Specialist Professional and Technical Services (SPATS) Framework
Lot 1 & Lot 2

Task 1127
Smart Motorway Incident and Infrastructure Investigation – M6 Junction 5 to 6

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Executive Summary

This report has been prepared as part of Highways England's response to the Smart Motorway Safety Evidence Stocktake and Action Plan. It delivers on the commitment of Smart Motorway Stocktake Action to investigate road user safety on the M6 Junctions 5 to 6 Bromford Viaduct.

The section of the M6 between Junctions 5 and 6 was upgraded to smart motorway as part of a wider programme of upgrades across what is known as the Birmingham Box. This converted the hard shoulder to enable it to be used as a temporary extra lane to provide more capacity when needed (based on demand); this concept is referred to as dynamic hard shoulder running (DHSR). The upgrade also delivered enhanced on-road technology to manage traffic flow. The Bromford Viaduct structure constrained the scheme and resulted in spacings between places of relative safety which are larger than elsewhere on the network.

In order to identify potential interventions in a robust way, this investigation was evidence-led. Analysis of a wide data set sign-posted possible areas of interest. Road safety analysis was applied to determine potential interventions, which answer the question posed for the scheme of, "what more could be done to improve road safety?"

Collision data from the three years prior to the scheme construction date (2009-2011) and the latest available data since the scheme opening date (May 2014 - April 2019, referred to as the 'after period') were analysed. The average number of injury collisions per year has decreased overall compared to the before period. However there has been a change in the average number of fatal collisions per year from zero in the before period to 0.6 in the after period. Two of the three recorded fatal collisions involved vehicles stopped in the nearside lane. There is a small change in the average number of serious injury collisions from 1.3 in the before period to 1.4 in the after period. A reduction in slight injury collisions, from 15.0 in the before period to 13.2 in the after period, is behind the overall reduction in average number of injury collisions per year.

Incident records show that breakdowns are the most common cause of live lane stops on this section, and that these occur on average at a rate of 1.1 per day. A similar number of non-live lane stops are also recorded on average, although changes to incident reporting in 2019 has left a limited data set for comparison within that year.

The emergency areas[1] provided are not fully compliant with standards due to the viaduct structure, with reduced visibility and amended dimensions, but no collision or operational issues have been found associated with their usage in six years since opening. Some evidence indicates the emergency areas are not frequently used by stopping drivers and that drivers could be unaware of the presence or purpose.

Emergency roadside telephones are provided along the viaduct. It is not typical to have telephones present directly adjacent to a lane which can be opened to traffic, but this feature at Bromford Viaduct is understood to have been subject to a risk assessment-supported decision at the time of scheme design. The emergency roadside telephones are not frequently used, however their presence could encourage stranded motorists to walk along the carriageway to a phone and could confuse users into thinking the nearside lane is a place of relative safety when the hard shoulder is open.

Operations did not raise concerns with the performance of this busy part of the network and additional on road resource is prioritised for responding to incidents on the viaduct.

The findings of this investigation must be viewed in context of the proposed improvements to smart motorways outlined in the smart motorway evidence stocktake and action plan[2]. The smart motorway evidence stocktake has already committed to:

[1] At the time of scheme design and construction these were referred to as emergency refuge areas (ERAs) as defined in the Motorways Traffic (England and Wales) Regulations 1982.

[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/873000/smart-motorway-safety-evidence-stocktake-and-action-plan.pdf

- End the use of dynamic hard shoulders by converting to all lane running.
- Faster roll out of stopped vehicle detection.
- Adding additional signing in advance of emergency areas.

For the M6 Junctions 5 to 6 (Bromford Viaduct) section, potential interventions focus around stopped vehicles and a system to reduce the number of breakdowns occurring on the viaduct, and to further improve information and assistance for those who do have to stop.

Potential interventions arising from the data review and focussed investigation are given in Table E1.

Table E1 M6 Junctions 5 to 6 potential interventions

Key Findings – Data Analysis	M6 J5 to 6 Potential interventions
0.34 live lane stops per mile per day: Opportunities **to reduce likelihood** of a live lane stop on the viaduct	A) Encourage use of facilities in advance of viaduct for discretionary stops or limping vehicles, by additional signage on the approach to Bromford Viaduct (above and beyond standards)
	B) Investigate possibility of constructing additional place of relative safety on J5 northbound diverge
	C) Add continual sequence of signs with distance to next emergency area throughout viaduct (above and beyond standards)
	D) To better highlight their presence on approach, add larger more conspicuous signs at viaduct emergency areas (above and beyond standards)
Increase in average collision severity: Opportunities **to reduce impact** of a live lane stop on the viaduct	E) Consider hard shoulder monitoring CCTV-based Stopped Vehicle Detection system
	F) Review opening and closing procedures and thresholds of hard shoulder to ensure it consistently matches traffic demand (i.e. not kept open longer when demand falls away)
	G) Review provision / retention of Emergency Roadside Telephones on viaduct
	H) Coloured surfacing on 1.2 metre kerbed area between edge of LBS1 and parapet, with information signs for those stopped
	I) Investigate the development and provision of a continuous emergency call strip on parapet, e.g. “Press to Alert Help”

Table of Contents

Table of Figures

List of Tables

1. Scope and Purpose

This report has been prepared as part of Highways England's response to the Smart Motorway Safety Evidence Stocktake and Action Plan. This states:

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

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

This report delivers this investigation into what more could be done to improve road user safety on the M6 junction 5 -6 (Bromford Viaduct) section.

In order to identify interventions in a robust way this investigation is evidence-led. Analysis of a wide data set sign-posted possible areas of interest. Road safety analysis was applied to determine potential interventions. The recommendations provide a robust answer to the question posed for the scheme of, "what more could be done to improve road safety?".

This report sets out the data sources and methodology used, the specific areas of investigation, interpretation and conclusions regarding collision occurrences, incident occurrences, and identifies potential interventions. This process is illustrated in Figure 1.1.

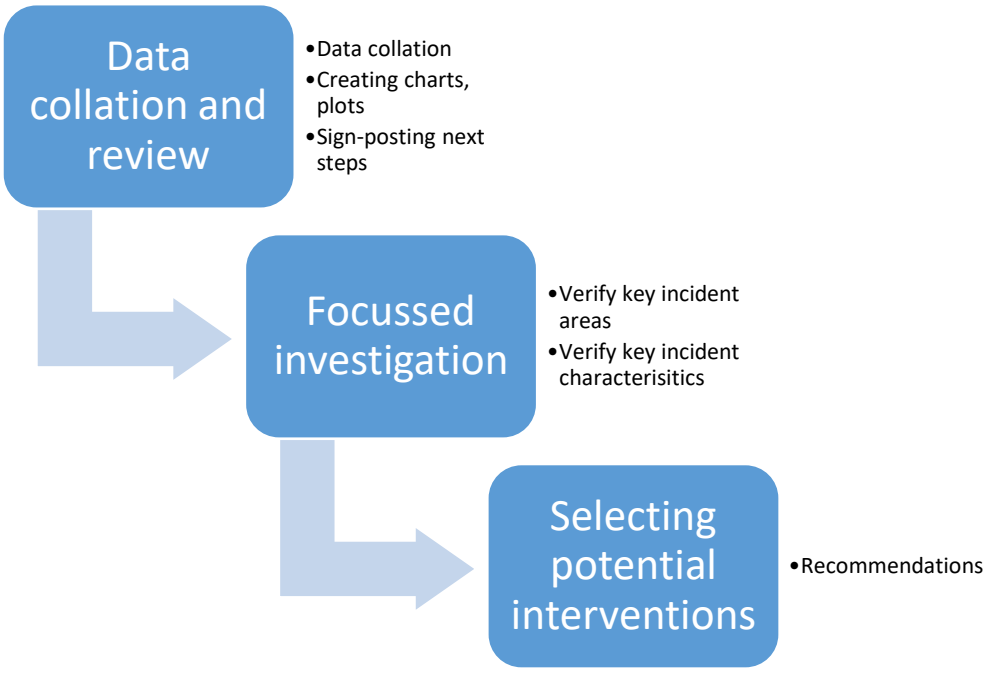

Figure 1.1 Structure of investigation

2. Methodology

2.1 Stage 1 - Data collation and review

A variety of data types and means of analysis formed the first stage of assessment. Data and information inputs were reviewed with the initial objective of sign-posting trends, findings or areas of interest that warrant further analysis.

The Stage 4 (post-opening) Road Safety Audits (RSAs) were reviewed to understand road safety observations made after the scheme was opened to traffic and how these were resolved. If appropriate, earlier RSAs were also reviewed (prior to scheme opening) to investigate trends or continuity in the types of observations raised in the stage 4 road safety audit.

Collision data from the three years prior to the scheme start of construction date and the latest available data since the scheme opening date were analysed; these sets were compared as the average number of collisions per year. Only injury collisions are captured in this dataset (often referred to as 'STATS 19 data'), with data obtained via Regional or Area teams from police records. The data was considered by location and by trend, illustrated using data plots. The trends reviewed included collision and casualty severity, proportion of collisions that have occurred in darkness or daylight, weather conditions, vehicle type and collision type (e.g. nose to tail, side swipe etc).

Approximately half of English police forces adopted the CRASH (Collision Recording and Sharing) system of collision reporting, including West Midlands police (the police force local to this section of the M6) who adopted CRASH in November 2015. This report shows the data as reported to or by the police and does not make any adjustments.

CRASH is an injury-based severity reporting systems where the officer records the most severe injury for the casualty. The injuries are then automatically converted to a severity level from 'slight' to 'serious'. This system eliminates the uncertainty in determining severity that arises from the officer having to make their own judgement and means that the new severity level data observed from these systems using injury based methods are expected to be more accurate than the data from other systems. Further reading on the potential impacts of changes to the reporting system is available on the gov.uk website[3].

In addition to collision data, Operations' incident data was reviewed for this section of the road network, with the aim of giving insight into the occurrence of breakdowns and the proportion of stops in live and non-live lanes. Incidents were characterised as having impact on the operational performance of a scheme (e.g. congestion / formation of queues), these do not necessarily result in injury but have the potential to do so.

Design information for this scheme, including the Design Strategy Record documents and Departures from Standards Checklist, were reviewed to understand the philosophy and rationale behind the road layout. The potential operational impact of the Departures from Standards was assessed and summarised.

To gain an understanding of the operation of the scheme in practice, feedback from consultation with local Operations stakeholders and high quality dashcam video from a recent drive-through in July 2020 were reviewed.

The outcome of the review identifies emerging areas and aspects that warrant further investigation and focussed road safety analysis (Stage 2 of the methodology).

2.2 Stage 2 - Focussed investigation

Road safety analysis drew upon the sign-posted elements from the initial data analysis in Stage 1, considering their relative significance in both isolation and potential combination. Key points for identifying issues for further consideration included whether:

[3] https://www.gov.uk/government/statistics/reported-road-casualties-great-britain-main-results-2018

- the number of a particular collision type has increased since the smart motorway opened.
- there is a location where a number of collisions and/or incidents have occurred.
- there may be a trend of common factor in collision occurrence.
- an issue has become more noticeable or frequent over the years of operation.

In addition to the specifically identified elements, the focussed investigation included a detailed review of:

- all serious injury and fatal collisions occurring post-opening;
- all collisions involving a live lane stop; and,
- for any further areas of interest identified in the Data Review stage, injury collisions of all severities.

Where the analysis identified prospective links between collisions and/or incidents, either spatially (i.e. a cluster) or by common factor (e.g. collisions in wet conditions), these were taken forward for identification of potential interventions.

The outputs from this stage of the investigation were:

- Data on all prospective issues.
- Sifting of issues with no clear pattern, trend or appropriate treatment.
- Issues potentially linked to collisions and/or incidents taken forward for intervention recommendations.

2.3 Stage 3 - Potential interventions

This element of the methodology considers prospective interventions or control measures for the specific issues that are likely to be linked to collisions and/or incidents. These were specific to the scheme and the issues identified.

The output from this stage of the investigation will address what more could be done to mitigate future collisions and/or incidents. Potential interventions will be recommended in context of other Stocktake Action Plan measures, including the roll-out of stopped vehicle detection, and the conversion of existing dynamic hard shoulder running sections to all lane running.

3. M6 Junction 5 to Junction 6 Section Outline

The section of the M6 between junctions 5 and 6 was upgraded to smart motorway as part of a wider programme of upgrades across what is known as the Birmingham Box, where the M6 in the West Midlands links with the M5 and M42, to operate collectively as a strategic 'box' of motorways surrounding Birmingham. The Birmingham Box Phase 3 scheme included the M6 motorway between junctions 5 and 8 (including on-slips and off-slips). The route section was approximately 9.7 miles (15.6km), with 5.3 miles (8.5km) of the route elevated including:

- M6 Junction 5 to 6 Bromford and Gravelly Hill Viaducts (including Junction 6 - Spaghetti Junction).
- M6 Junction 6 to 7 Witton Viaduct.
- M6 Junction 7 Thornbridge Viaduct.
- M6 Junction 7 Questlett Viaduct.
- M6 Junction 8 Ray Hall Viaduct.

Smart motorways convert the hard shoulder to add capacity without the need for land take, introducing speed limits to manage congestion at peak and non-peak times, as well as support incident management. The key smart motorway features introduced by the scheme on the Junction 5 to 6 section were:

- Conversion of the hard shoulder to enable it to be used as a temporary extra lane to provide more capacity when needed (based on demand); this concept is referred to as dynamic hard shoulder running (DHSR). As such this lane is referred to as lane below signal 1 (LBS1) throughout this report.
- Introduction of enhanced on-road technology, including CCTV, signalling and variable mandatory speed limits (VMSL) to manage traffic flow; national speed limits apply and LBS1 is closed to running traffic unless signals display lower limits and a speed over LBS1.
- On this section the hard shoulder is only open to traffic at busy times to relieve congestion to provide four lanes; when LBS1 is open to traffic a mandatory speed limit operates of 50 or 60mph (or lower if required to protect a queue or an incident).

Further points of note:

- The scheme was designed using Highways England’s Interim Advice Note 111/09.
- Construction work for the scheme commenced in January 2012.
- The scheme was opened to traffic in April 2014.
- The information in Table 3.1 describes the operating regimes elsewhere on the Birmingham Box section of the M6.

Table 3.1 - Upgrades to M6 links and operational regimes as part of the Birmingham Box Smart Motorway

Link/Junction	Operating regime	Phase
J4-5	Dynamic hard shoulder running	One
J5 (A452)	Through junction running[4]	Three
J5-6	**Dynamic hard shoulder running**	**Three**
J6 (A38M)	No through junction running	Three
J6-7	Dynamic hard shoulder running	Three
J7 (A34)	No through junction running	Three
J7-8	All lane running (4 lanes northbound, 3 lanes southbound)	Three
J8 intra junction (M5)	Controlled motorway	Three
J8-9	Dynamic hard shoulder running	Two

The M6 J5-6 link is approximately 5.3km long; almost all of the link is on the Bromford Viaduct above the main Leicester to Birmingham railway line. On the northbound carriageway there are 6 signal gantries, one advance direction sign and one combined sign and signal gantry. On the southbound carriageway there are nine signal gantries (there is no southbound exit at Junction 5).

One emergency area is provided in each direction over Bromford Viaduct between Junctions 5 and 6. The central reserve has a double-sided steel vehicle restraint system and lighting columns are also located in the central reserve. The extent of the area under investigation is shown in Figure 3.1.

For this M6 J5 to 6 Bromford Viaduct section, installation of stopped vehicle detection and conversion to all lane running is programmed for completion by early 2024.

Figure 3.1 Extent of investigation area

[4] Through junction running means that the hard shoulder through the junction is dynamically managed and may be opened to traffic.

4. Data collation and review

This section contains the results of the initial review and analysis of the key data sources. Key outputs from this section are taken forward to the following section for further focussed safety analysis.

4.1 Road Safety Audit Stage 4 review

The Stage 4 Road Safety Audit was undertaken in November 2016 and issued to Highways England in October 2019. The Road Safety Audit was undertaken in accordance with HD 19/15 and included a site visit. Earlier Stage 1, 2, interim 3 and 3 Road Safety Audits were completed on the scheme. The review of the Stage 4 Road Safety Audit is described in Table 4.1.

Table 4.1 M6 Birmingham Box Phase 3 Road Safety Audit Stage 4A (issues related to J5-6 only)

	Summary of Road Safety Audit 4A	Relevance to this investigation
Collision analysis	The report includes a brief overview consisting of before and after collision numbers and a comparison of after collision rates with collision rates for motorways taken from DfT Road Casualties Great Britain 2015. It notes there are the same number of collisions before (65) and after (65) but with increased severity ratio post scheme completion (1.6% to 4.6%). There was a higher average collision rate in comparison to national motorway figures (15.2 compared to 8.3 collisions per million vehicle miles) but lower severity ratio (4.6% compared to 12.8%).	The reported analysis of collision data is limited to severity and broad collision type, i.e. shunt, lane change and loss of control.
Traffic conditions	The report used automatic traffic count data for 2014. No comparison with pre-opening flows is provided.	Report does not indicate if the scheme has resulted in any significant changes in traffic flow as based on 2014 levels. The percentage HGVs noted as 18% and 20% north/southbound respectively.
Review of previous Road Safety Audits	There were 9 issues raised at Road Safety Audit 3. Seven of the issues (not detailed in the Road Safety Audit 4A) were not accepted and exception reports were signed off. The remaining two issues were accepted, one was addressed and the other remains at stage 4A and related to the positioning of the emergency roadside telephones and accessibility for those with mobility impairment.	Five issues in the Road Safety Audit 1, 2 in the interim Road Safety Audit 3 and 7 in the Road Safety Audit 3 were not accepted by the Designer[5]. The Stage 4A Road Safety Audit does not state how many of the issues at Road Safety Audit Stage 2 were accepted or not.
Identified road safety problems	Positioning of emergency roadside telephones.	As identified during the site visit.
Conclusions/ recommendations	Collision severity has increased but is still less than national motorway severity ratio. Reduction in shunts but an increase in lane change and loss of control type collisions.	A similar number of collisions were recorded before and after scheme completion and there was a lower severity ratio than nationally although an increase in comparison to the before data. The Stage 4 did not go into further detail with respect to the collision data analysis to identify, *locations at which personal injury collisions have occurred; and personal injury collisions that appear to arise*

[5] It is not unusual for points of difference to arise between an RSA team and a designer, with some issues not accepted and an exceptions report written.

		from similar causes or show common factors. [HD 19/15 para 2.45]
Key points		Excluding the Road Safety Audit 2, 15 of the 31 issues raised in Road Safety Audits were not accepted by the Design Organisation resulting in 14 exception reports.

Key findings

The review of the Stage 4 Road Safety Audit has highlighted further actions for the investigation:

- A detailed analysis of collisions will be required.
- A detailed review of emergency roadside telephone usage is justified.
- A review of the problems and recommendations identified at Road Safety Audit Stage 2 and 3 that were subject to exception reports.

4.2 Collision data review

This section compares the collisions before and after the Birmingham Box Phase 3 smart motorway scheme between Junctions 5 and 6 on the M6.

At the start of the analysis it was noted that, at the time of writing, two fatal collisions on the southbound carriageway were not included in the STATS 19 data from Police records provided by Operations. As such the additional information was collated from the West Midlands Police Collision investigation unit documentation[6]. As these collisions have not yet been included in STATS 19 data used it has not been possible to include the circumstances in all parts of the analysis and this may result in some inconsistency in the numbers quoted throughout this section.

The scheme before period is 2009, 2010 and 2011, the three years prior to the construction of the adjacent Birmingham Box Phase 2 scheme (M6 Junction 8 to 10a). This is because the extensive temporary traffic management associated with Phase 2 influenced local traffic speeds and collisions between Junctions 5 and 6 at the time. The three year period has been selected as a manageable and representative data set to provide comparison for the data after the smart motorway scheme opened on this section. Average traffic (annual average daily traffic) in this period was 127,933 vehicles per day.

The scheme after period comprises the five years of collision data since opening to traffic; May 2014 to April 2019. The operational data used is considered unvalidated data. Using this data rather than validated data meant the most recent collisions could be included and meant the investigation could include the full description of the collision circumstances. Average traffic (annual average daily traffic) in this period was 136,126 vehicles per day, an increase of 6% over the before period. This data is plotted in Figure 4.2.

The after data for 2016 included 13 duplicate collision entries; these had unique reference numbers and the descriptions varied. However, the details in the accident, vehicle and casualty record duplicated other records, so these were removed from the data set.

4.2.1 Severity

Table 4.2 and Figure 4.1 show that the average number of injury collisions per year has decreased overall compared to the before period. However there has been a change in the average number of fatal collisions per year from zero in the before period to 0.6 in the after period. There is a small change in the average number of serious injury collisions from 1.3 in the before period to 1.4 in the after period. Fatal and serious injury collisions are assessed in detail in section 5.1. A reduction in slight injury collisions, from 15.0 in the before period to 13.2 in the after period, is behind the overall reduction in average number of injury collisions per year.

[6] CIU Ref 2 92 / 2018 for the collision in 2018 and 2017-177-2471 for the collision in 2017.

Table 4.2 Collision severity, by year, for the before and after data periods

	Before				After						Mean number of collisions /yr	
Severity	Y1	Y2	Y3	Total	Y1	Y2	Y3	Y4	Y5	Total	Before	After
Fatal	0	0	0	0	0	1	0	1	1	3	0.0	0.6
Serious	1	2	1	4	2	0	1	2	2	7	1.3	1.4
Slight	18	13	14	45	16	20	16	8	6	66	15.0	13.2
All	19	15	15	49	18	21	17	11	9	76	16.3	15.0

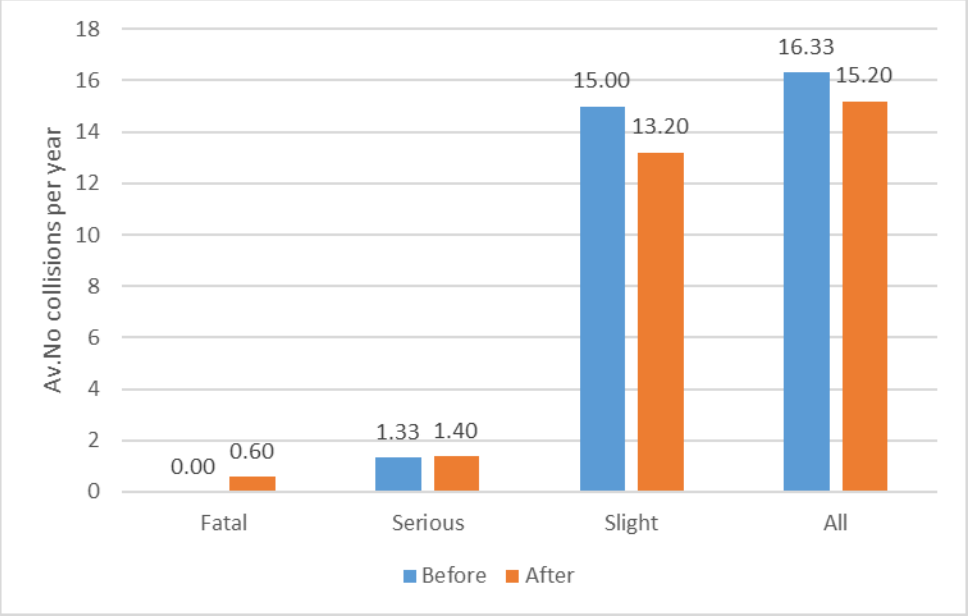

Figure 4.1 Mean number of collisions per year by severity

In the three years prior to the scheme the proportion of collisions of killed or seriously injured severity on the section was 8.2%, in the after period this proportion was 13.2% Whilst this is an increase, this section is below the average for motorways on the strategic road network; the 2018 SRN Casualty Report indicates 17% of motorway collisions were fatal or serious in 2018.

The 2018 rate of fatal collisions per motorway mile in the same report is 0.039 [7], on this section of the M6 it is 0.18 [8] per year per motorway mile across the after period.

[7] 74 fatal collisions recorded on 1,905 miles of motorways – 2018 SRN Casualty Report.
[8] 0.6 fatal collisions per year on average across a 3.3 mile section.

Figure 4.2 Location of all after collisions

4.2.2 Lighting condition

This section compares the proportion of collisions before and after the scheme by lighting condition. The whole of the section from Junction 5 to 6 was lit by a system of street lights from the central reservation prior to the introduction of the smart motorway and remains lit.

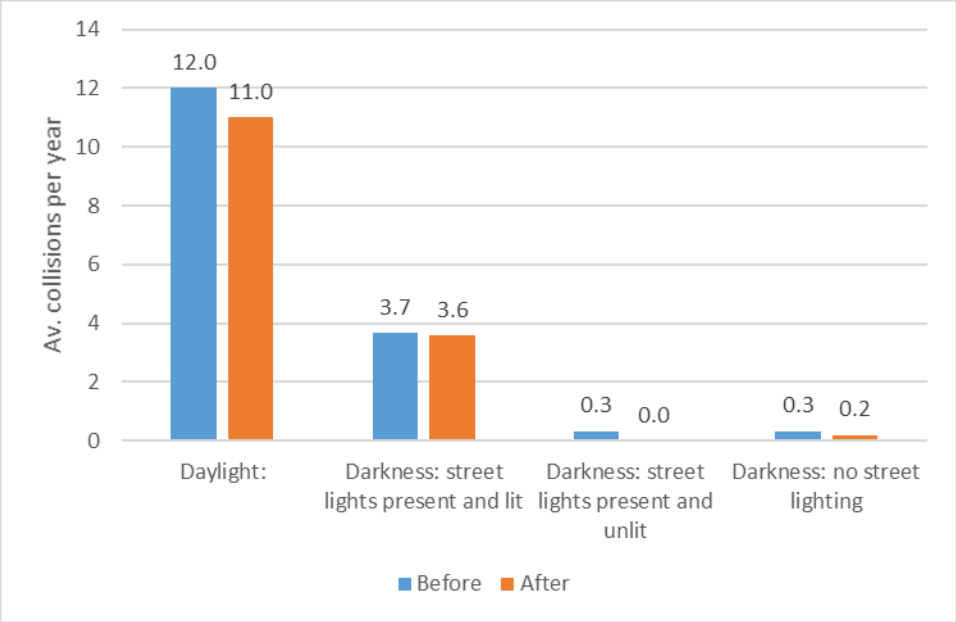

Figure 4.3 Average number of collisions per year by lighting condition for the before and after data periods

Figure 4.3 shows very little real change in the proportion of collisions occurring in daylight or in the hours of darkness. Collisions occurring in the hours of darkness account for 26% of all collisions in the after period. The proportion of collisions occurring in the hours of darkness across the Highways England motorway network is 30%, based on the 2018 SRN casualty report. As such the proportion at Bromford Viaduct is slightly lower than national motorway averages.

4.2.3 Collisions by weather and road conditions

The analysis compared collisions before and after by road conditions. Figure 4.4 shows very little real change in the distribution of collisions between the before and after periods. The upgrade to smart motorway will have included an aspect of resurfacing that could explain the reduction in wet surface collisions.

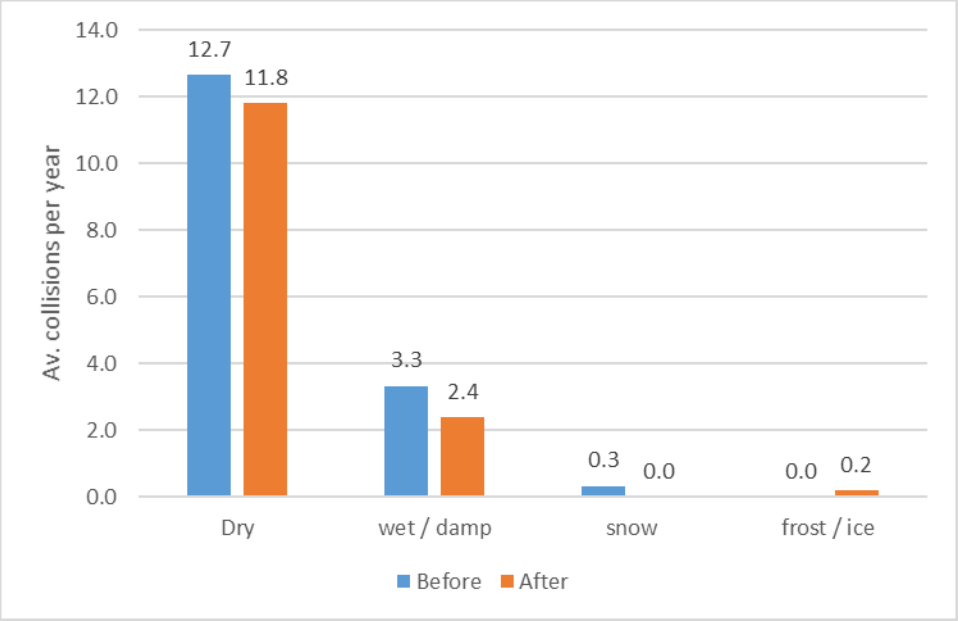

Figure 4.4 Average number of collisions per year by road surface condition (weather related) for the before and after data periods

4.2.4 Collisions by vehicle type

The analysis compared collisions before and after by type of vehicles involved and this is shown in Figure 4.5. There is a noticeable reduction in the number of goods vehicles involved in collisions and an increase in the number of collisions which include cars. The proportion of goods vehicles involved in collisions fell from 33% to 12%.

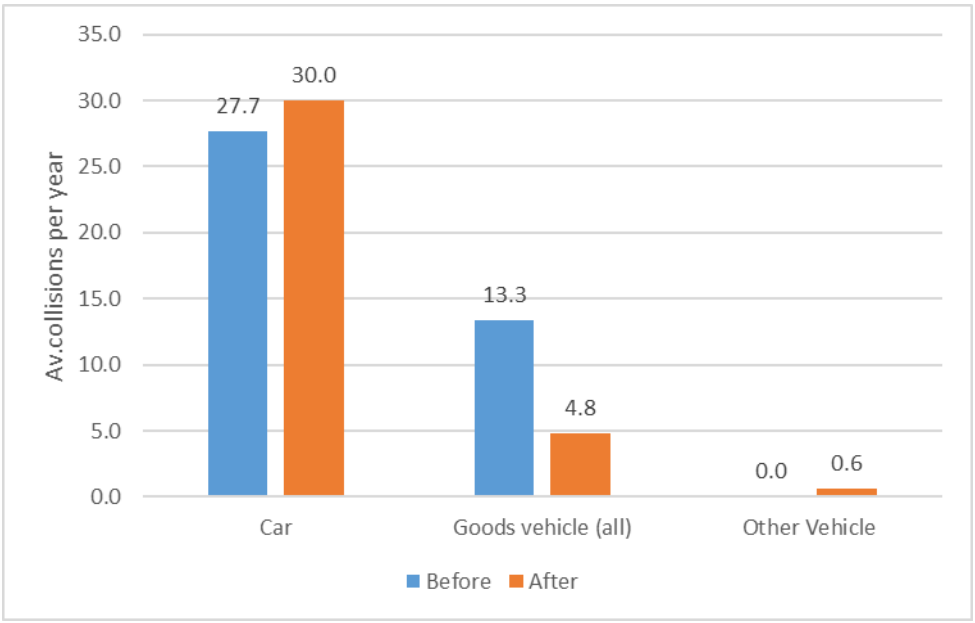

Figure 4.5 Average number of vehicle types per year involved in collisions for the before and after data periods

4.2.5 Collisions by vehicle manoeuvre and point of impact

The analysis compared the manoeuvre recorded for vehicles involved in collisions in the before and after data; the results are shown in Figure 4.6. The accumulative total of vehicle movements classed as going ahead (all), slowing or stopping, or waiting to go ahead but held up, has increased. This could indicate an increase in shunt collisions, which would be unusual as smart motorways tend to reduce this

type of collision[9]. The total proportion of changing lane collisions has fallen and the number of collisions classed as 'parked' has increased.

The analysis of 'first point of impact' (refer to Figure 4.7) data shows little change in proportions other than the number of collisions with first point of impact as offside increasing. In contrast to Figure 4.6, this does not indicate an increase in shunt collisions as the proportion of front or rear first point of impact has fallen. The number of side impacts has increased in the after period, which again provides a counter-indication to the vehicle manoeuvre records seen in Figure 4.6.

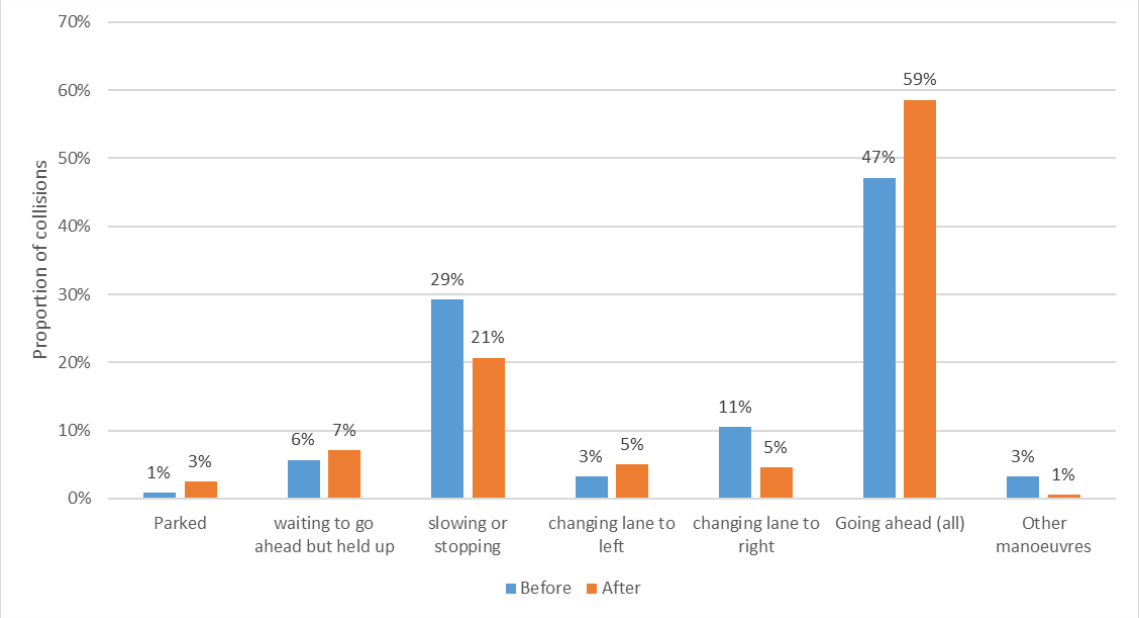

Figure 4.6 Proportion of vehicles per year by movement involved in collisions for the before and after data periods

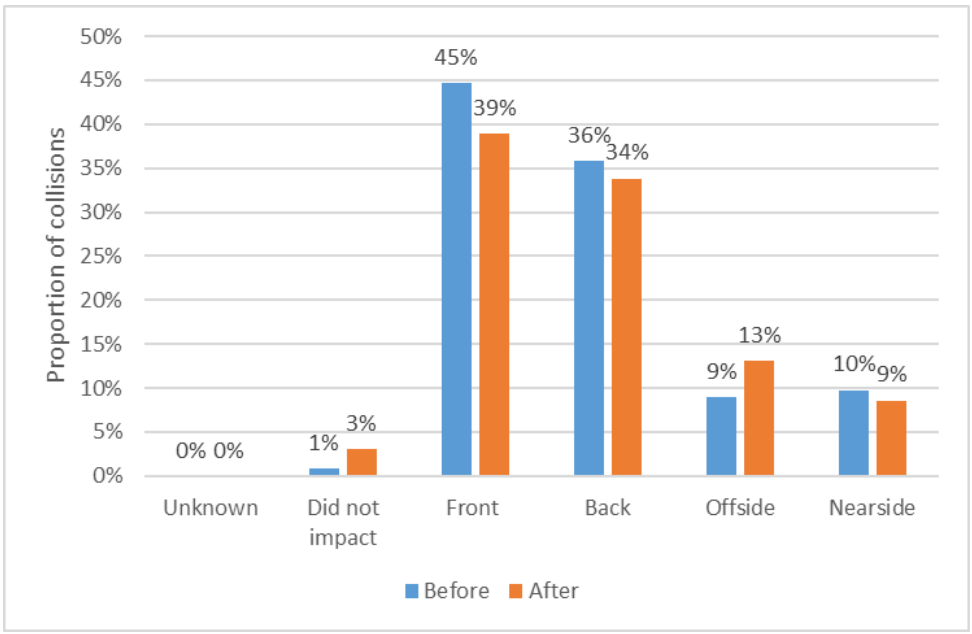

Figure 4.7 Proportion of vehicles by first point of impact for the before and after data periods

4.2.6 Collisions by day of week

The analysis compared the proportion of collisions occurring by day of week and is reported in Figure

[9] The SM-ALR Overarching Safety Report 2019 reported a 22% reduction in shunt collisions.

4.8. This type of analysis is informative as weekday motorway collisions can be associated with regular users and congestion whilst weekend collisions could indicate less familiar users. In the before collision data, 67% of all collisions occur during weekdays (Mon-Fri), however this only marginally increases to 70% in the after data. There is however a shift in the proportion of collisions occurring on Mondays and Fridays away from Tuesdays, Wednesdays and Thursdays.

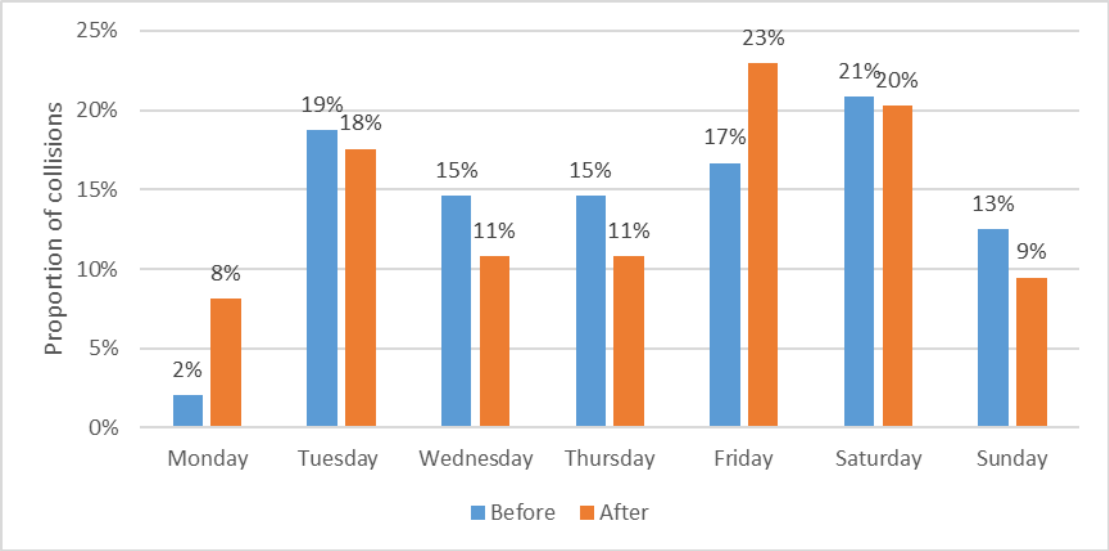

Figure 4.8 Average proportion of collisions per year by day of occurrence

Key findings

The collision data analysis has identified areas for further investigation:

- Based on number of collisions, overall average number of injury collisions per year has reduced, although the number of fatal collisions have increased.
- The number of fatal collisions and the KSI ratio have increased in the after period.
- Fewer goods vehicles are involved in collisions which means a greater proportion of collisions involve cars.
- Vehicle manoeuvre and vehicle first point of impact data give no clear indication as to whether the proportion of shunt collisions has changed in the after period.

4.3 Incident data review

In addition to collision data, Operations' incident data from the latest three years of smart motorway operation between junctions 5 and 6 on the M6 has been reviewed, with a focus on incidents most likely to affect live lanes (and which may otherwise or previously have involved use of the hard shoulder). The three most recent years' of data have been used in order to provide a manageable but robust data set.

Looking at all entries in the log there was an average of 3,061 recorded incidents per year on the Viaduct between 2017-2019. Considering the latest full year (2019) in depth, 1,011 of the entries related to opening and closure of LBS1 as a running lane and a further 329 were some form of duplication identified by the operators in the Regional Operations Centre. A breakdown of the remaining incident data records from 2019 is shown in Figure 4.9. This shows an analysis of the nature of the incidents in 2019, based on the final closure code, with hard shoulder opening / closing activities and duplicate entries removed.

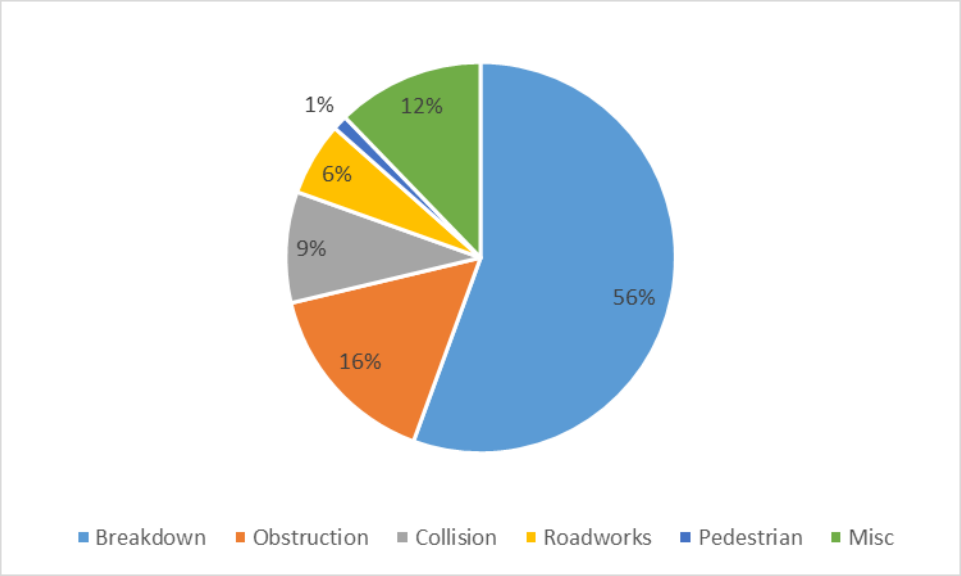

Figure 4.9 Proportion of incidents by type (2019)

Figure 4.9 shows that breakdowns make up 56% of incidents on the viaduct with 1,053 events in 2019. This equates to just over 20 a week or nearly 3 a day. There were 174 collisions recorded (9% of incidents) which is higher than those reported officially in validated injury collision data (it is important to note that this will include *all* collisions of which Operations are made aware, which will include damage-only collisions not captured elsewhere).

There were also 23 incidents related to the presence of a pedestrian on the network, which, given the elevated and isolated nature of the section, suggests stranded motorists may be walking from their stopped vehicles to emergency telephones or to seek a place of refuge.

The location of breakdowns in live lanes compared to non-live lanes has been compared across the three years of available data showing relatively even splits; refer to Figure 4.10[10].

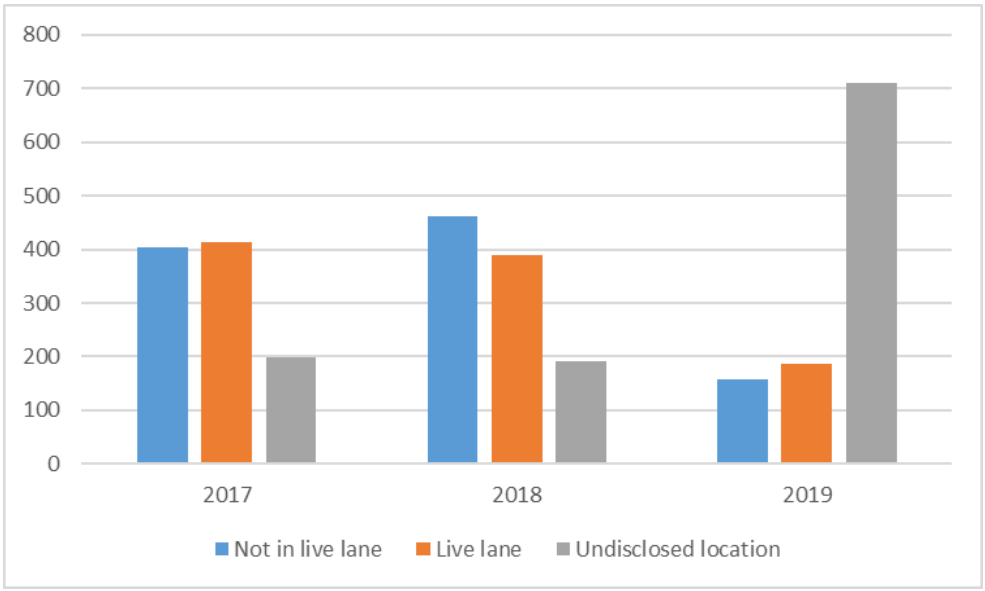

Figure 4.10 Number of breakdown incidents by type and year (2017-2019)

[10] The way Incident data was reported changed part way through 2019, which included the way location information was categorised. For the purposes of this analysis and to ensure comparison of equivalent data, 2019 post-change data has been separated out into the Breakdown Undisclosed field and not compared to the location data from 2017 and 2018 and the early part of 2019.

These reported breakdowns have been further analysed by day of the week and time of day; the results are shown in Figure 4.11 and Figure 4.12. The day of week analysis shows very little discernible difference between the number of breakdowns occurring on weekdays and weekends. The hour of day analysis shows that the number of breakdowns seems to peak later in the afternoon and early evening. There is also a noticeable increase in the am peak.

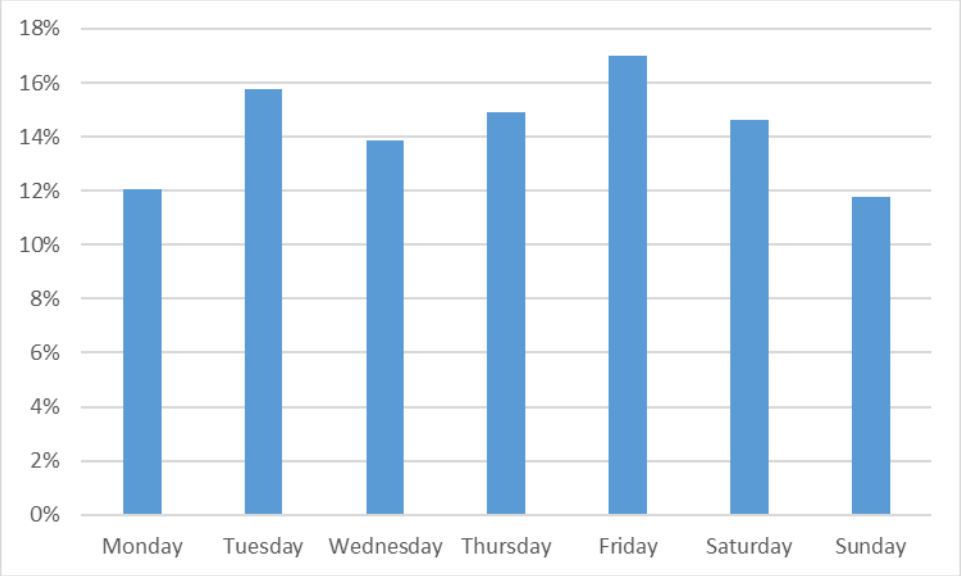

Figure 4.11 Proportion of breakdown incidents by day of the week

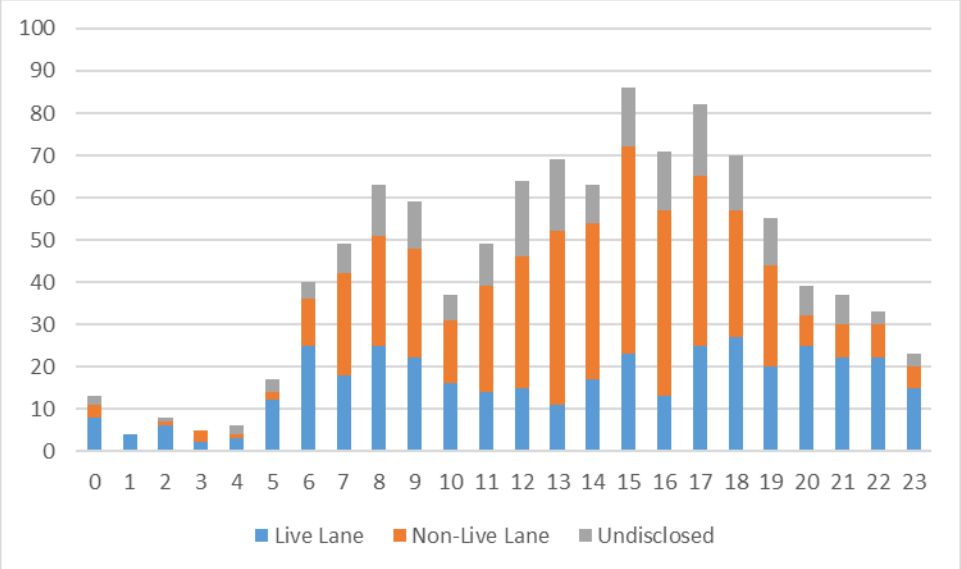

Figure 4.12 Number of breakdown incidents by hour of day

The analysis of breakdowns by the hour of occurrence has also shown that live lane stops are more common during the busiest times of the day when LBS1 is more likely to be in use as a running lane, as more vehicles are present on the section. Note that higher traffic flows during peak hours make a breakdown incident more likely under any circumstances as more vehicles are present on the network. The data indicates an overall live lane breakdown rate of approximately 1.1 per day on this section; for the 5.3km length of motorway averaging 0.34 per mile per day or 124 per mile per year.

Finally, an analysis of the breakdowns that were notified to the Regional Operations Centre by users of the emergency telephones on the viaduct was undertaken. Based on the 2019 data for breakdown

incidents classed as non-live lane, six of the 115 incidents were notified via an emergency telephone. This represents just above 5% of breakdowns. For live lane breakdowns the figure for notification via emergency telephone rises to seventeen (15%).

This appears counter-intuitive as non live-lane breakdowns in this section must by definition be located in the emergency area or on a closed LBS1 where emergency telephones are provided. Live lane breakdowns could occur anywhere else, where an emergency telephone may not be adjacent, yet record a higher number of emergency telephone notifications. The implication for road user behaviour is that live lane breakdowns are viewed as higher risk so the 'official' emergency telephone is sought out to summon help or raise awareness; it is highly likely that doing so involved walking along or adjacent to the carriageway, potentially introducing further risks. In contrast, breakdowns in the emergency area could be perceived by those involved as more routine or lower risk, so the close-at-hand emergency telephone is seldom used.

Key findings

The collision and incident data analysis has highlighted some issues that will warrant further investigation:

- The rate of live lane breakdowns indicates that these incidents are daily occurrences on this section (averaging 1.1 per day or 0.34 per mile per day).
- The emergency telephones are used to contact the Regional Operations Centre in 15% of live lane breakdowns and only 5% of non-live lane breakdowns.
- There is an implication that drivers of some stranded vehicles may be walking along the section to emergency telephone locations.

4.4 Design strategy record review

The Birmingham Box Phase 3 scheme design strategy record has been reviewed to identify potential operational or safety related departures or relaxations recorded at the design stage. Table 4.3 includes commentary on the design strategy record entries which could have a bearing on operational safety of the section between Junction 5 and 6 of the M6.

Table 4.3 Design strategy record entries which could have a bearing on operational safety

DAS ID	Element	Location	Potential relevance to this work	Follow-on
59650	Junction Design	Junction 6 diverge Slip Road	Sub-standard Nose (39m), taper (62m) and ghost island tail lengths (70m). Also, no overlap has been provided between the nose and the ghost island.	Check operational and safety performance of diverge.
60130	Emergency area dimensions	Northbound emergency area at Rail Crossing	Emergency area has a 23m entry taper (required 25m) and a 35m exit taper (required is 45m).	Check for evidence of collisions in and around the emergency area linked to reduced geometry.
60134	Visibility	Southbound emergency area at Rail Crossing	The standard entry and exit Stopping Sight Distance requirements for an emergency area are 160m and 215m respectively. However, the achievable entry and exit stopping sight distance for this emergency area are 137m and 152m respectively.	Check for evidence of whether road users are able to identify the emergency area due to reduced visibility.
60333	Signs	Junction 6 northbound approach	Non provision of tiger tail signs as per TD22, on the approach to Junction 6.	Check operational and safety performance of diverge.
61074	Lane width	Whole section	A sub-standard lane width of 3.2m to be used for LBS1.	Check for evidence of collisions related to usage of LBS1.

DAS ID	Element	Location	Potential relevance to this work	Follow-on
61202	Emergency refuge area spacing	Northbound and southbound ERAs at Rail Crossing	Only one emergency area for each carriageway on this link means that emergency area spacing is significantly above the maximum permitted.	Rejected. See later departure from standard DAS reference 64828 below.
64272	Emergency telephones	Whole section	Provision of emergency telephones outside of ERAs, next to the hard shoulder on the main carriageway where hard shoulder running (HSR) is to be implemented.	Check if emergency telephones are used and if their provision on viaduct causes inappropriate stops in live lane.
64828	Emergency refuge area spacing	Northbound and southbound ERAs at Rail Crossing	Due to the entire 5.40km long link between Jn 5 and Jn 6 being located on Bromford Viaduct, only one emergency area for each carriageway is provided. Result is 3.6km & 2.7km gaps northbound, 2.9km & 3.8km gaps southbound	Check rates of live lane stops and collisions as a result of reduced emergency area provision.

Key findings

The review has shown that the project team delivering the Birmingham Box Phase 3 scheme at Bromford Viaduct faced a challenging set of constraints. The result is that gaps between emergency areas on both carriageways on Bromford Viaduct exceeded those recommended in the contemporary design standards and that elements of their design had to be varied to accommodate them within the structure.

As part of this investigation the impact of the key decisions on operation and safety are considered, and the following design aspects will be considered further:

- Junction 6 northbound exit.
- Safety at the northbound and southbound emergency areas.
- Relationship between emergency area provision and breakdown rate.
- Usefulness of the emergency telephones provided.

4.5 Operations feedback

The Operations Team spoke to this investigation team via Microsoft Teams on 17th August 2020. Key points are noted below.

Traffic Officers are stationed at each end of the viaduct to reduce response times to incidents. However, these resources cannot provide continuous incident response at Bromford Viaduct as there are no facilities for traffic officers, shift changes occur and there is a need to also respond to incidents elsewhere. One risk that is common to the viaducts in the area is projectiles falling from vehicles over parapets into the areas below.

Congestion is commonplace on the viaduct, especially caused by the J6 northbound exit, which means that for a proportion of the day traffic speeds will be low.

Operations staff stated that further upgrades to existing emergency areas to make them more obvious to users could be beneficial. They also felt that provision of defined waiting places, behind vehicle restraint systems where possible, could be beneficial as the fear of being near the parapet and edge of viaduct may reassure stranded users.

Technology reliability was not noted as a major concern; opening of LBS1 is reliant on a level of operational technology, meaning safeguards were in place. Serious collisions can occur quickly from the point at which the vehicle stops before Highways England can be made aware and signals set.

Key findings

Whilst the feedback from operations staff was generally positive it has further highlighted two issues:

- Junction 6 northbound exit congestion.
- Perceived lack of driver awareness of the emergency areas.

4.6 Data review outputs

Figure 4.13 shows how the high-level issues identified link to the data sources used in this phase of the investigation. The following specific questions will be considered in more detail in the following section:

- Are there particular sections of the viaduct that account for the increased number of collisions, specifically slight collisions and collisions involving cars only? Is the J6 Northbound exit one such area?
- Are there collision occurrences and safety issues at the northbound and southbound emergency areas?
- What proportion of emergency telephone calls are from the emergency areas and are the emergency telephones on the link beneficial?
- Is the spacing between emergency area places of relative safety contributing to the live lane breakdown rate, and are the emergency areas being underused?
- Is there a particular common event or cause for the fatal and serious collisions that have occurred?
- Do the recommendations provided at Road Safety Audit Stage 2 and 3 offer any potential opportunities to improve safety?

In addition to the above, the focussed investigation will include an analysis of fatal and serious collisions and live lane stop- related collisions.

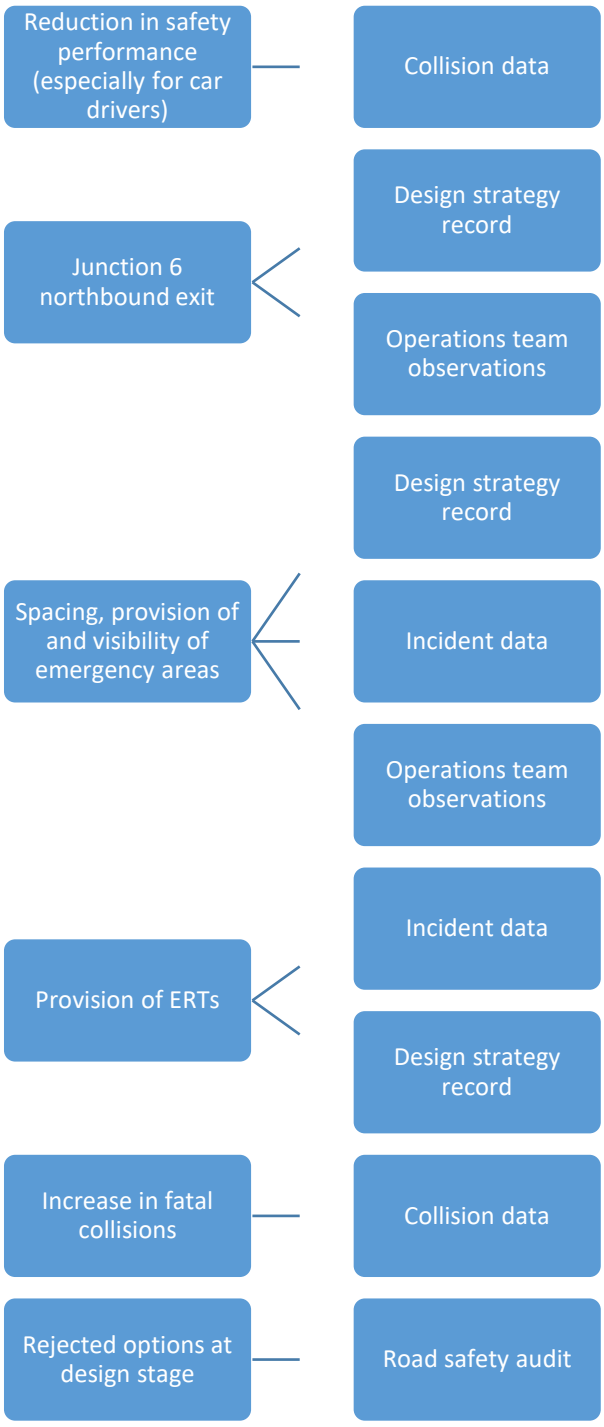

Figure 4.13 Source of the factors to be considered for further safety analysis

5. Focussed Investigation

This section investigates in detail the key factors or areas identified in the preceding chapter, plus any additional factors which come to light. It commences with a review of all collisions of fatal and serious severity, and all collisions associated with live lane stops. The objective of this section is to identify and verify treatable safety issues, or to clarify where certain factors or areas cannot be linked to a safety issue.

5.1 Fatal and serious collisions review

The purpose of this part of the investigation is to determine if there is a particular common event or cause for the fatal and serious collisions that have occurred. These are shown in Figure 5.1 .

5.1.1 Fatal collisions

Three fatal collisions have been recorded on the M6 between Junctions 5 and 6 since the Birmingham Box Phase 3 Smart Motorway scheme became fully operational. Table 5.1 summarises the circumstances for the three collisions.

Table 5.1 Details of fatal collisions

Collision Ref.	Carriageway	Date & Time	Conditions	Detail	Casualties	Comment
Z4905416	Northbound	04/02/2016 at 01:50. (Thursday)	Wet and in the dark on a lit section of carriageway	Two vehicles involved; Vehicle 1 was a car and vehicle 2 was a large goods vehicle (larger than 7.5 tones). The contributory factor was noted as exceeding the speed limit.	Two males both fatally injured aged 26 and 42.	Limited detail is available to inform the investigation.
Unknown – (referenced as 18082017 on Fig 5.1)	Southbound	18/08/2017 at 09:11. (Friday)	Dry in daylight	Two vehicles involved; vehicle 2 (a recovery truck) makes a **live lane stop in LBS1** which is open to traffic. The Regulation 28 report to Prevent Future Deaths written by the coroner states that, "*Mr Ahmed activated his hazard lights, exited his lorry, opened the bonnet and stood looking into the engine*." The vehicle is present for 2 minutes and 15 seconds when vehicle 1, a goods vehicle, collides with the rear of vehicle 2.A 60mph speed restriction was in place. The driver of the stopped vehicle was under the influence of drugs.	One male of 36 was fatally injured and one male of 34 was slightly injured.	The next place of relative safety was an emergency refuge area 300m downstream from the collision location.

Unknown – (referenced as 31052018 on Fig 5.1)	Southbound	31/05/2018 at 19:29. (Thursday)	Dry/light	A car **stops for unknown reason in LBS1** whilst it is open. An approaching goods vehicle collides with the rear of the car. A 60mph speed restriction was in place. The Regulation 28 report to Prevent Future Deaths written by the coroner states that, *"It is not known why the Toyota Yaris stopped but there is no evidence of a fault with the vehicle causing it to stop, illness of the driver or a hazard in the road*."	An 8-year-old boy was fatally injured but the injuries to the 3 others involved are unknown.	The collision occurred approx. 3 miles along the link (M6 B MP179). The closest place of relative safety was 1 mile upstream with a further facility 1.5 miles downstream. Collision was 650m downstream of a signal gantry.

5.1.2 Serious collisions

A total of eight serious injury collisions have been recorded on the M6 between junctions 5 and 6 between May 2014 and April 2019; see Table 5.2 . Of the collisions:

- Five were recorded on the northbound carriageway and three on the southbound carriageway.
- Two were recorded on a wet road surface.
- Three were darkness collisions of which two were reported as lit.

Table 5.2 Details of serious injury collisions

collision Ref.	Carriageway	Date & Time	Conditions	Detail	Casualties Sex | Age	Comment
Z0036414	Northbound	18/10/2014 18:54	Dark(lit)/dry	Limited detail. Collision involved a goods vehicle and a car. Contributory factors were fatigue, illness or disability.	M35 M60	Limited details to fully understand the type of collision
Z0007515	Northbound	15/03/2015 07:45	Light/wet	**Lane changing**. Contributory factors were impaired by alcohol, aggressive driving, careless/reckless.	F23 F38 F21 M27	
107551	Northbound	28/08/2016 04:25	Light/dry	**Rear shunt**. Contributory factor was travelling too fast.	M58 M20 M21 M22 M21	Although recorded as light, it is likely that this collision was actually in the hours of darkness given the time of occurrence.

collision Ref.	Carriageway	Date & Time	Conditions	Detail	Casualties Sex | Age	Comment
284320	Southbound just after junction 6	06/04/2018 01:13	Dark/dry	**Live lane stop in lane 3**. A goods vehicle in lane 2 has tyre blow out and stops in lane 3. Two other vehicles, a goods vehicle and a car collide with the stopped vehicle.	M54	Live lane stop shortly after junction 6 when LBS1 was **not open**. It also involved a tyre blowout. The operating regime was not a significant factor. It should be noted that this section is lit by street lighting; this may have been missed from the collision report.
206659	Northbound	02/07/2017 17:10	Light/dry	**Rear shunt in lane 3 in stationary traffic**. Contributory factors were failure to look, judge.	M34 M27 M38	
334570	Southbound	21/09/2018 18:37	Light/dry	**Lane change from 3 to 4 resulting in 4 vehicle rear shunt**.	F45 M53 M25	
199771	Southbound	05/07/2017 09:07	Light/dry	A car **changed from lane 2 to 3 and was struck by a goods vehicle**. Contributory factors were aggressive driving, careless.	M48	A 40mph limit was displayed on the gantries suggesting queue protection had been triggered and congestion was present.
337855	Northbound	21/09/2018 00:36	Dark(lit)/wet	A vehicle **lost control on standing water** in lane 3. Contributory factors were too fast, braking.	M35 M51 M22 M34 M39	

Figure 5.1 Location of fatal and serious collisions (including emergency telephones and signal gantry locations)

Northbound serious injury collisions

Of the five serious injury collisions recorded on the northbound carriageway two involved a rear shunt, one changing lane, one loss of control and one unknown. Three of the collisions occurred in a weekday peak. The shunt type collisions would indicate congested driving conditions, and this is reflected in some of the collision descriptions, i.e. stationary traffic. Two of the collisions were recorded in the dark and two on a wet road surface. The number of recorded serious collisions has remained reasonably consistent since 2015, averaging one per year.

Southbound serious injury collisions

Of the three serious injury collisions recorded on the southbound carriageway two involved lane changing and one a live lane stop. The live lane stop occurred at night and involved the tyre of a goods vehicle in lane 2 bursting and the driver stopping in lane 3. Two other vehicles subsequently collide with the stopped vehicle. The serious collisions on the southbound carriageway occurred in 2017 and 2018.

Fatal and serious injury collision locations

Four of the serious injury and two of the fatal collisions were recorded within approximately one kilometre of the emergency area on Bromford Viaduct. Four of these collisions were northbound and two southbound.

There have been three live lane stop collisions; two fatal and one serious; all occurred southbound, one was close to the emergency area location occurring 300m before it.

Key findings

The fatal collision on the northbound carriageway does not appear to relate to the smart motorway operation; occurring at night and away from LBS1. Two of the three fatal collisions involved a live lane stop southbound in LBS1. In both instances LBS1 was open to traffic. In at least one of the collisions reports indicate that the vehicle could have continued to a place of relative safety. These two live lane stops appear to be on sweeping right hand bends with high sided vehicles in LBS2 possibly reducing forward visibility to the stopped vehicle. The Regional Operations Centre were not alerted so had not set signals to protect the stranded vehicle in either instance and a 60mph restriction was in place as standard when LBS1 is open. Highways England's own CCTV footage reviewed in the Regional Operations Centre indicated that in both instances other approaching vehicles avoided the obstacle before the collision.

There are twice as many serious collisions northbound as southbound and a distinction between the most frequent type of collision being recorded on each; rear shunt type collisions northbound and lane changing southbound. There is a general increase in serious collisions southbound and a decrease northbound, but these are small numbers. There have been three live lane stop- related collisions of fatal or serious injury severity on the southbound carriageway, one in 2017 and two in 2018. Two of the collisions were recorded prior to the emergency area.

The findings from the review of the fatal and serious collisions are:

- Given some of the occurrences in LBS1, it appears that the status of LBS1 may not be clear to some users in emergency situations.
- The location of places of relative safety may not be obvious to users.
- Once a vehicle is stopped, high levels of traffic and horizontal alignment may obscure the stopped vehicle and may increase the risk of a collision occurring before signals can be set.

5.2 Live lane stop related collisions

The slight injury severity collision descriptions have been interrogated to identify any further live lane or hardshoulder stop related collisions. This has highlighted five further collisions which may have been as a result of a vehicle stop, see Table 5.3.

Table 5.3 Live lane stop related collisions

Ref.	Location	Date Time	Conditions	Detail	Casualties Sex | Age	Comment
Z0047614	Northbound at MP 182/4	Tuesday 15/12/14 at 22:10	Fine, dry and dark.	A car travelling northbound strikes a parked vehicle (car). Result of failing to look properly.	F28	Unclear whether the stopped vehicle was in LBS1. Injured person was passenger in approaching vehicle. Lack of injury in stopped vehicle suggests they may have left the vehicle.
Z0044414	Southbound at MP 181/8	Saturday 21/11/14 at 16:40.	Wet surface, dark and raining.	A car stopped behind a stationary vehicle (car) and this resulted in it being struck from behind by a HGV. Causation factors listed as failing to look properly and reduced vision due to the weather.	M42 M29 M21	Unclear whether the stopped vehicle was in LBS1. All casualties were in the vehicle struck by HGV.
Z0035515	Southbound at MP 179/3	Tuesday 02/11/15 at 20:15.	Dry, dark and fine.	Two vehicles are stopped and a HGV and car collide as they attempt to slow down to avoid the stopped vehicles. Contributory factors listed as failing to look properly, judge other person path or speed and poor manoeuvre.	F29	Unclear whether the stopped vehicle was in LBS1. The casualty was in an upstream car who likely could not see the obstacle because of HGV in front of them.
346978	Southbound (approx. at J6)	Friday 26/07/18 at 12:20	Dry, bright and fine.	Vehicle stops in lane 2 for unknown reason and a 5 vehicle collision results. Contributory factors listed as inexperience/ nervous and uncertain.	M51 M9 M28 F46	Lack of detail to explain why first vehicle stopped in live lane but the resultant collision did not injure the occupant.
318260	Northbound	Saturday 03/08/18 at 10:43	Dry, bright and fine.	A collision between two HGVs who had come to a stop behind a broken down car. Following too close and failing to look properly listed as contributory factors.	M29	Occurred downstream of emergency area. LBS1 was open to traffic and a 60mph speed limit was set. Occupant of vehicle stopped in LBS1 was unharmed.

The limited information available about these collisions, specifically the lane the vehicle came to stop in and the reason for the stop make it difficult to draw conclusions from the events. One of the collisions (318260) is clearly on LBS1 when it is in operation.

5.3 Provision and use of places of relative safety

In order to understand the possible reasons behind live lane breakdowns on the viaduct, the provision of emergency areas and places of relative safety is considered. Two further related questions were posed by the data collation and review stage, which are considered here:

- What is the level of use of the emergency areas on the viaduct?
- What proportion of emergency telephone calls are from the emergency area?

Table 5.4 provides a summary of all the places of relative safety provided for motorists travelling though this part of the network. Measurement is approximate, based on marker posts and from decision points. On the neighbouring sections of the M6 to the north and south of Bromford viaduct the road also operates with dynamic hardshoulder running. As such LBS1 is a running lane at busy times.

Along the viaduct emergency roadside telephones are provided on the top of the parapet. Emergency phones were present before the scheme and a decision was taken to retain their use[11]. These are not regularly spaced, some are approximately 1km apart but at the northern end there are two pairs located 300m apart. The most northern pair are located on a section of the viaduct where all lanes are permanently live and are adjacent to the merge/diverge lane for junction 6. This could encourage drivers to make a live lane stop in order to use the emergency roadside telephone.

Table 5.4 Places of relative safety on, and around, Bromford Viaduct

Northbound		Southbound	
Emergency area on the J7-6 Link		Emergency area on the J7-6 Link	
J6 northbound entry slip		Hardshoulder (with emergency telephone) on J7 exit.	
Intra junction hard shoulder (with emergency telephone) at J6 Interchange		Wide intra junction hard shoulder (with emergency telephone) at J6 Interchange	
Hardshoulder on J6 Northbound exit slip		J6 Southbound entry slip	
No provision (3 No emergency telephones)		No provision (3 No emergency telephones)	
Northbound emergency area on viaduct		Southbound emergency area on viaduct	
No provision (2 No emergency telephones)		No provision (1 No emergency telephone)	
J5 Northbound exit slip (no hardshoulder)		J5 Southbound entry slip	
Emergency area on the J5-4 Link		Emergency area on the J5-4 Link	

Further interrogation of the incident data with respect to emergency telephone usage is shown in Table 5.5. It has already been established that for non-live lane breakdowns 5% were notified using an emergency telephone. Based on the incident data it would appear that some of the emergency telephones are not used at all, or used less than once per year. Eighty-one percent of emergency telephone calls come from the emergency area emergency telephones, the southbound emergency area being used nearly twice as often as the northbound emergency area emergency telephone. Emergency telephone 1 southbound, located adjacent to a live lane on the junction 6 merge has not been used. However, emergency telephone 5 northbound, located adjacent to a live lane at the junction 6 exit has been used three times a year. One record suggests the caller had walked from a position parked on LBS1 upstream to reach the emergency telephone.

[11] Departure from standard ref 64272

Table 5.5 No of incidents raised by emergency telephones (2017-2019)

Northbound	All	Per year	Southbound	All	Per year
Emergency telephone 1	0	0.0	Emergency telephone 1	0	0.0
Emergency telephone 2	1	0.3	Emergency telephone 2	1	0.3
Emergency telephone 3	11	3.7	Emergency telephone 3	14	4.7
Emergency area	65	21.7	Emergency area	119	39.7
Emergency telephone 4	4	1.3	Emergency telephone 4	4	1.3
Emergency telephone 5	9	3.0			

The incident logs suggest that there was originally an additional emergency telephone on the southbound, which would have formed a pair with emergency telephone 2 on the northbound. There are no records of calls from the phone since 2017 and the unit is missing based on the drive-through undertaken for this investigation. It has not been possible to determine any further information on what has happened to this unit.

Key findings

During the design of the smart motorway scheme the decision to retain emergency roadside telephones away from the emergency areas on the viaduct was supported by risk assessment as it was a departure from the advice contained in standards at the time. It appears that:

- Many of the emergency telephones are very infrequently used and some are not used at all.
- Two emergency telephones are adjacent to permanent live lanes.
- One of the emergency telephones provided at opening is missing and there is no record of calls in the last two years.
- The emergency telephone situated in the northbound emergency area is used less frequently than that in the southbound emergency area.
- The retained emergency telephones could be a prompt for ex-vehicle pedestrians to walk to / from them.

5.4 Safety at the emergency areas

The two emergency areas on the Bromford viaduct are unique in terms of their layout. Several of their features are not fully compliant with the standard in place at the time of design but the associated departures were approved. The non-compliant nature of the facilities is understandable given the limited space on the viaduct and the difficulties involved with improving provision. The emergency areas are a mitigation for live lane stops but it is important to understand if the design constraints have resulted in potential safety issues. The features subject to a departure from standards were:

- The taper length for entry and exit sections on the northbound.
- The visibility for entry and exit to the facility on the southbound.

The emergency areas were recently upgraded to feature orange surfacing and new more prominent advance signing. Figure 5.2 and Figure 5.3 show the approach to the northbound emergency area. Figure 5.4 shows the injury collisions occurring close to the emergency areas.

Table 5.6 Number and severity of collisions in proximity to emergency areas

Direction	Fatal	Serious	Slight	Total
Northbound	1	3	14	18
Southbound	1	0	14	15
Total	**2**	**3**	**28**	**33**

There were slightly more collisions recorded on the northbound carriageway (18 No.) compared to the southbound carriageway (15 No.). Interrogation of the descriptions and circumstances suggest none of these collisions involve vehicles entering or leaving the emergency area facilities. Collisions on the northbound appear to be related to congestion, queuing and sudden changes in the general vehicle speed resulting in shunt and swerving collisions. Nine of the eighteen collisions make direct reference to the congestion being present. Based on the time of day and descriptions 78% would have taken place when LBS1 was likely to have been open due to high traffic flows.

On the southbound there is a no clear link to congestion and LBS1 would likely have been operational in 53% of the events. One collision, reference 155060, relates to a vehicle attempting to reach LBS1 when their nearside tyre comes off the vehicle.

Figure 5.2 View of northbound emergency area at 200 yards sign.

Figure 5.3 View of northbound emergency area at confirmation sign.

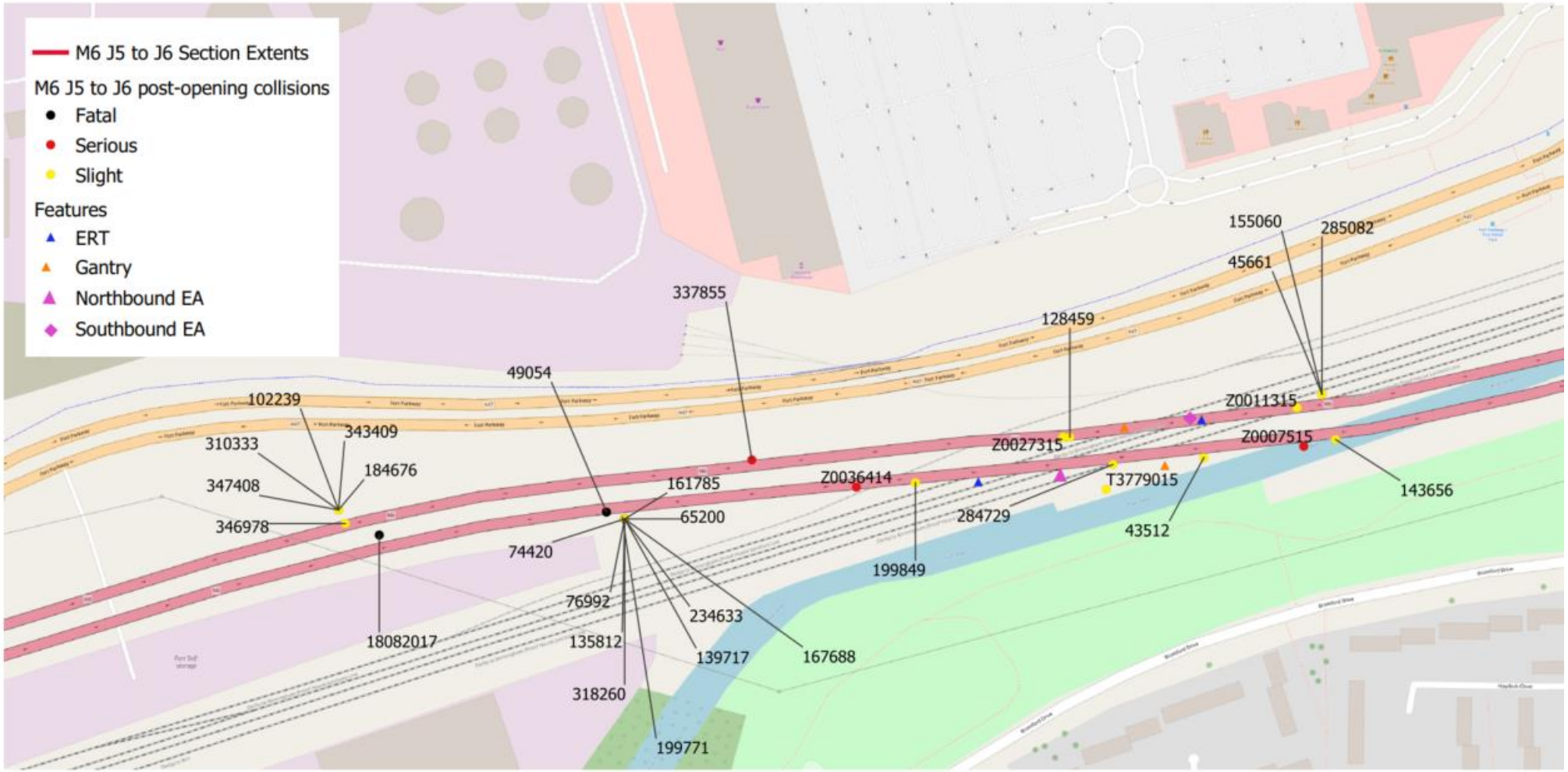

Figure 5.4 – Location of collisions in after period close to the emergency areas.

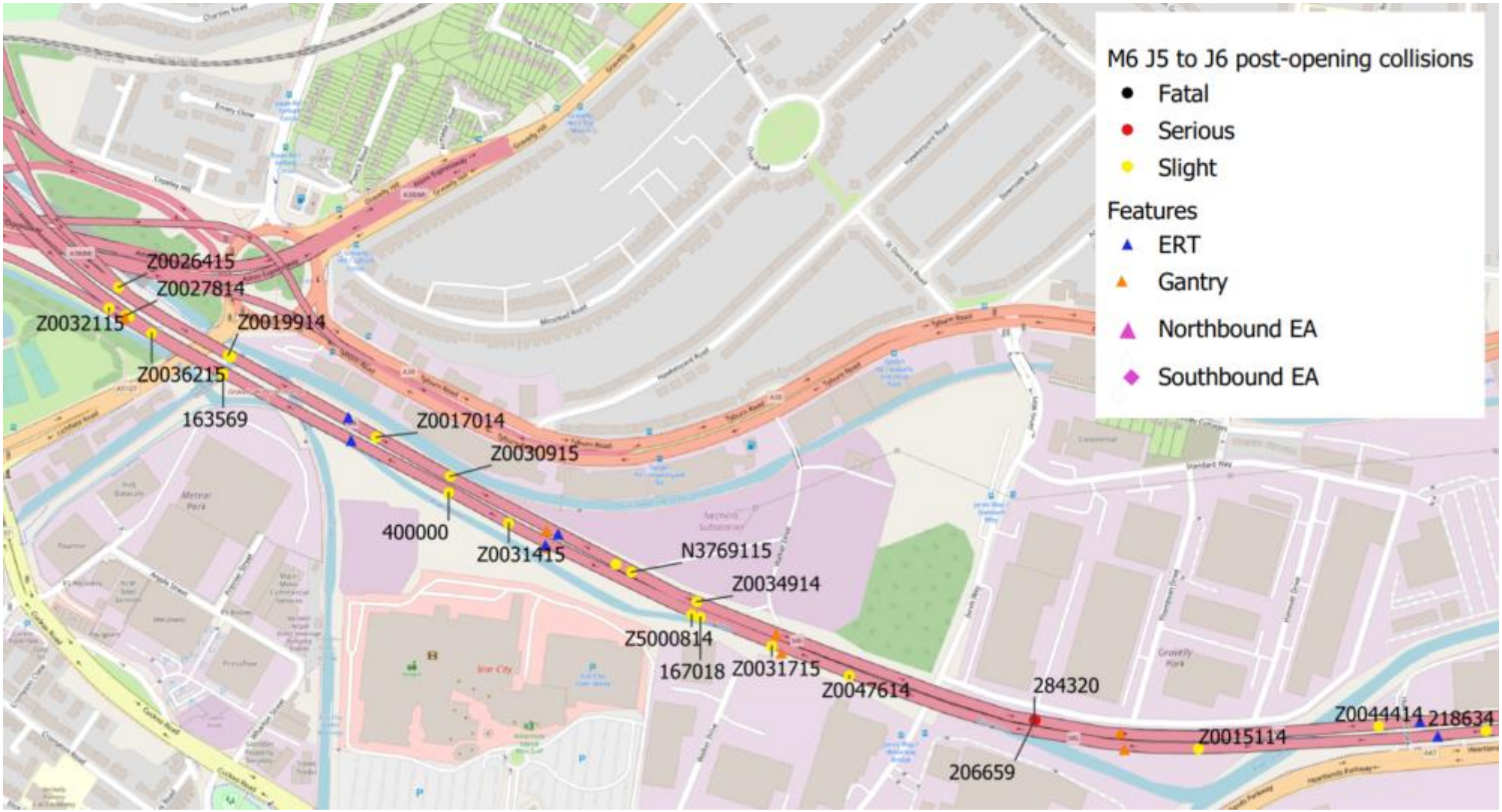

Figure 5.5 – Location of collisions in after period at junction 6.

5.5 Review of design and construction stage road safety audits

As a result of the data collation and review stage there was a query over possible rejected safety recommendations from earlier stages of the road safety audit process. As such the investigation has reviewed the problems and recommendations raised by the audit teams and the responses made by the scheme designer.

The Stage 2 Road Safety Audit was instructed in June 2011 and undertaken in July 2011. The Stage 3 Road Safety Audit was instructed in October 2013 and completed between March and August 2014.

A full list of the problems and recommendations reviewed is included in Appendix A. The main recommendations that appear relevant to the investigation are reported in Table 5.7.

Table 5.7 Problems and recommendations of relevance from design and construction stage road safety audits

Road Safety Audit Stage	Location	Road safety audit problem	Recommendation	Designer response	Relevance to this investigation
Stage 3	Various emergency area locations throughout the scheme.	Sign NP2937 "drivers must use phone and await advice to join main carriageway" not present in the emergency areas. This could lead to motorists using the emergency area and then attempting to re-join the main carriageway by themselves. This could be during a period of hard shoulder running and thus the vehicle leaving the emergency area would be doing so from a standing stop, and entering a running lane where vehicles could be travelling 60mph. This could lead to sideswipe or rear end shunt type collisions.	The NP2937 signs should be erected in all the emergency areas especially before the scheme becomes operational either live or during the trial weekends.	None available	These traffic signs were not a design requirement in standards for this scheme. It was unclear during the drive through if these traffic signs have been installed, the indication from Google Streetview is that the sign may be present on the southbound side. The safety of vehicles exiting emergency areas is an aspect of the provision that is relevant to the investigation.
Stage 3	M6 north & southbound carriageways Bromford Viaduct emergency area (also see 2.4.1 & 3.4.1)	The emergency telephone has been situated too high for mobility impaired road users to reach, which could cause a prolonged length of time in the emergency area which heightens the risk of vehicle conflict.	The emergency telephone should be erected at a height that is acceptable for all road users, including the mobility impaired road users.	None available	This aspect of the emergency telephone provision is relevant to the investigation.

Key findings

Many of the issues identified in this investigation were not identified at the design and construction stages of road safety audit. However, two of the problems and recommendations link to the investigation:

- Traffic signs were recommended for the emergency areas that would encourage drivers to use the emergency telephone.
- The emergency telephones were noted as being too high for mobility impaired road users.

5.6 Other developing collision cluster sites on the viaduct

The approach to Junction 6 was highlighted as a developing collision cluster site in the data collation and review stage. Figure 5.5 shows the location of the collisions at the junction and includes all collisions on the northbound from the ½ mile advance direction sign. In total there were 13 collisions all of which were of a slight severity. Interrogation of the descriptions and details shows that nine of the collisions were related to congestion. Whilst there are five collisions located close to the exit itself there is no suggestion from the collision descriptions that the geometry or layout has contributed to the events. All but one of the collisions is attributed to driver behaviour and failure to react to conditions.

6. Potential interventions

The preceding sections have identified the following key findings, which are considered for specific potential interventions. The potential interventions answer the question posed for the scheme of, “what more could be done to improve safety?”. They must be viewed in context of the overall proposed improvements to smart motorways, which for this scheme is planned to result in conversion to all lane running by March 2025.

For the M6 Junctions 5 to 6 (Bromford Viaduct) section, potential interventions focus around stopped vehicles and a system to reduce the number of breakdowns occurring on the viaduct, and to further improve information and assistance for those who do have to stop.

Table 6.1 Smart Motorway Incident and Infrastructure Investigation potential interventions

Key findings	Existing, programmed or national campaign control measures	Potential interventions
The key findings of this investigation are all focussed on the risk of vehicles stopping in live lanes and the associated consequences as this is the main issue identified. The key findings are: a) Road user safety on the viaduct has not substantially improved with conversion to dynamic hard shoulder running smart motorway and the average number of fatal collisions per year has increased. b) Breakdowns occur frequently on the viaduct. c) Based on the number of live lane stops that occur in LBS1, the emergency areas appear to be underutilised and the status of LBS1 may not be obvious to all road users. A steady flow of vehicles in LBS1 at peak times reiterates to other drivers that it is not a place of relative safety; operation of LBS1 when traffic flows are low could	Highways England continue campaigns relating to suitable DIY checks of vehicles to reduce instances of breakdowns – fuel level, oil / water level, tyre pressure and tread. Guidance exists and is readily searchable relating to Smart Motorways and what to do if you breakdown. Updates to the Highway Code, to explicitly cover smart motorways and breakdowns, are planned. The smart motorway evidence stocktake has already committed to: •End the use of dynamic hard shoulders by converting to all lane running; paired with roll out of stopped vehicle detection. •Consider a national programme of installing additional emergency areas. The stocktake commitment to enhance emergency areas with	**A. Consider additional signing to advise approaching drivers to use places of relative safety prior to reaching the viaduct.** Implement a system of signing on the approach to the viaduct section that warns drivers of the limited places of relative safety on the viaduct ahead and that encourages drivers to consider their ability to continue (e.g. fuel level) and to use the next available place of relative safety if necessary. The system of signing should encourage southbound drivers to leave at J6 or stop on the hard shoulder intra junction. On the northbound approach it should encourage drivers to use the existing mainline emergency area or leave the M6 at J5. The signing should be similar to the existing scheme for places of relative safety but carry appropriate warning messages i.e. “no emergency layby for x miles ahead, follow Jx for emergency layby” (such a sign could be valuable but may require a non-prescribed signs application to DfT). These places of relative safety should be upgraded to include orange surfacing to match the upgraded emergency areas if required. Suitable complimentary messages for overhead signals on the approach should be developed and may require DfT approval. **B. Investigate feasibility of a new place of relative safety on the junction 5 northbound exit slip road.** This new facility would allow those seeking to stop to avoid the viaduct and may reduce the number of downstream live lane stops. The slip road has no hard shoulder currently. **C. Consider additional signing for existing emergency areas.** To encourage drivers to continue to the emergency area on either carriageway wherever possible, additional advance signs should be provided throughout the viaduct. This should complement the existing 1 mile, 1/3 mile/200 yard signs

increase the risk that drivers are unaware of its changeable status. d) The presence of emergency telephones adjacent to live lanes when LBS1 is open may encourage stranded road users to walk along the motorway and their presence could act as encouragement to stop, even when LBS1 is open.	orange surfacing and comprehensive approach signing has already been met on Bromford Viaduct.	and mean that a driver joining the viaduct has more regular reminders of the distance to the next place of relative safety. **D.** Additionally, subject to a review to identify the best location for approaching driver sightlines, **consider an additional emergency area traffic sign** installed at the most visible part of the emergency area. This should use the largest practicable and permitted x-height by DfT approval (i.e. typeface font size) to highlight its presence to approaching traffic. **E. Consider the provision of a camera based stopped vehicle detection system for LBS1.** The fixed hard shoulder monitoring cameras provide a potentially suitable feed for a software-based system which can 'watch' LBS1 and detect a stopped vehicle, alerting staff in the Regional Operations Centre and enabling signals to be set. **F. Review the operation of LBS1 to more closely match dynamic changes in traffic flow.** Complete a review of the procedures for opening and closing LBS1 to identify any potential for improvement and to determine if it is consistently being used when justified by traffic levels, and closed promptly when traffic levels fall. **G. Review the continued provision of emergency roadside telephones which are not at emergency areas.** With the benefit of operational data, re-assess the safety risk of each emergency roadside telephone adjacent to live lanes. **H. Consider improved provision and signing for users who exit their broken down vehicles.** Consider providing coloured surfacing in the area between the nearside road marking in LBS1 and the viaduct parapet. Consider providing information signs at regular points along the parapet edge at a right angle to the carriageway. These signs should affirm the coloured area as somewhere to stand, for example "emergency area, await help". In tandem, an information campaign, for example at local motorway service areas, may prove beneficial. **I. Investigate whether an emergency call strip could be added along the viaduct parapet.** This could be similar to a panic strip and be linked to an alarm in the Highways England Regional Operations Centre. The strip could be configured into blocks (each block a section between two signal gantries) along the viaduct so that operators receive an alert that provides an approximate location of the stranded person. This would make the setting of upstream signals with "report of stranded vehicle" or similar, quick and efficient. The strip should be coloured, set at an easy to reach height and have a repeating instruction along its length i.e. "press to alert help". This technology in this setting is untested and as such would need development for deployment on a viaduct.

7. Conclusion

The safety of the smart motorway section of the M6 between junctions 5 and 6 has been investigated in response to the Smart Motorway Safety Evidence Stocktake and Action Plan. This is a unique section of the network with the M6 carried on the Bromford viaduct for the majority of the link and dynamic hard shoulder running operation with one emergency area provided in each direction.

This section has seen a minor reduction in overall collisions since conversion to smart motorway based on the 5 years of operational safety data available. However, three fatal collisions have occurred since the smart motorway became operational.

Live lane breakdowns are reported at a rate of just over one per day on average on this section. Two of the three fatal collisions that occurred involved stops in LBS1 when it was open to traffic and there have been other injury collisions that are related to live lane stops. These events are not frequent but have the potential to be high severity collisions.

The emergency areas are not fully compliant with standards in terms of location and dimensions – this is due to the constraints of the viaduct structure. However, no apparent safety issues have been identified with their use. The findings indicate they are not always being used to make stops and that drivers maybe unaware of the presence or purpose.

Emergency telephones are provided along the viaduct which is not the convention on schemes where LBS1 is open to traffic. These emergency telephones are not frequently used and two are positioned adjacent to live lanes. The presence of emergency telephones could encourage stranded motorists to stop, walk to a phone and may confuse users into thinking LBS1 is a place of relative safety when it is open to traffic.

The Highways England Operations team did not raise any concerns with the performance of this busy part of the network and additional on road resource is prioritised for responding to incidents on the viaduct.

Nine key recommendations are made:

A. Consider additional signing to advise approaching drivers to use places of relative safety prior to reaching the viaduct.

B. Investigate feasibility of a new place of relative safety on the junction 5 northbound exit slip road.

C. Consider additional signing for existing emergency areas to encourage drivers to continue to the emergency area whenever possible.

D. Consider additional emergency area traffic signs to highlight its presence to approaching traffic

E. Consider the provision of a camera based stopped vehicle detection system for LBS1.

F. Re-assess the operation of LBS1 to more closely match dynamic changes in traffic flow.

G. Re-assess the continued provision of emergency roadside telephones which are not at emergency areas.

H. Consider improved provision and signing for users who exit their broken down vehicles.

I. Investigate whether an emergency call strip could be added along the viaduct parapet.

Appendices

Appendix A. Review of design and construction stage road safety audits

Road Safety Audit Stage	Location	Nature of problem – taken from road safety audit reports	Recommendation	Designer response	Relevance to this investigation
Illustrative Stage 2	M6 Bromford Viaduct. emergency areas above Railway line, north and south.	Unknown containment level of parapet means that a vehicle that continues through the proposed N2 barrier may not be contained.	Ensure the Bromford Viaduct concrete parapet is to current containment levels to restrict vehicles accordingly.	The project team confirmed that the containment level of the existing parapet was N2 and that the Area 9 team had no concerns with respect to condition.	The investigation is already considering safety at emergency area locations.
Stage 3	M6 emergency area locations	Inconspicuous box road markings in emergency area could lead to stopped vehicles being hit from rear from additional vehicle entering emergency area.	The box marking should be bolder to be conspicuous to road users.	None available	The emergency areas have recently been enhanced to improve their conspicuity and all road markings were renewed.
Stage 3	M6 north & southbound carriageways Bromford Viaduct emergency area	No provision for dropped kerb could lead to mobility impaired road users unable to access the emergency telephone.	Provision to accommodate mobility impaired road users at these locations should be provided accordingly.	None available	Not of direct relevance to the investigation.
Stage 3	At various locations throughout the elevated sections of the scheme	Use of splay kerbs next to hard shoulder running increases the chance of an errant vehicle striking the barrier causing conflict.	The audit team recommend that these kerbs be replaced with half batter kerbs.	None available	No evidence if this is causing an issue. Assumed that this may have been a measure to encourage drivers to pull in.
Stage 3	Various emergency area locations throughout the scheme.	Sign NP2937 “drivers must use phone and await advice to join main carriageway” are not present in all the emergency areas. This could lead to motorists using the emergency area and then attempting to re-join the	The MP2937 signs should be erected in all the emergency areas especially before the scheme becomes operational either live or during the trial weekends.	None available	It is unclear if these traffic signs have been installed. The safety of vehicles exiting emergency areas is already a

Road Safety Audit Stage	Location	Nature of problem – taken from road safety audit reports	Recommendation	Designer response	Relevance to this investigation
		main carriageway by themselves. This could be during a period of hard shoulder running and thus the vehicle leaving the emergency area would be doing so from a standing stop, and entering a running lane where vehicles could be travelling 60mph. This could lead to sideswipe or rear end shunt type collisions.			focus of the investigation.
Stage 3	Junction 6 southbound on slip, 1st gantry	AMI [signal over lane] over LBS1 is not clear to motorist joining from A38 which could lead to motorist speed being different to other road users, leading to rear end shunt, lane change or side swipe collisions.	Re-orientate the AMI in LBS 1 to align in is optimum position for motorists joining the main line M6 at junction 6.	None available	Whilst it is unclear if this was corrected the AMIs now appear suitably aligned.
Stage 3	M6 north & southbound carriageways Bromford Viaduct emergency area (also see 2.4.1).	Provision from emergency area dropped kerbs to Emergency Roadside Telephone (emergency telephone) is sloped and therefore not suitable for mobility impaired road users.	The path to the emergency telephone from the dropped kerb should be flat to allow safe access for mobility impaired road users.	None available	Not of direct relevance to the investigation.
Stage 3	M6 north & southbound carriageways Bromford Viaduct emergency area (also see 2.4.1 & 3.4.1)	The emergency telephone has been situated too high for mobility impaired road users to reach, which could cause a prolonged length of time in the emergency area which heightens the risk of vehicle conflict.	The emergency telephone should be erected at a height that is acceptable for all road users, including the mobility impaired road users.	None available	This aspect of the emergency telephone provision is relevant to the investigation.

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