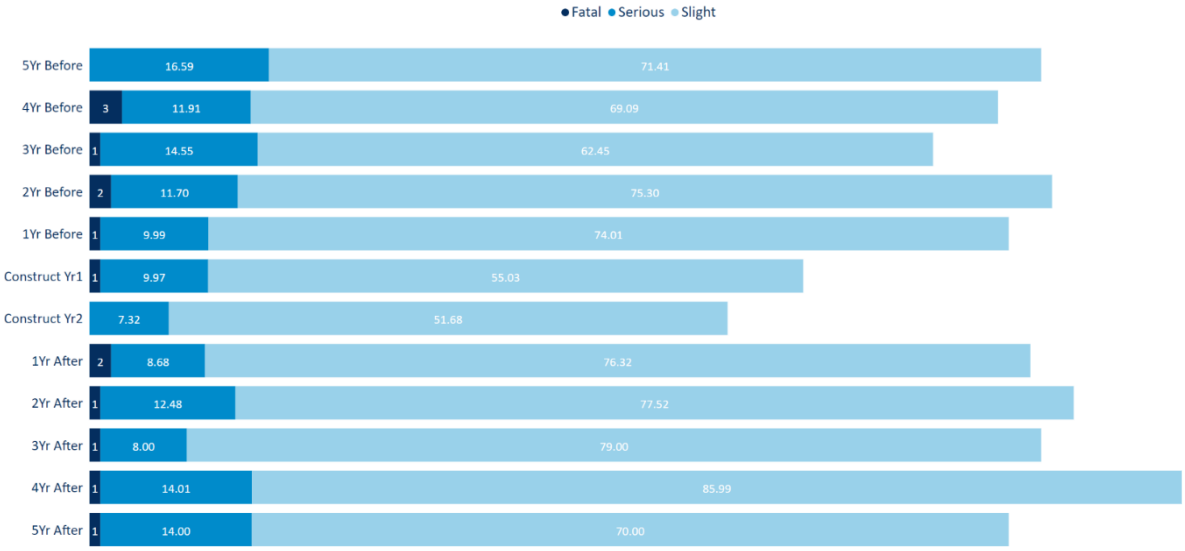
[24] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820588/severity-reporting-methodology-final-report.odt

[25] https://www.gov.uk/government/publications/guide-to-severity-adjustments-for-reported-road-casualty-statistics/guide-to-severity-adjustments-for-reported-road-casualties-great-britain#guidance-on-severity-adjustment-use

[26] Collision Severities within this report use the 2020 adjustment factor.

Figure 22 Severity of personal injury collisions within the project extent



Source: STATS19: 1st February 2008 to 29th November 2019.

How has traffic flow impacted casualty severity?

Like other transport authorities across the UK the key measure we use to assess the safety of roads, is Fatal and Weighted Injuries (FWI). This gives a fatality 10 times the weight of a serious casualty, and a serious casualty 10 times the weight of a slight casualty[27]. In effect, it takes all non-fatal injuries and adds them up using a weighting factor to give a total number of fatality equivalents[28]. This is represented by an annual average and a rate that standardises casualty severities against flow to show the likelihood of a fatality equivalent occurring per distance travelled.

There has been no change in the number of four fatality equivalents observed. The combined measure showed an extra 29 million vehicle miles was travelled before a fatality. Before the project, 147 million vehicle miles needed to be travelled before a fatality equivalent (0.7 fatality equivalents per hmvm[29]). After the project, this increased to 176 million vehicle miles (0.6 fatality equivalents per hmvm). The rate of fatality equivalents per hmvm has reduced. This suggests that, taking into account changes in traffic, the project is having a positive safety impact on the severity of casualties within the project extent.

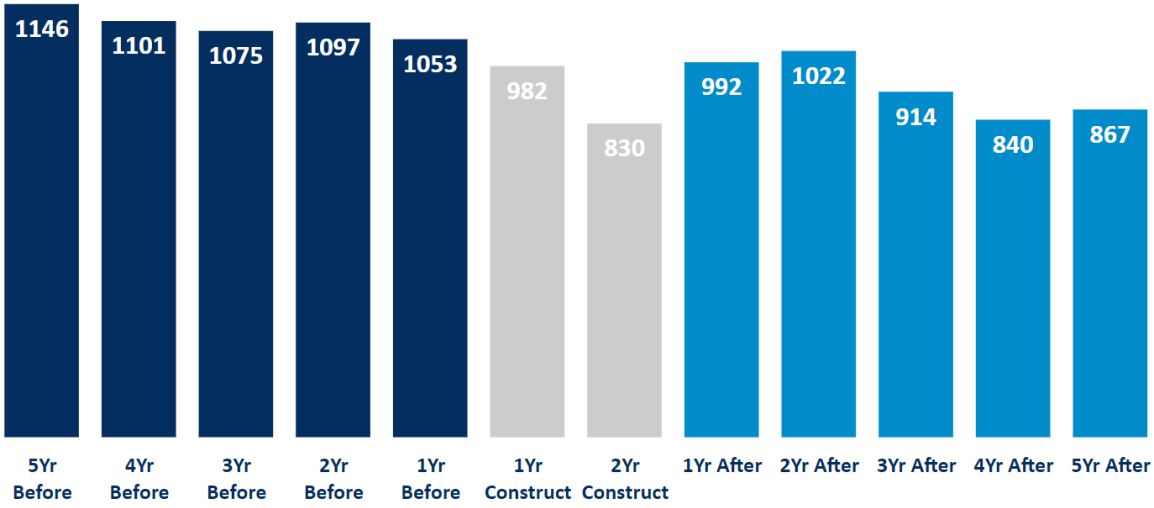
Road user safety on the wider area

What impact did the project have on safety for the wider area?

Personal injury collisions were observed for a wider model area, which was derived for the safety appraisal for the project (as shown in Figure 18). Before the project, an annual average of 1,094 collisions were observed. After the project, this had fallen to 927, a reduction of 167, as shown in Figure 23.

[27] The FWI weights Collisions based on their severity. A fatal collision is 1, a serious collision is 0.1 and a slight collision is 0.01. So 10 serious collisions, or 100 slight collisions are taken as being statistically equivalent to one fatality.
[28] Casualty Severities within this report use the 2020 adjustment factor.
[29] Hundred million vehicle miles.

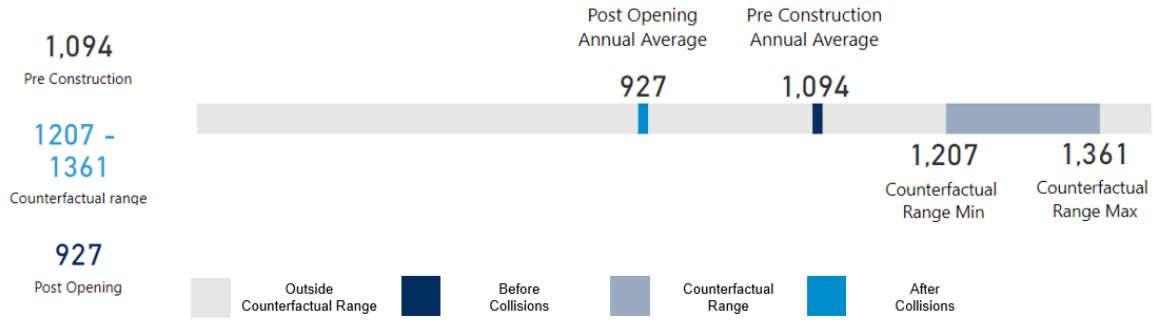
Figure 23 Annual personal injury collisions in wider area



Source: STATS19: 1st February 2008 to 29th November 2019.

The counterfactual analysis indicated that it is likely that an annual average of between 1,207 and 1,361 personal injury collisions would have occurred. The observed annual average of 927 personal injury collisions falls below the range, as shown in Figure 24. We can be confident that the observed reduction is significant. This suggests that the project is having a positive impact on safety in the wider area.

Figure 24 Observed and expected range of personal injury collisions in wider area (annual average)



Source: STATS19: 1st February 2008 to 29th November 2019.

How had traffic flows impacted collision rates in the wider area?

The evaluation has identified a decrease in the rate of collisions per per hmvm

Prior to construction, there was an annual average of 32 personal injury collisions per hmvm. After the project improvements were made there was a decrease to 26 personal injury collisions per hmvm. A decrease of six personal injury collisions per hmvm.

The distance travelled before a personal injury collision occurred increased from three to four million vehicle miles per personal injury collision.

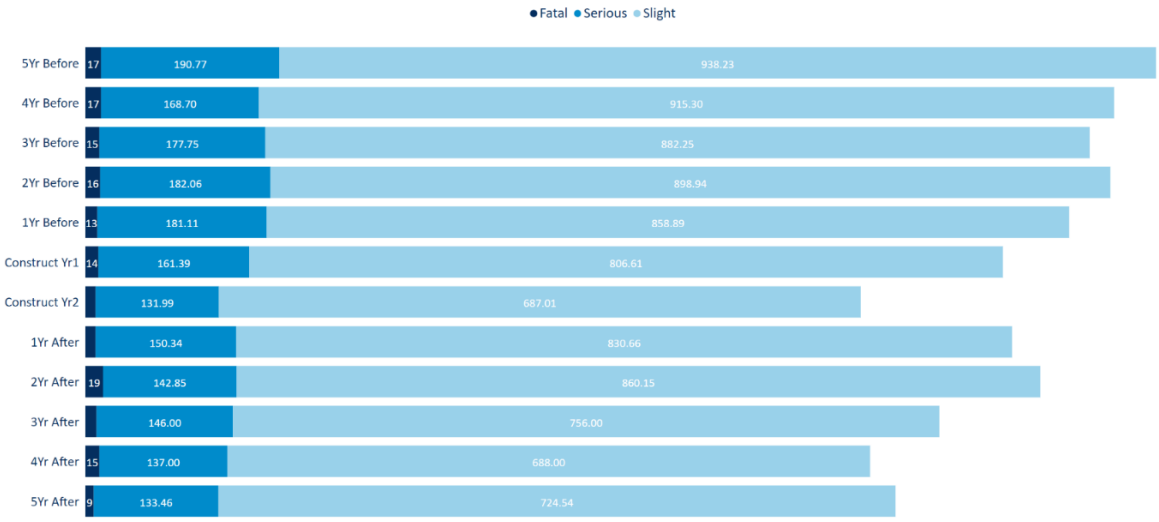
A counterfactual test was undertaken. It found that the collision rate would likely have been 29 collisions per hmvm in the counterfactual scenario. This indicates we have observed a larger reduction in the rate that personal injury collisions occur than predicted. Statistical testing indicates this reduction is significant suggesting that the project is having a positive impact on the wider area.

What impact did the project have on the severity of collisions in wider area?

Collision severity analysis was undertaken for the wider area using the same method as for the project extent. Figure 25 shows the severity of personal injury collisions in the wider area for the five years prior to construction of the smart motorway, during construction and the five years after construction.

After the project we have observed a reduction of 12 collisions resulting in fatalities (the total before construction was 78, compared to 66 after). There was an average of 38 fewer collisions per year resulting in serious injuries (the annual average before construction was 180, compared to 142 after). There was an average of 127 fewer collisions per year resulting in slight injuries (the annual average before construction was 899, compared to 772 after).

Figure 25 Personal injury collisions by severity in wider area



Source: STATS19: 1st February 2008 to 29th November 2019.

How had traffic flows impacted casualty severity in the wider area?

To understand the impact of the increased traffic flow on collision severity, the measure we use is fatalities and weighted injuries (FWI).

A reduction of nine fatality equivalents has been observed annually. The severity of casualties occurring after the project became operational has reduced in the wider area. Before the project an annual average 50 fatality equivalents were observed. After the project this had reduced to an annual average of 41 fatality equivalents.

The combined measure showed an increase of 17 million vehicle miles was travelled before a fatality. Before the project, 57 million vehicle miles needed to be travelled before a fatality (1.8 fatality per hmvm). After the project, this increased to 74 million vehicle miles (1.4 fatality per hmvm).

Is the project on track to achieve its safety objective?

The projects safety objective was for the number of collisions to be no greater than those before the project was implemented and for the severity ratio to not increase.

The evaluation found the number of personal injury collisions on the motorway increased from 85 to 90 but the collision rates reduced. The counterfactual test indicated that the after observation was within what would be expected had the road remained a conventional motorway. Counterfactual testing of collision rates confirmed the reduction in rates was not statistically significant.

The evaluation found the rate of fatality equivalents per hmvm has reduced which suggests the project is having a positive safety impact on the severity of casualties within the project extent.

The evaluation found the number of personal injury collisions increased, however given the upgraded motorway carried larger flows, the rate of collisions decreased. This finding was not statistically significant. The severity ratio improved. For the wider area, the number of personal injury collisions reduced by 10%. The five-year evaluation suggests that the project has improved safety in light of increased traffic but cannot confidently conclude it has met its objective[30].

[30] Projects are appraised over a 60-year period. This conclusion is based on the findings at five years after the project opened for traffic.

6. Environmental evaluation

The evaluation of environmental impacts compares the predicted impact from appraisal to observed impacts determined during a site visit. Post opening evaluations provide an opportunity for such findings to be captured early and ensure improvements are made, so the design outcome can be achieved.

The evaluation of environmental impacts used information on the predicted impacts gathered from the environmental appraisal within the business case, the environmental assessment report (EAR) and in consideration of the findings of the one-year after opening evaluation, compares them with findings obtained five-years after the projects opened for traffic.

Observed impacts have been determined during a site visit, supported by desktop research. The five-year after opening site visit was undertaken in August 2020.

Summary

The environmental assessment for the project predicted that in relation to landscape and visual impacts there would be overall slight adverse impacts on the environment. This was attributed to the gantries, and controlled motorway ALR signage increasing the perception of urbanisation within the countryside surroundings.

It was expected that mitigation measures would be better established five years after opening compared with the situation, one year after opening. Where insufficient evidence is available to determine the outcome five years after opening, perhaps because mitigation is yet to establish or because monitoring data is unavailable, this evaluation has mentioned it accordingly.

The outcome of the evaluation has been reported using the environmental Transport Analysis Guidance (TAG)[31] sub-objectives (noise, air quality, greenhouse gas emissions, landscape, heritage and biodiversity). Two of the environment sub-objectives were scoped out for the five-year after opening report and these were as follows:

- Townscape: The project was generally considered to be compatible with existing townscape character, resulting in an overall neutral effect with no townscape features expected to be affected.
- Water Environment: There were no outstanding issues from the one-year after opening evaluation, so this was scoped out for the five-year after opening report.

The five-year after environment evaluation had limitations due to the availability of reporting and maintenance monitoring which had also largely been absent at the one-year after opening report.

[31] TAG provides guidance on appraising transport options against the Government's objective for transport.

The impacts on severance, physical fitness, and journey ambience[32] are usually evaluated in POPE. The project was expected to have no direct effect on the activities of pedestrians, cyclists, or equestrians because there were no direct changes to existing facilities or routes for non-motorised users so physical fitness was scoped out. As there were no new severance issues generated by the project this was also scoped out. There were no outstanding issues from the one-year after opening evaluation regarding journey ambience, so this was also scoped out.

Based on observations made during the five-year after in relation to landscape and visual amenity, the findings established that the project had adversely impacted the visual amenity as expected. This is largely attributed to the loss of screening vegetation to accommodate the new motorway infrastructure. While the mitigation planting has minimised the impact of the new infrastructure to the visual landscape, in areas of the project where the soft estate is limited and the M25 is at elevation, the impacts to visual amenity are greater and the mitigation planting requires more time to develop to fully screen the gantries and Controlled Motorway ALR signage. This is particularly relevant to the western end of the project.

In relation to the landscape planting, the hedgerows near the landscape bunds around the Woodgreen Road Underbridge were establishing well. However, other planting within the project has had mixed success where in some cases there was excessive weed growth. A full evaluation could not be given because no evidence of maintenance and no species monitoring were available at the time of the five-year after evaluation. If after care (maintenance and monitoring) and reporting are not improved there is a risk that the planting plots may not provided their intended benefits by the design year.

No scheduled monuments were identified within the project footprint therefore, no scheduled monument heritage assets were impacted. The impacts of the project on archaeological assets could not be confirmed because there was no post-construction report for field archaeology available as proposed in the mitigation strategy for the Holly Hill Farm and Skinners Farm landscape bunds. For the historic buildings and conservation areas the impacts were as expected.

Noise

The business case predicted that without the project, the population annoyed by traffic noise would be 3,160 and that with the project, a slight increase was predicted (3,190 of the population). Overall, the project was expected to have a moderate adverse noise impact.

It was estimated that approximately 3% of the identified sensitive noise receptors would experience a minor adverse impact post-opening, and the remaining identified noise receptors would experience negligible impact. Where the minor adverse impacts were forecast, the expectation was that noise insulation for the façades of the Gables and Preston Grange, which are properties located on Barnet Road, and Brooke's Place caravans would be required.

[32] Journey ambience was a measure of the experience of travelling. This includes traveller care (e.g. information and facilities), travellers' views, and traveller stress factors (e.g. perceptions of safety, congestion and reliability). Refer to former TAG unit 3.3.12. It has now been replaced by the term 'journey quality'.

Twelve Noise Important Areas (NIAs)[33] were identified along the project. It was concluded that 11 had mitigation measures applied, ten NIAs were mitigated via low noise resurfacing and one with noise insulation. The NIA 5712 in Epping Forest is reported as not being mitigated and it is recommended that this be investigated.

The five-year after evaluation site visit concluded that the mitigation measures have largely been installed and are functioning as expected in relation to the expected level of noise impacts identified in the environmental assessment.

The observed AADT[34] traffic flows at five-years after range from 9% lower (J26 to J27) to 13% lower (J23 to J24) than forecast which is within the tolerance prescribed by POPE. Therefore, the impact of traffic on noise at five-years after opening was likely to be as expected.

Air quality

The local air quality assessment considered the impacts of the proposed project and concluded that there would be no overall significant effects on local air quality for human health or on designated ecological sites.

The appraisal, which supported the investment case, indicated that the project was expected to produce an overall slight adverse impact on air quality.

Measurements at five-years after for air quality demonstrated that for both Air Quality Management Areas[35] (AQMAs) in the vicinity of the project[36] observations exceeded the NO_2 annual mean objective prior to the opening of the project and that since 2020 there has been improvements to the NO_2 levels recorded.

Local air quality information for both Hertsmere Borough Council area and Epping Forest District Council area identified that exceedances in NO_2 and PM_{10} (where monitored) have not been attributed to the project. Air quality information for the Hertsmere Borough Council area reported exceedances prior to the project, and the Epping Forest District Council area attributed exceedances to road traffic utilising the B1393, not the project.

Based on the five-year after opening traffic data, there has been an overall reduction in traffic flows compared to the forecast in the assessment traffic model. It is concluded that the impact of the project on air quality is likely to be better than expected.

Greenhouse gases

The project was predicted to lead to an overall increase in greenhouse gas emissions. This was because the project was expected to lead to an additional 24,178 million vehicle kilometres travelled across the 60-year appraisal period.

[33] Noise Important Areas (NIAs) are locations identified by the Government as experiencing the highest noise levels as part of their Noise Action Plan. https://nationalhighways.co.uk/our-work/environment/air-quality-and-noise/noise/
[34] AADT – average annual daily traffic
[35] Air Quality Management Areas are locations a local authority determines that air quality is poor and where the national air quality objectives are not likely to be achieved. https://uk-air.defra.gov.uk/aqma.
[36] AQMA No.2 (HM86 Charleston Paddocks) and AQMA No.3 (HM61 Earls Corner).

Data was not available to compare the predicted and observed emissions five years after opening. However, the earlier traffic analysis shows observed traffic flows were lower than forecast which suggests operational emission changes are less than predicted.

Landscape

The effects of the project on landscape and visual amenity were predicted to be slight adverse which was largely attributed to the location of the works and the restricted nature of them.

The one-year after opening report detailed a reduction in highway infrastructure which was considered beneficial in reducing impacts on the landscape. During preliminary design, it was forecast that views for Elm Farm and Elm Cottage would be impacted by gantry signage from upper storey windows to the north of the properties and direct views to the east. However, during detailed design the gantries were removed and relocated which reduced impacts at Elm Farm and Elm Cottage on Bentley Heath Lane (see Figure 26).

Figure 26 Vehicles on the M25 and gantry viewed from Bentley Heath Lane (near Elm Farm)

For Barnet Road underbridge, visual intrusion impacts have increased as expected, due to the relocation of the superspan gantry further east. In the relocated area there would be less existing vegetation to screen the gantry, increasing visibility from Barnet Road Caravan Site and properties off Byers Close and Dove Lane at Potters Bar. The appearance of the 52 new gantries has increased the visual intrusion and the perception of urbanisation of the countryside as predicted.

During the five-year after opening site visit, it was noted that the landscape impact of vegetation removal was noticeable at the western end of the project, as was anticipated. The area impacted has narrow embankments that limited the opportunity for mitigation planting. The eastern end of the project had a larger volume of retained vegetation. Observations through Epping Village confirmed that expectations of landscape shielding was successful with mature woodland vegetation and the Bell Common Tunnel screening the views of the M25 from Epping Village.

It was expected that views from Dame Alice Owen School would be adversely impacted. Planting was undertaken on the embankment to mitigate the adverse impact to visual amenity. However, the five-year after opening site visit found there are open views from the Dame Alice Owen sports centre to the superspan gantry to the east of junction 23 (see Figure 27).

Figure 27 Open view of the M25 from the sports centre of Dame Alice Owen School

For views from receptors on Cattlegate Road, the appraisal noted that there was an existing screening provision by vegetation on either side of Cattlegate underpass. The five-year after opening site visit reiterated the one-year after report findings that some vegetation had been retained along the project at this location and that the impact to the receptors was better than expected (Figure 28).

Figure 28 View of the traffic over Cattlegate Road Bridge with Cattlegate and Woodhurst Farm properties nearby

Screening of the M25 has not occurred between the east and west of the project at Lee Valley. This area was previously urbanised before construction and so changes to the project has had a minimal impact on the landscape character.

In relation to mitigation measures the majority of hedgerows for screening around the landscape bunds are as expected. There is variation in the success of the other planting including the species-rich grassland. It has also been confirmed that there is little evidence of routine maintenance being undertaken, as identified at one year after. Based on the available information the general landscape character change is minimal.

Heritage of historic resources

At the time of preliminary design, it was determined that as most of the project was contained within the existing highway boundary, the impacts on buried archaeology were considered to be unlikely. Consequently, it was concluded that potential impacts were expected to be minimal and confined to direct effects caused by groundworks associated with the new Emergency Refuge Areas and gantries. The built heritage assets that were anticipated to have slight adverse effects were Copped Hall Park (Registered Park and Garden) and Copped Hall Park (Conservation Area).

The alternative design proposals for landscape bunds at Holly Hill and Skinners Farm identified that earthworks for the construction of the bunds had the potential to disturb or destroy buried archaeological remains. At the time of writing, archaeological reports were not available to inform this aspect of the evaluation.

For North Lodge School, grade II listed building, the project was expected to further increase the visual amenity of the motorway. During the five-year opening site visit this listed building was not accessible; however, the motorway gantries near Junction 23 could be viewed adjacent to the property and this was recorded to be as expected.

In summary, the project impact on heritage of historic resources was generally found to be as expected as the new gantries were screened from Copped Hall by intervening trees and woodland. As with the one-year after report, no archaeological reports were available for the five-year after opening evaluation.

Biodiversity

The appraisal predicted that there would be no long-term impacts to Lee Valley Special Protection Area (SPA) and Ramsar site, or Epping Forest Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI. The appraisal did forecast a slight adverse impact on Epping Forest SAC and SSSI during construction, due to the loss of low value verge side habitats. Overall, the appraisal anticipated that the project would have a slight adverse effect on ecological resource, but that the negligible value of the habitats reduced the impact to neutral.

The impacts during construction were mitigated with the inclusion of European Protected Species (EPS) licensing to minimise disturbance to Great Crested Newt habitats and foraging areas, pre-construction treatment of Japanese Knotweed, closure of badger setts and translocation of certain reptiles and newts.

The five-year after evaluation confirmed that, based on the Construction Environmental Management Plan, the mitigation for Great Crested Newt habitats was likely to have been completed. However, a report confirming the works being completed under the EPS licence was not available.

In relation to the proposed planting, the five-year after opening site visit confirmed that hedging was established and thriving, but the species-rich grassland on landscape bunds and other types of vegetation implemented for the project, were weed-ridden with no evidence of maintenance. Landscape and ecology monitoring reports were not available for the evaluation.

Accessibility to assess the enhancement measures was compromised during the site visit because it was deemed unsafe for surveyors. However, according to the one-year after report all enhancement measures were present. While the presence of the enhancement measures has been confirmed, there is no detail regarding the type utilised or the number implemented so commentary on the impact of the construction works on protected species is limited.

Construction works were confirmed to have occurred as planned within the highway, so the impact to species and habitats was likely to be minimal as expected. Observations during the five-year after site visit of the biodiversity mitigation was limited due to mitigation areas being unsafe for surveyors to access.

Due to the lack of available reports, data and access to mitigation measures, confidence on commenting on the effectiveness of the mitigation is low. It was noted that the observed poor weed control can impact the long-term delivery of the design year outcomes. Overall, the five-year after evaluation concluded that impacts to biodiversity were as expected however, the report also noted that more information was needed to confirm the conclusions reported in one-year after report. The five-year after also commented that whilst the mitigation was implemented, and new habitats were seen during the five-year after site visit, there is limited aftercare and monitoring evidence to comment with confidence how effective the mitigation has been.

Overview

The results of the evaluation are summarised against each of the Transport Appraisal Guidance (TAG)[37] environmental sub-objectives and presented in Table 2. In the table we report the evaluation as expected if we believe that the observed impacts at one year after are as predicted in the appraisal. We report them as better or worse than expected if we feel the observed impacts are better or worse than expected. Finally, we report impacts as too soon to say if we feel that at one year after there is insufficient evidence to draw firm conclusions.

[37] TAG provides guidance on appraising transport options against the Government's objective for transport.

Table 2 Summary of environmental findings M25 J23-27

Sub-Objective	Appraisal Summary Table score	Five-year Evaluation Outcome	Five-year Evaluation Summary
Noise	Moderate Adverse	As expected	Mitigation measures have largely been installed and are functioning as expected. A comparison of observed traffic flows against forecast suggests that traffic flows were lower than forecast so the overall impact of the project on noise is likely to be as expected.
Air Quality	NO_2: -21 PM_{10}: -5	Better than expected	Local AQMA reporting along the project indicates that exceedances are not attributed to the project. The five-year after opening traffic information also indicates that due to an overall reduction in observed traffic flows, the air quality impact of the project is (as at one-year after opening) likely to better than expected.
Greenhouse Gases	NPV: -£281.2m	Cannot be confirmed	Observed traffic flows five-years after opening are lower than forecast which suggests lower emissions along the project extent. However, there is insufficient data to quantify.
Landscape	Slight Adverse	As expected	General landscape character change was minimal as the M25 was already prominent and the works were largely online. The visual amenity has been impacted largely as expected. Screening vegetation has been lost to accommodate new infrastructure, but new planting has been provided to minimise the impacts. There is mixed success in mitigation planting with hedges doing well while other planting plots are overgrown with weeds, with little or no evidence of maintenance. Maintenance needs to be improved to ensure that design year outcomes are met.
Heritage of historic resource	Slight Adverse	As expected	The evidence gathered during the five-year after opening site visit suggests that, as expected, there were no scheduled monuments within the project footprint. Desk-based archaeological investigations were undertaken, but no-post excavation reports were available to confirm the results of proposed field archaeology and, therefore, the archaeological impacts of the project cannot be commented on. Impacts on historic buildings (North Lodge and Hill Hall), historic landscapes and Conservation Areas were largely as expected.
Biodiversity	Slight Adverse	As expected	The project works were largely online and impacts on species and habitats are likely to be limited to within the highway verge, as expected. From observations around landscape bunds and around the Woodgreen Road Underbridge, new hedgerows near landscape bunds were establishing very well five-years after opening. However, other planting types (e.g. species-rich grasslands on landscape bunds) were facing mixed success, with excessive weed growth noted in some vegetation plots. It was unclear what maintenance is being undertaken. While the mitigation was implemented, and new habitats were seen during the five-year after site visit, there is limited aftercare and monitoring evidence to comment with confidence on what maintenance is being undertaken and how effective the mitigation has been. Poor maintenance can affect long terms delivery of the design year outcomes.

7. Value for money

Summary

As part of the business case, an economic appraisal was conducted to determine the project's value for money. This assessment was based on an estimation of costs and benefits over a 60-year period.

The project was delivered at a cost of £180 million[38], which was below the £195 million forecast construction cost. In the first five years, the motorway provided additional capacity to support more users (an increase of around 22% from 2012 to 2019).

There was an overall improvement on safety, with an increase in the annual average number of collisions on the project extent, but a decrease in the rate of collisions when considering the increase in traffic in the corridor. There was a statistically significant decrease in the number of personal injury collisions over all roads within the wider area.

Overall, the evaluation indicated that in the first five years this investment is not on track to deliver the value for money anticipated over the 60-year life of the project. If the journey time trends observed within the first five years continue, the project is expected to deliver 'very poor' value for money[39].

Forecast value for money

An economic assessment is undertaken prior to construction to determine a project's value for money and inform the business case. The assessment is based on an estimation of costs and benefits. Some impacts of the project, such as journey time savings, changes to user costs, safety impacts and some environmental impacts can be monetised. This is undertaken using standard values that are consistent across government. The positive and negative impacts over the life of the project[40] are summed together and compared against the investment cost to produce a benefit cost ratio (BCR). The monetised impacts are considered alongside additional impacts which are not able to be monetised, to allocate the project a 'value for money' category.

The monetised benefits forecast by the appraisal that supported the full business case for the M25 junctions 23 to 27 are set out in Table 3. We have also included an indication of the proportion of the monetised benefits each impact accounted for and a summary of how we have treated the monetisation of each impact in this evaluation.

[38] This is the PVC (present value cost) of the project. This means it is presented in 2010 prices, discounted to 2010 to be comparable with the other monetary values presented.
[39] The value for money categories referenced are defined by the Department for Transport https://www.gov.uk/government/publications/dft-value-for-money-framework
[40] Typically project life is taken to be 60 years.

Table 3 Monetised benefits of the project (£ million)

	Forecast (£M)	% forecast monetised benefits[41]	Evaluation approach
Journey times	1,003	181%	Re-forecast for the project area only (not the wider area) using observed and counterfactual traffic flow and journey time data
Vehicle operating costs (VOC)	-298	-54%	Re-forecast using observed and forecast traffic flow and journey time data
Journey time & VOC during construction and maintenance	-308	-56%	Not evaluated (assumed as forecast)
Journey time reliability	64	12%	Monetised benefits assumed as forecast
Safety	72	13%	Re-forecast using observed and counterfactual[42] safety data
Greenhouse gases	-253	-46%	Monetised benefits assumed as forecast
Noise	-2	<1%	Monetised benefits assumed as forecast
Indirect tax revenues	276	50%	Re-forecast using observed and forecast traffic flow and journey time data
Total present value benefits	**554**		

Note: 2010 market prices discounted to a 2010 present value year. Due to rounding the numbers and percentages may not always add up exactly to the presented totals.

The forecast costs in the appraisal are set out in Table 4. Based on this information, the project was expected to provide 'high' value for money over the 60-year appraisal period.

Table 4 Cost of the project (£ million)

	Forecast (£M)	% forecast costs	Evaluation approach
Construction costs	195	84%	Current estimate of project cost
Maintenance costs	36	16%	Technology renewal (as forecast)
Total present value costs	**231**		

Note: 2010 prices discounted to 2010. Due to rounding the numbers and percentages may not always add up exactly to the presented totals.

[41] Disbenefits presented as negative numbers and percentages. The total of the positive and negative contributions total to 100%.

[42] We compared observed trends with an estimation of the trends if the road had remained a conventional motorway (i.e. a 'counterfactual' baseline).

Evaluation of costs

The project was delivered at a cost of £180 million[43], which was below the £195 million forecast construction cost (Table 4).

The appraisal expected that the project would result in an increase in technology renewal maintenance costs over the life of the project. As the majority of this maintenance is still in the future, the evaluation uses the same maintenance costs that were forecast within the full business case.

Evaluation of monetised benefits

Once a project has been operating for five-years, the evaluation monitors the construction costs and the trajectory of benefits to reforecast these for the 60-year project life. It is not proportionate to replicate modelling undertaken at the appraisal stage of a project or to monitor benefits over the entire lifecycle, so we take an assessment based on the trends observed over the first five years of operation and estimate the trend over the project life, based on these observations. This provides a useful indication and helps to identify opportunities for optimising benefits. In instances where it was not feasible to robustly compare forecast and five years after opening observed impacts, the findings have been presented with relevant caveats.

Monetised journey time benefits

As can be seen in Table 3, journey time benefits comprised the majority of the justification for investing in this smart motorway. The reforecast monetised journey time benefits are determined by comparing outturn journey times against a counterfactual estimate of what journey times are likely to have been without the project. Figure 9 and Figure 10, in section 4, indicate that the 'Forecast Without Project' journey times were always longer than the 'Forecast With Project' journey times.

The reforecast journey time analysis indicated that journey time benefits (£11m[44]) are not on track to that forecast. This is likely to be due to a combination of reasons including:

The observed daily traffic flows were lower than forecast. The forecasts were prepared before the impact of the 2008 recession and the effects of the subsequent austerity measures were fully known.

The five years after evaluation used a precautionary approach to determining the delays that would have occurred to road users had the smart motorway not been provided and flow breakdown events had become a more frequent occurrence.

Capacity bottlenecks at nearby junctions are causing longer queues than forecast and are of sufficient length to interact with the flows on the M25.

[43] This is the PVC (present value cost) of the project. This means it is presented in 2010 prices, discounted to 2010 to be comparable with the other monetary values presented.
[44] This is the contribution to the PVB of the project. This means it is presented in 2010 prices, discounted to 2010 to be comparable with the other monetary values presented.

Without further intervention, journey time benefits are unlikely to be on track to be realised. The appraisal assumed the project would deliver journey time savings for both those using the smart motorway and those using the surrounding road network, where congestion would be eased by the additional capacity on the M25. Our five years after evaluation has not monitored the journey time impact on the surrounding roads.

If the trends observed at the fifth year continue over the 60-year period, without any further action to optimise benefits, the monetised impacts on journey times would be £11 million[45]. This value only reflects journey time trends observed along the project's extent, whereas the appraisal also considered journey time changes on the surrounding road network.

Other reforecast impacts

The appraisal forecast an increase in the number of personal injury collisions on the project extent (due to no change in collision rates and higher traffic flows) and a benefit for roads within the wider model area (due to rerouting of traffic onto the project extent).

We have observed a disbenefit on the project extent (an increase annually of two collisions compared to the counterfactual scenario) and a benefit (a saving of 355 collisions per year compared to counterfactual scenario) for the wider area, which over 60 years we evaluated as a social welfare benefit of £86 million[46].

There are two further impacts associated with the changes in numbers and speeds of vehicles – indirect tax revenues and vehicle operating costs.

Indirect tax revenues are the benefit to the government (and therefore society) of the additional tax income from the additional fuel consumed due to increased speeds and distances travelled. This was forecast to be positive because more vehicles were forecast and they were forecast to be travelling at higher speeds, and therefore using more fuel and paying more tax. We have reforecast that the impact would be slightly smaller than the expected £276 million (Table 3), a reduction in indirect tax revenues collected to £235 million[47]. The benefit is smaller because our evaluation has shown that the daily traffic flows on the motorway are less than was forecast.

Vehicle operating costs refer to the fuel and other costs borne by the user (such as the wear and tear on vehicles). These vehicle operating costs increase with increased distance travelled. There was a forecast vehicle operating cost disbenefit of –£298 million (Table 3) and, based on the changes we have seen in observed traffic flows and journey times, we estimate the outturn impact to be a disbenefit of –£254 million[48].

[45] This is against a counterfactual where we have estimated what the journey time is likely to have been if the road had remained a conventional motorway.
[46] There is uncertainty regarding the extent that improvement to safety on roads within the wider model area may be attributed directly to the project. As a consequence, we have used the as forecast calculation for the wider model area.
[47] This is the contribution to the PVB of the project. This means it is presented in 2010 prices, discounted to 2010 to be comparable with the other monetary values presented.
[48] This is the contribution to the PVB of the project. This means it is presented in 2010 prices, discounted to 2010 to be comparable with the other monetary values presented.

Impacts assumed as forecast

The evaluation has not been able to reforecast the monetary value of journey time reliability[49], noise and carbon benefits[50], and these are reported as forecast. For noise and carbon impacts, this assumption is conservative because lower than forecast daily traffic flows are likely to mean that these impacts are better than forecast[51]. For journey time reliability this £64 million benefit (Table 3) might be generous because the variability in the application of speed limit restrictions might not be anticipated by motorway users[52].

Journey times and vehicle operating costs during construction and future maintenance were retained as forecast at –£308 million (Table 3).

Overall value for money

The primary reason for the overall reduced level of benefits associated with the M25 junctions 23 to 27 project is the lack of journey time savings. The appraisal forecast greater traffic flows and larger improvements in journey times than were observed five years after opening. This has affected the expected value for money.

When considering an investment's value for money, we also consider benefits that we are not able to monetise. For this project, noise was scored moderate adverse and wider economic benefits might be relevant. With few non-monetised benefits to take into consideration, it is likely that this project has offered 'very poor' value for money.

Based on the evidence from the first five years, this project is not on track to realise the anticipated value for money. However, there have been benefits delivered - construction of the project was delivered under budget, it is delivering safety benefits to road users and most of the environmental benefits are as expected, or better.

[49] It has not been possible to re-forecast the monetised reliability impact for this project because our evaluation method reuses the files used in the appraisal and these were not able to be located for this project.
[50] We do not have a method for reforecasting the monetised impact of noise or carbon impacts. These generally have a small contribution to the monetised benefits and therefore the impact of assuming as forecast is unlikely to impact on the value for money rating of the project.
[51] Refer to section 6 for further detail on noise and greenhouse gas impacts.
[52] Refer to section 4 for further detail on reliability.

Appendix A

A.1 Safety counterfactual methodology

Personal injury collisions (hereafter referred to as collisions) on the strategic road network are rare and can be caused by many factors. Due to their unpredictable nature, we monitor trends over many years before we can be confident that a real change has occurred as result of the project.

To establish whether any change in collision numbers is due to the project or part of wider regional trends we have established a test we call the Counterfactual. The Counterfactual answers the question: What would have likely occurred without the project being implemented? To answer this question, we estimate the range of collisions that could have occurred without the project in place. Previous Post Opening Project Evaluations answered this question by looking at national trends in collisions. Adjustments have been made to the methodology for estimating the Counterfactual. These have been made to address the following areas:

Amended Data Collection Method

- Revised method for identifying collisions that occurred on the network.
- Only validated STATS19 information is used for reporting purposes.

Adjusting for Traffic Flows

- Baseline traffic flows are an important factor when determining the counterfactual. We now assume that without the changes made to the network, the trends would follow regional background traffic growth patterns.
- We can now calculate the collision rate for the busiest stretches of conventional motorways.

Better Differentiation between different types of motorway

- The existing methodology only had one definition of motorway.
- The new method allows us to differentiate between conventional motorways, conventional motorways with high traffic flows and smart motorways.

Assessing Regional Trends

- The new method uses regional rather than national trends for collision rates and background traffic growth, which provides greater granularity and makes the hypotheses more realistic.

We have found that the adjustments have resulted in a slight change from the previous methodology. We still have confidence in the accuracy of the previous methodology but believe we have made suitable changes that will ensure a methodology fit for purpose for the future.

Since this project, smart motorways have evolved. More recent all lane running projects have demonstrated that they are making journeys more reliable for those travelling during congested periods, enabling us to operate the road at a higher speed limit for longer periods, whilst maintaining safety.

A.2 Incident reporting methodology

Police forces choose how they collect STATS19 data. Some police forces do this electronically, for example using mobile devices, while others complete paper forms which are later digitised. In addition, some collisions are reported by members of the public after the event. Since 2016, new data collection systems (called CRaSH and COPA) have been introduced by some police forces.

Before these new systems, reporting police officers categorised the severity of non-killed casualties as either serious or slight according to their own judgment of the injuries sustained. This was based on information available within a short time of the collision, and often did not reflect the results of medical examination. This sometimes led to casualties being incorrectly classified as slight injuries when they were serious, or vice versa.

In April 2016 nearly all police forces transferred from 'Stats19' to CRaSH (Collision Recording and Sharing) system for reporting personal injury collisions. In CRaSH reporting, police officers record the types of injuries suffered by the casualty rather than the severity. In the previous system the determination of severity was at the discretion of the reporting police officer. CRaSH automatically converted the injury type to a severity classification. This led to implications for reporting on collision severity as there had been an increase in the number of serious collisions recorded[53].

These changes make it difficult to monitor trends in the number of KSI casualties over time or between different police forces. To help with this, the Office for National Statistics (ONS) has undertaken research to identify methods of estimating and adjusting for the increased recording of serious injuries in the new systems. Based on this work, DfT have published an adjusted time series of KSIs at the national level and statistical adjustments at the record level. These adjustments are based on estimates of how casualty severities may have been recorded had injury-based severity reporting systems always been used.

The adjustments will be reviewed by the ONS and DfT as more data becomes available, and it is possible that further refinements will be made to the adjustment methodology in the future. Currently it is not possible to reliably adjust collision severity information at the granular level required for this project.

53 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820588/severity-reporting-methodology-final-report.odt

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