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HIGHWAYS AGENCY

Incident Policy for Managed Motorways

Final Report

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This report is prepared by the Highways Consultancy Group/Highways Research Group (HCG/HRG). HCG/HRG is a Consortium of four core suppliers, namely Mott MacDonald, Scott Wilson, Owen Williams and CIRIA, supported by an extensive supply chain.

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Executive Summary

Scott Wilson Ltd and Mott MacDonald were commissioned by the Highways Agency (HA) to undertake a task to investigate the effects of Managed Motorway (MM) operations on the following areas;

1) access of the 'first responder' to an incident,
2) the assigned incident type / classification which determines the response grade of the Traffic Officers and maintenance contractors, and
3) the ability of the Traffic Officer Service (TOS) to manage one or more incidents at the same time as managing multiple Managed Motorway sections.

The task was delivered in two phases, commencing with a scoping report to determine the outline risks to these areas and identify appropriate methodologies to further analyse these risks. The second phase of this task involved establishing the nature of these risks and how these may alter between MM schemes when in operation. The work was supported by Network Operations and appropriate Managed Motorways work stream leaders.

Incident access

This sub-task was concerned with assessing access for incident responders when Managed Motorways are operational (i.e. hard shoulder running is active). In order to evaluate this risk, several items of work have been undertaken with the key findings including;

1) the majority of hard shoulder (LBS1) clearance times are 4 minutes or less after Red-X (STOP) signal application over LBS1,
2) the time window between incident detection and Red-X (STOP) signal application is critical to the speed of lane clearance, and
3) on sections operating hard shoulder running, a lane has been cleared at least 3 minutes prior to the Police taking control of the incident.

Operational practices on future schemes should focus on the speed of the TOS decision to apply the Red-X (STOP) signal following an incident. Considerations will include;

1) density and position of detection equipment,
2) work flows between desk staff,
3) incident arrangements between the Highways Agency, Emergency Services (ES) and Incident Support Unit (ISU), and
4) potential co-location for incident management.

An improved understanding of queue dynamics in relation to Red-X (STOP) signals would better inform future policy decisions resulting in reduced TOS response time and hence potential traffic delay.

Incident type / classification

This sub-task was principally concerned with identifying whether similar incidents require a different incident management approach if they occur on a Managed Motorway as opposed to a non-Managed Motorway. In order to evaluate this several items of work were undertaken with the key findings including;

1) The incident classification system can not differentiate between incidents on the hard shoulder (LBS1) and those in the ERA. This hinders analysis of incident trends and TOS workload. It is recommended that additional incident classification includes defining breakdowns in the hard shoulder (LBS1) and those in the ERAs.

2) On Managed Motorway sections the hard shoulder (LBS1) is treated as a live lane even when not in operation, due to safety requirements. This increases TOS on-road assignment time by an average of 40% when compared to non Managed Motorway sections (due to the additional activities, for example setting out of cones). It is recommended that the need for this requirement is subject to review in balance with the operational knowledge gained to date.

3) The increased monitoring capability in the RCC has reduced TOS on-road workload as operators can more readily determine whether an on-road patrol is required at an incident. However, once the on-road patrol is assigned to the incident, there is currently little scope for on-going monitoring in the RCC to allow an incident to be downgraded and thus de-assign the on-road patrol. It is recommended that the feasibility of such practices is investigated in order to further realise the benefits of such monitoring technology.

Incident handling with multiple Managed Motorways

This sub-task was concerned with evaluating the potential impact on incident management as a result of the Managed Motorway implementation. In order to evaluate this, several items of work were undertaken with the key findings indentifying the effect of Managed Motorway implementation on;

1) incident type,
2) mode of detection,
3) effect on TOS workload, and
4) effect on performance.

These results have been applied to the creation of the TOS resource workload model, being developed by IBI for the Managed Motorways Operations Group.

From the key findings, considerations for national schemes were given including the factors affecting variations between schemes in terms of incident type and mode of incident detection.

When comparing variations in incident characteristics between national schemes, it was found that aside from breakdowns in the hard shoulder being the dominant incident type, significant variations are attributed to;

1) traffic characteristics,
2) effect of DHS construction programme,
3) regional practices, and
4) speed of detection.

Further while the majority of calls on all schemes originate from the TOS routine patrol, significant variations in other call origins are attributed to;

1) usage of codes,
2) regional practices,
3) nature of incidents, and
4) detection technology.

Finally, while the detailed numerical analysis relating to such findings have been utilised in the TOS workload resource model, adequate scheme specific recommendations can only be made after;

1) detailed incident analysis,
2) observation and discussion with the RCC's, and
3) scheme details are confirmed.

While a preliminary analysis has been undertake to ascertain the relationship between; patrol density, traffic flow and TOS performance, establishing a clear relationships would allow:

1) appropriate TOS resource allocation based on traffic characteristics,
2) and appraisal of future MM schemes supported by evidence based TOS performance data.

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Glossary of Terms

Average Vehicle Delay	An estimate of the average delay experienced by vehicles due to an incident (minutes per 10 vehicle miles).
Control room staff	Traffic officers located in the RCC who; 1) coordinate communication, 2) detection incidents through systems such as CCTV and MIDAS, 3) allocate on-road Traffic Officer patrols to incidents and 4) control variable-message signals.
Dynamic use of the Hard Shoulder	Provides an additional running lane through the utilisation of the hard shoulder during periods of high vehicle flow.
Emergency Services	Fire and Rescue Service, Ambulance and Police.
Incident Creation Date	A time stamp which is created automatically when an RCC operator starts an incident log
Incident Start Date	A manual time stamp which the operator can type in if the system is working offline. It defaults to the creation date if blank.
Incident Clearance Time	The time duration between the TO's arrival and restoring the carriageway.
Incident type code (opening code)	A code which is used to describe initial classification of an incident - note that the classification may change as the incident progresses.
Final classification code(s)	Codes to indicate the main incident descriptions (e.g. breakdown, traffic collision) and sub-codes to provide further qualifiers (e.g. number of lanes closed, visibility).
Managed Motorway	Refers to a range of measures to dynamically manage road capacity, traffic demand and incidents - see section 4.7.1 for further details.
On-road staff	Traffic Officers who undertake patrolling duties on the road.
Through Junction Running	Opening of the hard shoulder within the junction to enable traffic approaching on the opened hard shoulder (DHS) to have the option of either exiting the motorway or continuing through the junction on the hard shoulder (LBS1).
Traffic Officer Service	The Highway Agency Traffic Officer Service; i.e. both the RCC operators and the on-road Traffic Officers.

List of Abbreviations

AADT	Annual Average Daily Traffic
ATM	Active Traffic Management
AVD	Average Vehicle Delay
C&C	Command and Control
CCF	Change Control Forms
CCTV	Closed Circuit Television
DHS	Dynamic use of the Hard Shoulder
ERA	Emergency Refuge Areas
ERTs	Emergency Refuge Telephones
ES	Emergency Services
HA	Highways Agency
HALOGEN	Highways Agency Logging Environment
HATRIS	Highways Agency Traffic Information System
HCRC	Hazard Control Review Committee
IDM	Investment Decision Model
ITIS	Integrated Transport Information Systems
ISU	Incident Support Unit
JTR	Journey Time Reliability
KPI	Key Performance Indicators
LBS	Lane Below Signal
LGV	Large Goods Vehicle
MIDAS	Motorway Incident Detection and Automatic Signalling
MM	Managed Motorway
MTV	Motorway Traffic Viewer
NTCC	National Traffic Control Centre
PSA	Public Service Agreement
quRIUs	Queuing Rapid Intelligence in Unplanned Situations
RCC	Regional Control Centre
RIF	Road Information Framework
RTC	Road Traffic Collision
TJR	Through Junction Running
TOS	Traffic Officer Service
URN	Unique Reference Number
VMS	Variable Message Sign
WMRCC	West Midlands Regional Control Centre

1. INTRODUCTION

A Managed Motorway will generally open the hard shoulder to traffic at peak flow times. The introduction and continued roll-out of Managed Motorways has had an impact on incident management policy and practice.

It has been recognised that the introduction of Managed Motorways could have an effect on:

- The access of the 'first responder' to an incident (i.e. where congestion has resulted and so the responder may not be able to access the incident location via the hard shoulder, as would be the usual method).
- The assigned incident type / classification that determines the response grade of the Traffic Officers Service (TOS) and maintenance contractors.
- The ability of the TOS to manage one or more incidents at the same time as managing multiple Managed Motorways.

This task related to the provision of consultancy support to evaluate the effect that the Managed Motorway programme will have on incident management. There were three sub-tasks within this task:

- Managed Motorways – Incident access
- Managed Motorways – Incident type / classification
- Managed Motorways – Incident handling with multiple Managed Motorways

The task was delivered in two phases, commencing with a scoping report to determine the outline risks to these areas and identify appropriate methodologies to further analyse these risks. The second phase of this task involved establishing the nature of these risks and how these may alter between MM schemes when in operation. The scoping report is summarised at the beginning of each section and is included in Appendix A. The second phase of this task is presented herein. It should be noted that the term "Managed Motorways" describes a range of traffic management measures, including the Dynamic use of the Hard Shoulder (DHS), as detailed in section 4.7.1.

2. MANAGED MOTORWAYS: INCIDENT ACCESS

2.1 Introduction

This sub-task was concerned with assessing incident access for incident responders when Managed Motorways are operational (i.e. hard shoulder running is active). The principal concern was that responders to the incident will be impeded by slow moving or static traffic, with consequential detrimental effects on health and safety and congestion. In order to evaluate this risk several items of initial work have been undertaken, as summarised in section 2.2 and detailed in Appendix A, with the main works detailed in section 2.3.

2.2 Initial Work

The initial work undertaken involved a phased approach commencing with an assessment of likely traffic flows and associated queue build-up for various scenarios of lane closure as calculated by the HA's quRIUs Model. The introduction of DHS was found to reduce the corresponding rate of queue build-up for a given scenario. Further work on the quRIUs model is being undertaken as part of Task 029 (Timeline – phase 2).

The rate of traffic clearance on LBS1 following the application of Red-X (STOP) signals was assessed through correlation of MIDAS and HALOGEN data. An initial sample of 20 no. incidents revealed that on average the hard shoulder was cleared 3 minutes after the introduction of the first Red-X (STOP) signal, although there was a reasonably large spread of clearance times as detailed in section 2.5.

In addition, historic incidents handled by the West Midlands Regional Control Centre (WMRCC) during the period 01/04/08-31/03/09 were analysed to identify trends in incident access and the principal differences between the sections of DHS and non-DHS operation. Key differences were found in three areas:

1. Traffic officers detect a much greater proportion of incident on DHS sections.
2. Traffic officer response times, from incident detection to arrival at the incident, are generally lower on DHS sections.
3. When traffic officer travel time is less than approximately 7 minutes, the evidence suggests that non-DHS sections exhibit a lower response time.

Finally, discussion and observations with the WMRCC were undertaken to provide both context to the data and a dynamic preliminary qualitative validation of results as the work progressed. In additional to negotiations relating to data access, the following was noted:

> Observations following an incident where one lane was blocked (LBS3) revealed an average rate of queue build up, as defined by MIDAS loops, of approximately 100 metres per minute for a flow rate of approximately 4,100 vehicles per hour. This approximately correlates with the relationship found through the quRIUs model.

In relation to incident access, WMRCC staff reported that the Red-X (STOP) signal lanes immediately upstream of an incident always clear by the time the Emergency Services (ES) get to the scene. {It should be noted that this observation is based on a limited number of incidents, for instance only 3no. incidents became police lead on the M42: J 3a-7 between 01/04/07 and 31/03/10}.

WMRCC staff felt that MM sections, in general, were safer than standard non-MM sections due to:

- the detection technology,
- the ability to communicate with motorists in the queue,
- and the ability to let traffic continue flowing past the incident in a controlled manner.

This was corroborated by an independent consultant (written correspondence was held by Bruce Nowell of Mouchel who has been heavily involved in the development of operational policy relating to the ATM pilot on the M42) who found that the intensively managed nature of the road has resulted in fewer serious incidents. Where incidents did occur, a reduced affect on traffic delay was attributed to the ability to open the hard shoulder to clear traffic and the intensive nature of the signalling to close appropriate lanes allowing a faster detection, access and clear up than is possible on other motorways.

Given these initial findings, further investigation was considered beneficial in areas detailed in the following sections.

2.3 Confirm details of specific incidents

The progress of this item has been subject to ongoing discussion regarding the use of C&C logs. Due to timescales, this item is suggested for future work. As detailed in section 5.1.1, access to C&C logs would provide a more in-depth insight into incidents, especially where longer clearance times are observed when the Red-X (STOP) signal is applied within 4 minutes of the incident being detected.

2.4 Lane clearance following a Red-X signal

The compliance of drivers to Red-X (STOP) signal gantry signals will affect the degree to which an emergency access route (typically hard shoulder) is kept clear and hence the travel time of the responders to reach an incident. The compliance of drivers to Red-X (STOP) signal gantry signals has been assessed during previous work (Task 766 (387) - Managed Motorway Compliance) where HALOGEN and MIDAS data have been cross-correlated. The assessment concerned the compliance levels associated with a Red-X (STOP) signal gantry signal being activated immediately following an incident; i.e. how quickly does the traffic migrate from the hard shoulder to lane one, and how those remaining react to the responder vehicles.

In order to assess the traffic characteristics of lane clearance following a Red-X (STOP) signal, times and locations of incidents which occurred during the period 01/04/08-31/03/09 were analysed.

A total of 102 no. incidents were identified with analysis of MTV plots confirming that; 1) DHS was in operation prior to the Red-X (STOP) signal being set, and 2) Red-X (STOP) signal was introduced following the incident.

HALOGEN log data were downloaded/ processed to determine the time and location of where the Red-X (STOP) signals were implemented. MIDAS loop data were processed to understand how long it took for vehicles to clear the hard shoulder following the introduction of the Red-X (STOP) signal.

By way of illustration, for incidents where LBS1 only (i.e. the hard shoulder) is blocked, the relationship between time interval from incident detection to Red-X (STOP) signal application and subsequent clearance time is illustrated in Figure 1.

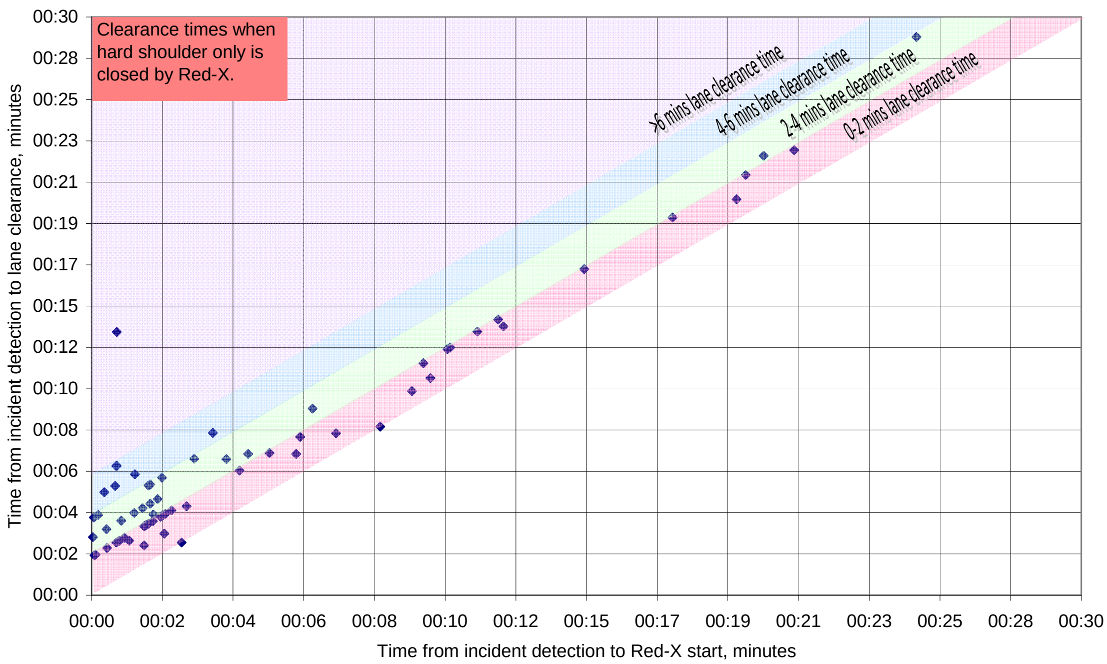

Figure 1: Duration of hard shoulder clearance time following Red-X (STOP) signal illumination over the hard shoulder

The interpretation of Figure 1 against 2 criteria is of use:

1. Time taken to clear the lane after incident detection – y-axis

   On initial examination, it is apparent that a key factor in the time for vehicles to clear the hard shoulder following the introduction of the Red-X (STOP) signal is the time at which the Red-X (STOP) signal is applied relative to incident detection. This is an encouraging result and means that the sooner a Red-X (STOP) signal is set the sooner the lane is clear for use by the emergency services.

   The majority of clearance times from the application of the Red-X (STOP) signal are less than 5 minutes (90th percentile is 4 minutes, 24 seconds). The overall duration from incident detection to the lane being clear is less the sooner the Red-X (STOP) signal is set. However, the data shows that the lane clearance element of the overall duration is longer if the Red-X (STOP) signal is set within 4 minutes of the incident being detected. While this may be attributed, in some part, to the presence of turbulent traffic flows within the section examined as traffic moves from 4 to 3 lane running, further analysis would be required to verify this.

   Where incidents required LBS1 only (i.e. the hard shoulder) to be closed using the Red-X (STOP) signal, only 3 no. incidents result in clearance times of greater than 5 minutes. It is therefore not considered practicable to undertake further statistically significant analysis on this data without further context, namely in the form of C&C logs. The progress of this is subject to ongoing discussion; this item is suggested for future work.

While the above analysis has established the distribution of lane clearance times following incident detection, this needs to be correlated with ES/ISU response times in order to identify the risk of responder delay.

An outline analysis has been undertaken to correlate timings of when the Police took control of incidents on the DHS section (as recorded in RIF data) and when the lane with the Red-X (STOP) signal was cleared after an incident. From the RIF data, only 3 incidents during the period 01/04/07-31/03/08 required the police to lead during DHS operations with the Police taking control at least 3 minutes after a lane had been cleared.

While this provides an indication as to the effects of DHS on ES response, further analysis would be required to establish the risk of responder delay. The exact times of the ES/ISU arrival may be ascertained through C&C logs, thereby providing more accuracy and a greater range of data sets (compared to Police led incidents only) on which to undertake analysis. It has not been possible to ascertain these records within the timeframe of this task.

It is recommended that these findings are presented and discussed with relevant stakeholders.

2.5 DHS impact on incident related vehicle delay

Delay-causing incidents have been analysed to assess the effect of DHS on vehicle delay. This has been undertaken through utilisation of the iBulk software developed as part of task 029 (Timeline Model). A comparison has been made between incidents occurring at peak hours during the midweek over the period 01/04/08 to 31/03/09 on the DHS sections (M42: J3a-7) and comparative sections of the M6 and M42. The section from J3a-7 on the M42 was compared with Hard Shoulder plus 3 lane sections with similar AADTs (Annual Average Daily Traffic), namely; M42: J7-9 both carriageways, and both carriageways on the M6 between; J2-3, J4a-5, J6-8, and J10-10a. For further details see Appendix C. It should be noted that the quRIUs model, on which iBulk depends, was not developed with DHS in mind (McCormick and Skelly, 2008) and therefore any findings need to be considered with due caution and be taken as indicative only.

Analysis of the incident frequency (normalised per km) and timings of each stage in the incident process revealed:

1. The vehicle delay attributed to each DHS incident is approximately 40% less than the corresponding incidents on non-DHS sections.
2. The rate (per km) of delay-causing incidents is approximately 45% greater on the DHS than the corresponding incidents on non-DHS sections. This may be expected as incidents which would have been dealt with on the hard shoulder (on the conventional 3 lane plus hard shoulder arrangement), now require a lane closure of LBS1 (if the incident is not contained within the ERA), and hence result in vehicle delay.

2.6 Applicability to future MM schemes

Due to the frequent changes in construction programme and scope of the early DHS schemes; this section focuses on making general recommendations to be considered for other DHS schemes.

In relation to the effect of DHS on incident access, an initial point to note is that DHS introduction should, if correctly designed, markedly reduce the rate of incidents requiring ES response. Although this is implicitly embedded in the design process, verification of this will then be assessed through the Post Opening Project Evaluation (POPE) process.

Where incidents do occur which block one or more lanes and require additional response, be it TOS, ES or ISU, the decision to apply a Red-X (STOP) signal and request further support on site should be made as soon as possible. This speed of decision is chiefly affected by the speed and accuracy of information received and the management arrangements between the HA, ES and ISU. The speed and accuracy of information will be dependent on the density and position of *functioning* detection equipment such as CCTV and MIDAS as well as the management arrangements of desk staff in the RCC to handle such information. With regards to the management arrangements between the HA, ES and ISU, the benefits of co-location on incident management, following the recent trial at the WMRCC, should be recognised. From discussion with WMRCC staff it is apparent that there are large regional differences in management arrangements between HA and ES with corresponding differences in operation and observed results. The implications of each regional arrangement would need to be considered prior to DHS implementation.

2.7 Effect of staggered Red-X (STOP) signal implementation

The effect staggered implementation of the Red-X (STOP) signal has been studied in more detail (see Appendix B), with a clarification of terms given below and illustrated in Figure 2.

- Non-staggered implementation: A Red-X (STOP) is set on 2 or more consecutive gantries at the same time.
- Staggered implementation: A Red-X (STOP) is set on one gantry at 'Time A' and a second (or third) Red-X (STOP) is set on the previous gantry upstream of the initial gantry at later 'Time B'.

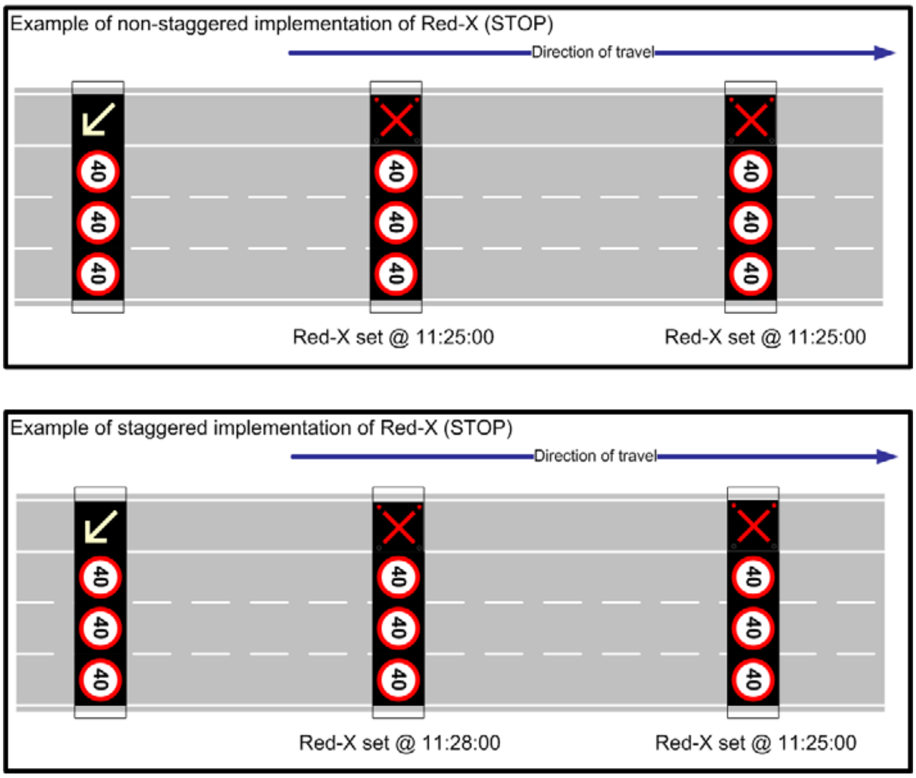

Figure 2: Illustration of non-staggered and staggered implementation of Red-X (STOP) signals

As detailed in Appendix B, such incidents appeared to have a longer Red-X duration when compared to incidents with non-staggered implementation of the Red-X (STOP) signal.

The 15 minute traffic flows prior to the time of an incident were examined as a part of this analysis, to investigate whether traffic demand had an effect on the signal implementation and duration; however, the analysis has not shown traffic demand to be a contributing factor.

The relationship between the Red-X (STOP) signals and types of incidents and ERA utilisation (i.e. whether the incident vehicle uses the ERA or breaks down on the hard shoulder or live lane) has not been investigated within this report. It is possible that these two factors may have an effect on traffic behaviour, as breaking down on the live lane could potentially create a larger bottleneck on the carriageway being considered. Further details of the analysis undertaken may be found in Appendix B.

3. MANAGED MOTORWAYS: INCIDENT TYPE / CLASSIFICATION

3.1 Introduction

This sub-task was principally concerned with identifying whether similar incidents require a different incident management approach if they occur on a Managed Motorway as opposed to a non-Managed Motorway.

For example, if a breakdown occurs in a live lane on a non-Managed Motorway section then the vehicle could be moved to the hard shoulder, with normal capacity quickly restored. However, if this occurs within a peak flow period (i.e. DHS in operational status) then a decision needs to be made as to whether to move the vehicle to LBS1 and so reduce capacity, or whether to physically remove the vehicle from the motorway or into an ERA (i.e. tow – vehicle recovery option).

It should be noted that the definition for an immediate response grade is: ‘An obstruction on or related to the live carriageway that is likely to cause congestion or threaten safety’. Consequently, a breakdown on the hard shoulder, LBS1 if DHS is in operation, of a DHS section, in both operational and non-operational status, would be assigned a response grade of ‘immediate’. This sub-task concentrates on whether the mobilisation of resources and operational policy and practice of the TOS, RCC and maintenance contractors needs to be tailored for Managed Motorways. In order to evaluate this several subtasks were undertaken as part of either initial or main works detailed in sections 3.2 and 3.3, respectively.

3.2 Initial work

The initial work undertaken involved a phased approach commencing with an assessment of historic incidents handled by the WMRCC during the period 01/04/08-31/03/09. These were analysed to identify trends in incident type, response and classification at different times and on both DHS and non-DHS sections. Discussions and observations with the WMRCC were undertaken to provide both context to the data and a preliminary validation of results as the work progressed. Finally, the Managed Motorway policies and associated amendments were examined.

Statistical analysis of incident timeline data on the 2 sets of data (DHS and non-DHS sections) discussion and observation with the WMRCC initially highlighted three key effects of DHS operation, which may be summarised as:

1. The increased quantity of monitoring equipment results in a greater number of incidents being detected. Under normal non-DHS conditions these incidents, such as vehicles stopping on the hard shoulder, may not have been detected. The effect of this earlier detection on TOS KPIs and procedures is not fully understood and hence may require further work.

2. Breakdowns in the hard shoulder (LBS1) on DHS sections are treated as a breakdown in a live lane regardless of whether DHS is in operation or not. This is due to an elevated risk of vehicles running in LBS1 even when DHS is not in operation, with associated procedures regarding response times, and traffic management.

3. There appears to be an overlap of usage between the classifications of breakdowns in the hard shoulder (BH) and breakdowns in the live lane (BL), where incidents that occur in LBS1 are either assigned BH or BL.

The last finding leads to the recommendation for additional incident classification(s) which clearly identifies where an incident occurs in an ERA or LBS1.

There have been a number of the key operational changes that have occurred since the implementation of DHS in 2006. The key changes and drivers for them were examined to provide a background to the developments made to date.

3.3 Main Works

3.3.1 Validation of preliminary findings/ RCC observations and discussions

While the preliminary findings have undergone a degree of validation, on-road observations have not been possible within the timescales of this task, due to organisational changes within the WMRCC.

3.3.2 Effect of early detection

Due to organisational changes within the WMRCC, preventing on-road observations within the timeframe available, the effect of early detection is not reported. However, this subject is discussed in Task 029 (Timeline Study).

3.3.3 Ascertain requirements for additional Incident Classification

In addition to the recommendation for additional incident classification(s) which clearly identifies where an incident occurs in an ERA or LBS1, further classification codes are required to describe the management of DHS operations. Such codes would describe the duties undertaken to open/ close DHS sections. While such codes have been introduced in Autumn 2009, there is currently insufficient data on which to undertake statistically significant analysis.

3.3.4 Effect of treating LBS1 as a live lane overnight

Preliminary analysis into the effects of an immediate classification being assigned to all breakdowns occurring in LBS1 overnight is detailed herein.

In order to establish the effect on TOS workload, a comparison was undertaken between incidents occurring on the DHS section (M42: J3a-7) with comparative non-DHS sections of the M42 and M6 over the period of 12 months (01/04/08-31/03/09). The timing of each stage in the incident timeline for both DHS and non-DHS sections are presented in Appendix C with the pertinent average times given in Table 1.

Table 1: Average times for incidents detected between 22:00-06:00

Average times for incidents detected between 22:00-06:00	M42: J3a-7 DHS Section		Comparison non-DHS Sections	
	Breakdown – Hard shoulder	Breakdown – Live Lane	Breakdown – Hard shoulder	Breakdown – Live Lane
Average Desk Times, minutes	2.9	1.4	4.2	2.0
Average Assignment Times, minutes	14.8	20.8	20.7	25.2

From Table 1, the following may be observed:

- Breakdowns between 22:00 and 06:00 in the live lane have lower average desk times than the equivalent times for breakdowns on the hard shoulder for both DHS and non-DHS sections.
- Both breakdowns in live lane and hard shoulder have lower average on-road assignment times on the DHS sections than the respective times for the non-DHS comparison sections.
- When compared to breakdowns in the hard shoulder, breakdowns in the live lane occurring between 22:00-06:00 involve increases in on-road assignment time of an average of 40% on DHS section and 20% on non-DHS sections.

While the on-road TOS workload is clearly increased as a result of this practice, it is not clear whether this additional time impacts on resource requirements or reduced services levels elsewhere on the network.

4. MANAGED MOTORWAYS: MANAGING MULTIPLE INCIDENTS WITH MULTIPLE MANAGED MOTORWAYS

4.1 Introduction

Managed Motorways require a level of TOS resource in terms of opening (CCTV and traffic officer sweeps), closing, sign and speed setting and on-going supervision. The seven RCCs have different levels of technology (e.g. CCTV, loops, ANPR, etc.) and TO resource levels to support the incident management activities. The various regions also have their unique characteristics in terms of traffic flow, incident rates, incident types, TO outstation positioning and maintenance contractor out-station positioning.

A number of these RCCs will shortly need to extend their roles to encompass the seven forthcoming Managed Motorway schemes. It is understood that the HA wishes to investigate whether an additional level of resource is required in terms of RCC and TO staff for these regions that are 'new' to Managed Motorways. Naturally, the HA needs to negate any potential detrimental impact on incident management as a result of the Managed Motorway implementation.

There were several related ongoing work streams related to this subject and it has been necessary to interface with these work streams as part of this sub-task. In order to evaluate the potential impact on incident management as a result of multiple Managed Motorway implementation within the area of a single regional control centre, several items of work were undertaken as part of an initial and main phase of works, detailed in sections 4.2 and 4.3, respectively. It should be noted that the term "Managed Motorways" describes a range of traffic management measures, including the Dynamic use of the Hard Shoulder (DHS), as detailed in section 4.7.1.

4.2 Initial work

Resource analysis of the TOS in the West Midlands region has been undertaken to determine whether current incident management is adversely affected by Managed Motorway operations. This has been undertaken through two routes, 1) observation of the RCC and discussion with staff and 2) a more quantitative approach achieved through analysis of incident timeline data sets for DHS and non-DHS network sections.

A preliminary analysis of data taken from the Timeline model (Task 029) suggests:

- Slightly longer desk times on DHS sections with corresponding higher rates of CCTV detected incidents. Initial observations suggest that early indication of incidents through monitoring technology such as MIDAS or CCTV result in slightly longer desk times as the control room staff ascertain the location of the incident themselves with the use of CCTV. While this may lengthen desk times, it is likely to reduce the use of on-road resources through better targeting of deployment in terms of determining whether on-road resource is actually required.

- Shorter travel time by on-road resource on DHS sections. This is likely to be a function of initial locating of incidents by the control room staff.
- Greater deployment durations on DHS sections, likely due to the higher proportion of breakdown in live lanes experienced on DHS Sections, with this classification requiring more time input from on-road resource due to policy requirements.
- Greater rate of incidents at night, primarily due to a greater proportion of breakdowns in a live lane being detected through detection technology monitored at the RCC.

4.3 Effect on Incidents

The effect of DHS introduction on incident rates has been established through two means:

1) comparison of the M42 DHS section with comparative sections of the M42 and M6 over the period of 12 months (01/04/08-31/03/09). Ideally, the comparative section would have been on the M42: J3a-7 prior to DHS operation. However, such a comparison was not possible due to the numerous changes in the incident reporting procedures over this time and the prolonged nature of the ATM pilot scheme which introduced a series of changes to the section and hence influencing traffic behaviour. Therefore, comparison sections comprised links, detailed in Appendix C, with hard shoulder plus 3 lane sections with similar AADTs and daily flow rate characteristics. The incident rates have been normalised to provide an incident rate per km.

2) analysis of RIF data on the M6: J4-5 for the period between 01/09/09 and 27/01/10. Given that DHS was introduced on the 30/11/09, the data presented gives a period of pre- and post- DHS introduction of 90 and 58 days, respectively.

4.3.1 Incident type

The dominant incident types for both the M42: J3a-7 and the comparison sections were correlated as illustrated in Figure 3. Details of the comparison sections are provided in Appendix C.

From this analysis, it is evident that the introduction of DHS results in a much greater rate of incident detection with corresponding increases in incident rates. Notable increases appear to be chiefly associated with three underlying causes:

1) Change in incident classifications: The most notable examples being Breakdowns in the Live Lane, where policy dictates that any vehicle broken down in LBS1 (i.e. Hard Shoulder) should be classified as a Breakdown in the Live Lane and not Breakdown in the Hard Shoulder.

2) Improved detection: The increased concentration of traffic monitoring equipment associated with DHS allows the RCC to detect incidents which would otherwise have occurred and been resolved without the HAs knowledge. These are predominantly either congestion related or where vehicles make short stops in hard shoulder for a variety of reasons. For instance the rate of hard shoulder drive-away incidents are 16 times greater on the DHS sections.

3) DHS opening and closing procedures: While the data indicates that rate of tasked incidents is approximately 20 times greater on DHS sections, the exact nature of these tasks is not known. Suffice to say they chiefly involve clearance sweeps, RCC operations and manual checks by the on-road TOS. The need for additional incident codes to record these activities has been identified, with MM related incident codes introduced in time for the opening of DHS sections on the M6: J4-5 in Autumn 2009.

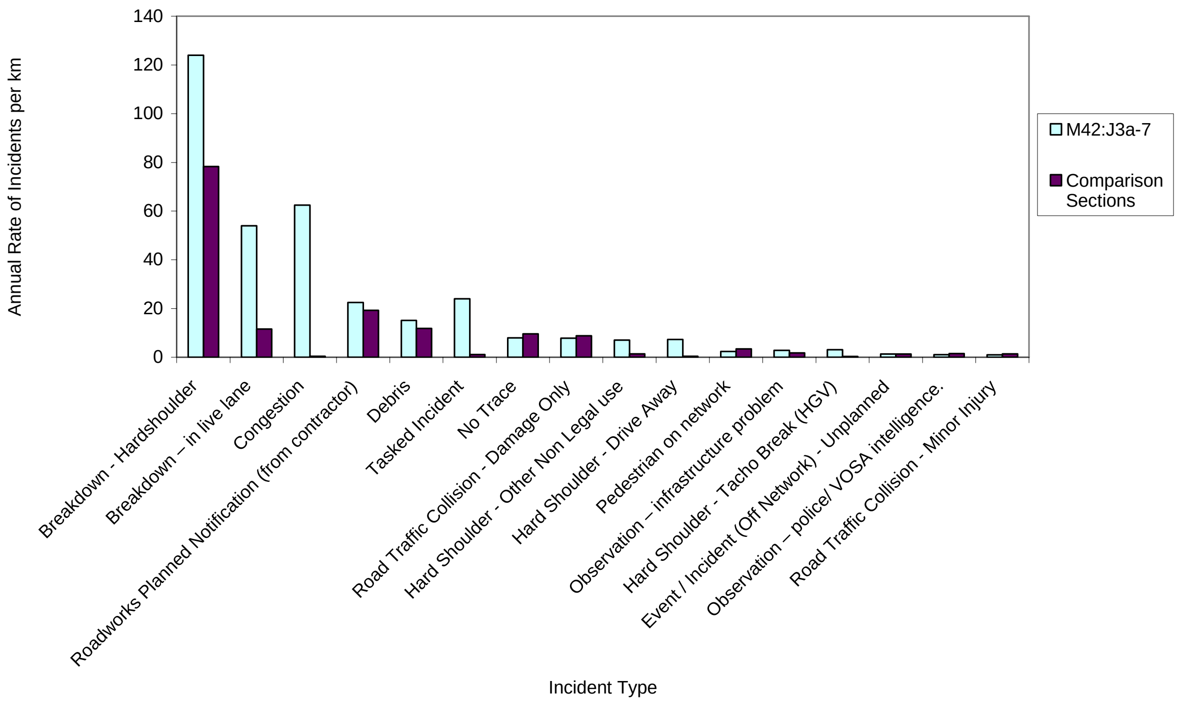

Figure 3: Annual rate of incidents sub-divided into incident type for both the M42 DHS pilot scheme and comparison sections

A similar comparison has been undertaken in relation to DHS introduction on the M6: J4-5 on 30/11/09. These are compared to the M42 DHS section in terms of ratios of incident rates on non-DHS : DHS sections, as illustrated in Figure 4.

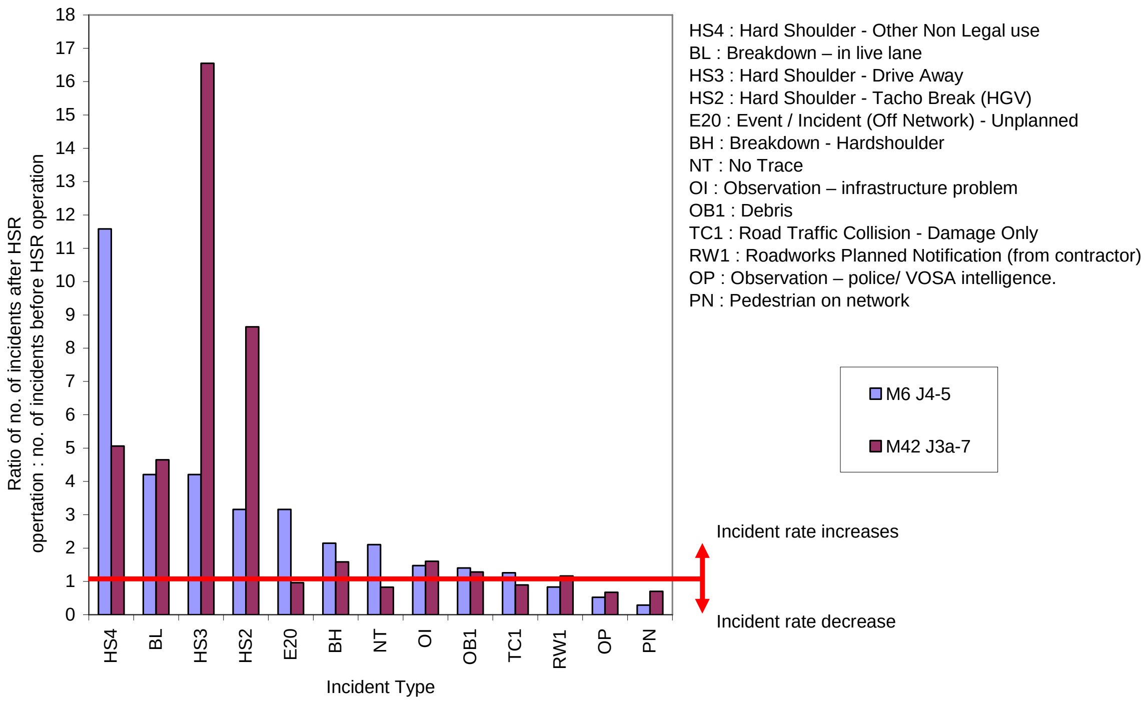

Figure 4: Ratios of incident detection rates for DHS versus non-DHS sections

It may be observed from Figure 4, that there is generally good agreement between the two data sets (M6 and M42) for most incident types, with the exceptions of:

1. Stops in the Hard Shoulder (HS series)
2. Event / Incident (Off Network) – Unplanned (E20)
3. No Trace (NT)

The reasons for these observations are not clear at this stage, but may include differences in traffic / geographic characteristics, seasonal effects and changes in operational policy, as described below.

1) Traffic and geographic characteristics: The sections examined are known to differ in traffic characteristics with the greatest impact being on breakdowns and unplanned event / incident (off network). For instance, during analysis of incidents around the Birmingham road network, an extremely high number of incidents were detected on the M6 where breakdowns occurred in a live lane. From discussion with WMRCC staff, some of these incidents are thought to be due to vehicles running out of fuel.

2) *Seasonal Effects:* While the M42 and comparison sections were analysed using 12 months data, the analysis of the M6: J4-5 pre- and post-DHS operation was undertaken over 4 months including the Christmas period. Data from the M42 and comparison sections suggest that the incident rates for the month of December are approximately 50% greater than the annual monthly average, thus influencing results.

3) *Changes in Operational Policy:* In order to maximise the benefits of working experience in terms of operational efficiency, practices have been refined over recent years. The exact effect on the incident rates has not been established.

4.4 Mode of Incident Detection

The dominant incident detection modes for both the M42: J3a-7 and the comparison sections were correlated as illustrated in Figure 5.

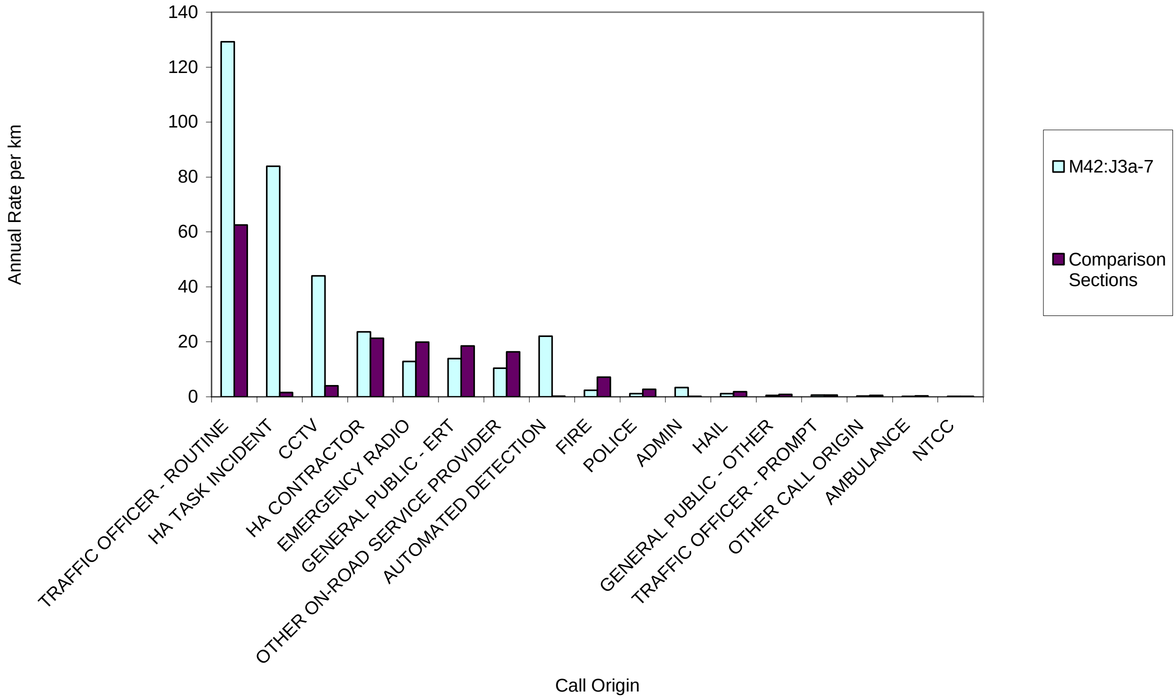

Figure 5: Annual rate of incidents sub-divided into call origin for both the M42 DHS pilot scheme and comparison sections

From this analysis, it is evident that the introduction of DHS significantly alters the mode of incident detection. This is chiefly associated with increased concentration of detection technology. This has resulted in a greater proportion of incidents being detected which would otherwise have occurred and been resolved without the HAs knowledge. Coupled with this, the time period between incident occurrence and detection is potentially shortened, therefore reducing the portion of incidents being detected by other means, i.e. emergency services, general public, or other on-road service providers.

Although similar observations have been made in relation to DHS introduction on the M6: J4-5 on 30/11/09, the phased nature of changes in operational procedures, coupled with numerous road works, does not allow for a meaningful comparison during the period analysed.

4.5 Effect on TOS Workload

The effect on TOS workload in terms of the distribution of timings for each stage in the incident process for each major incident type has been analysed for both DHS and non-DHS sections. The detailed analysis is included in Appendix C with a brief outline contained herein. These results have applied in the creation of the TOS resource workload model, being developed by IBI for the Managed Motorways Operations Group.

As an illustration of the effect on average work load, Table 2 provides the mean and standard deviation of incident stage timings for immediate grade responses to incidents with closure codes including:

- Breakdown - Hard shoulder
- Breakdown – in live lane
- Debris
- Road Traffic Collision - Damage Only
- Road Traffic Collision - Minor Injury
- Road Traffic Collision – Serious Injury

Table 2: The effect of DHS implementation on incident stage timings and their variability

Section		Duration of Incident Stage, minutes			
		Desk Time	Travel Time	Response Time	Clearance Time
non-DHS comparison sections	No. of incidents per km	27		26	
M42: J3a-7		62		53	
non-DHS comparison sections	Mean	2.1	7.5	9.3	53.3
M42: J3a-7		1.8	5.3	6.8	44.5
non-DHS comparison sections	Standard Deviation	3.3	7.5	8.5	1201.0
M42: J3a-7		3.4	7.0	8.1	1045.6

It may be observed from Table 2 that:

- The rate of immediate graded incidents per km is significantly greater on the DHS sections, which is likely to be due to the increased quantity of monitoring equipment as illustrated in Figure 5.
- There is a marked reduction in incident rates on DHS sections between those handled in the RCC (62 no. per km) and those handle by the on-road patrols (53 no. per km). This marked reduction demonstrates the RCC operator’s ability to handle certain incidents without the need for an on-road patrol to be present at the scene of an incident.

- The mean timings for all incident stages are significantly lower on the DHS sections. This is likely to be due to an increased quantity of monitoring equipment allowing the desk staff to handle incidents more efficiently. For instance, the increased quantity of monitoring equipment will facilitate better locating of incidents thereby better targeting on-road patrols.
- The majority of standard deviations suggesting greater uniformity in incident processes.

While these preliminary findings provide further insight into the effect of DHS on TOS operations, a TOS resource workload model is being developed by IBI for the Managed Motorways Operations Group. In addition to the incident data supplied, this model will take into account factors such as;

- the resource required to open/close DHS sections,
- the effect of equipment faults on TOS workload, and
- the distribution of incident timings and occurrence throughout the week.

4.6 Effect on Performance

To assess the effect of DHS operation on TOS performance a preliminary analysis was undertaken on all incidents occurring between 01/04/08 and 31/03/09 on the M42, M40, M5 and M6 within the WMRCC network. For each incident, the patrol density was ascertained (as detailed in section 4.2.3 of the scoping report - Appendix A) along with an estimated vehicular flow rate obtained from the quRIUs model.

This data was further broken down for immediate responses only and subdivided into four groups as illustrated in Figure 6. These four groups represent:

1. Low patrol density, low vehicular flow
   This group of incidents occurs either over night or on lightly trafficked sections. These lightly trafficked sections predominantly comprise sections of the M40 and sections of the M42 and M5 which are located away from Birmingham.
2. Low patrol density, high vehicular flow
   This group comprises the largest proportion of peak time incidents on both DHS and non-DHS sections. This group represents the greatest demand on patrol resource.
3. High patrol density, high vehicular flow
   This group comprises peak time incidents on heavily trafficked sections which are subject to high rates of patrol density. These sections are predominantly on the DHS section (M42: J3a-7) with isolated non-DHS sections situated in close proximity to Birmingham.

4. High patrol density, low vehicular flow.
   This group predominantly comprises lightly trafficked sections which receive a high density of patrol resource. This may be due to operational restrictions between outstations which result in short sections being served by two patrols. The low quantity of incidents in this group suggests a reasonably optimised patrolling strategy.

The ‘response only’ group represents those incidents occurring on sections of the M40 (J11-15) and M42 (J10-11) where there are no patrols present at certain times of the day. Incidents which are detected and require HA presence are attended by the nearest available on-road patrol.

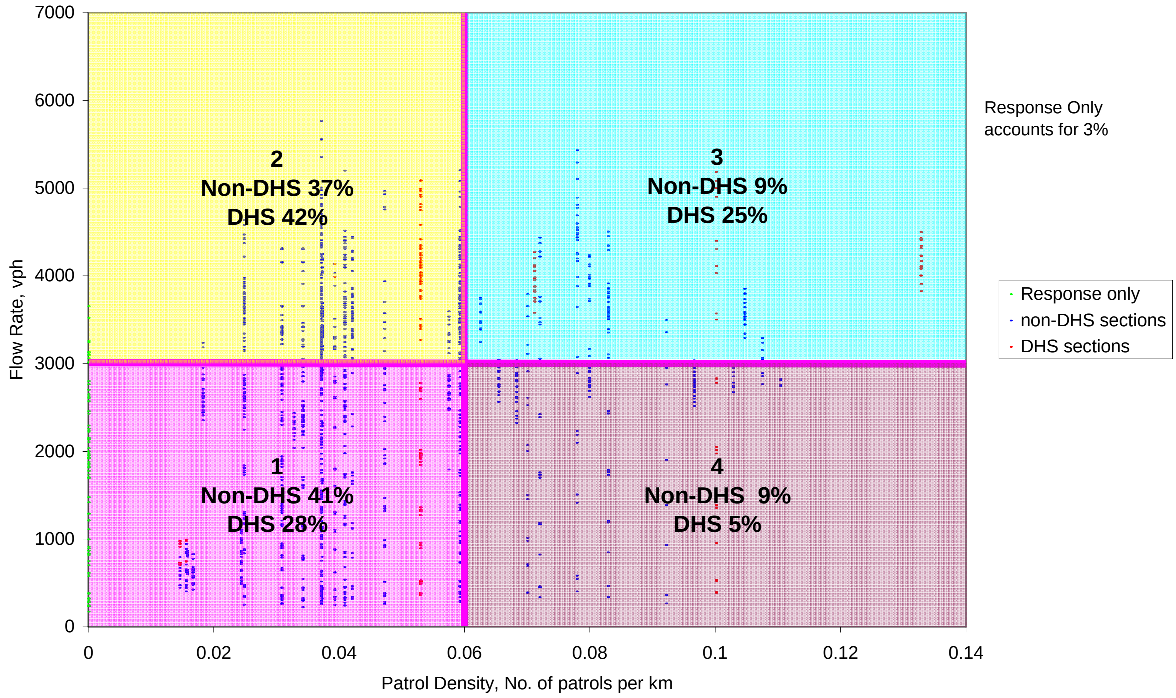

Figure 6: Relationship between patrol density and vehicular flow rate for immediate response graded incidents, sub-divided into groups

In order to ascertain whether the response time varied with patrol density and/or traffic flow, the distribution of response times for each of these groups (i.e. Groups 1-4 and ‘response only’ sections) was analysed for the non-DHS sections, as illustrated in Figure 7.

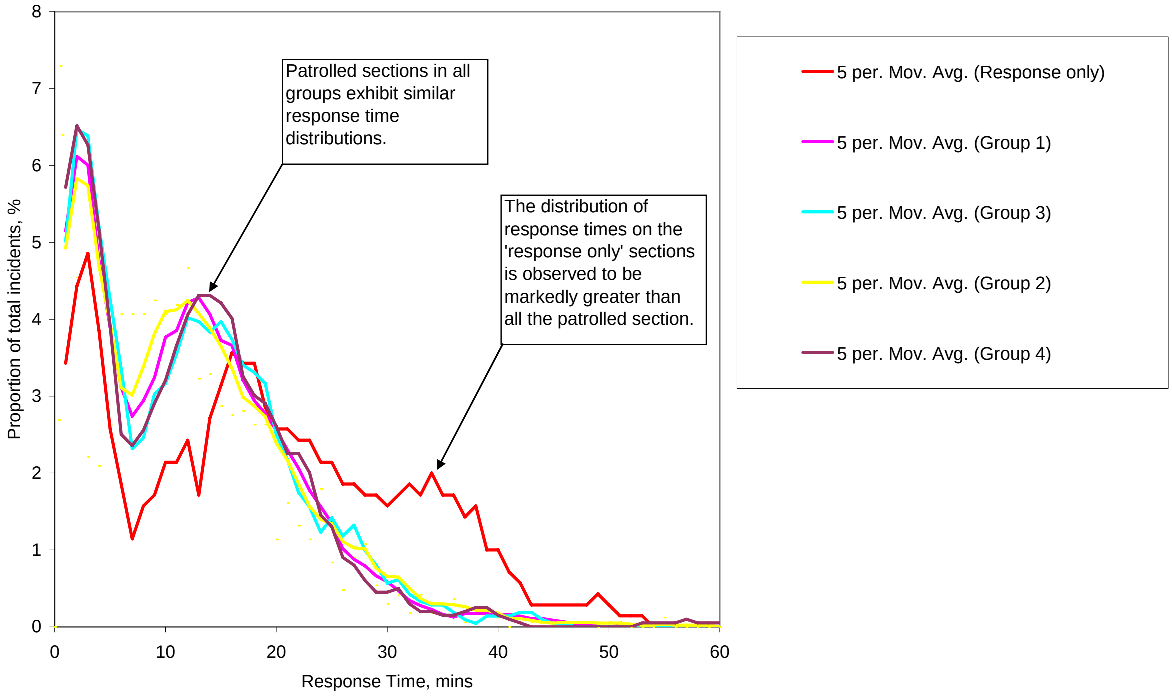

Figure 7: Distribution of response timings for the various sub-groups

It may be observed that the distribution of response times exhibits little discernable variation between groups where patrols are present (i.e. groups 1-4). However, the effect of having no patrols at certain times of the day and locations may be clearly observed where the response only section exhibits lengthier response times.

Brief analysis to ascertain a relationship between; patrol density, traffic flow and TOS performance in terms of TOS detected incidents and response times has been undertaken. While variations in performance have been observed, analysis to date does not reveal clear relationships therefore suggesting that further incident variables require identification.

4.7 Considerations for National Schemes

At the time of this research, the forthcoming Managed Motorway programme comprises those schemes detailed in Table 3.

Table 3: Outline details of forthcoming Managed Motorway Schemes

No.	Month	Region	Scheme	Approximate Length, km
1	Nov 2011	NW	M60 Jct 8 - 12	8
2	Nov 2011	NW	M62 Jct 18 - 20	12
3	Jan 2012	WM	M6 Jct 5 - 8	13
4	Jul 2012	SW	M4 Jct 19 - 20	5
			M5 Jct 15 - 17	10
5	Oct 2012	NE	M62 Jct 25 - 30	21
6	Dec 2012	E	M1 Jct 10 - 13	24
7	Jan 2013	NE	M1 Jct 32 - 35a	16

4.7.1 Managed Motorways – levels of implementation

These seven schemes which form the first tranche are at different stages in the design and construction process and will implement different measures under the term "Managed Motorways" which refers to a range of measures to dynamically manage road capacity, traffic demand and incidents to increase the efficiency of road use, improve safety and reduce the environmental impact of motorway use (Managed Motorways Delivery Office, 2009).

Specific measures include:

- Dynamic use of the Hard Shoulder (DHS): using the Hard Shoulder as a running lane between junctions when traffic demand exceeds the capacity of the normal running lanes;
- Through Junction Running (TJR): extending the dynamic use of the Hard Shoulder through the junction thus avoiding lane drop / lane gain at junctions;
- Provision of Emergency Refuge Areas (ERAs): providing special areas adjacent to the Hard Shoulder where drivers can stop safely in an emergency;
- Variable Mandatory Speed Limits: setting speed limits dynamically in response to congestion levels;
- Queue Protection: setting lane signals (lane closed, lane divert, reduced speed limits) to protect incidents, queues and roadworks;
- Access Control (also known as Ramp Metering): regulating the amount of traffic entering the carriageway from the on slip to maintain the flow on the main carriageway;
- Driver information: creating an informed driver environment by providing roadside information on Variable Message Signs (VMS).

4.7.2 Pre-MM implementation incident classification analysis on regional schemes

In order to provide an initial pre-DHS overview of incident characteristics for the various schemes, RIF data for the period 01/01/09 to 31/12/09 was analysed. Initial analysis included comparison of dominant closure codes and call origins as illustrated in Figures 8 and 9, respectively. It should be noted that the following analysis and observations have been made without validatory discussion with the RCCs and hence should be treated with due consideration.

It is clear from Figure 8 that significant variations in incident types exist between schemes, with the most marked observations being:

- The large rate of breakdowns on the hard shoulder observed on M6: J5-8, followed by M62: J25-30 and M1: J10-13.
- The marked differences in the rates of tasked incident on the M60: J8-12 and M1 J10-13, compared with other schemes.

- The split between two groups of schemes, where certain schemes (i.e. M60: J8-12, M6: J5-8, M62: J25-30, and M1: J32-35a) consistently yield greater rates of certain incidents (i.e. Roadworks, Debris, Breakdowns in the Live Lane, and Road Traffic Collisions).

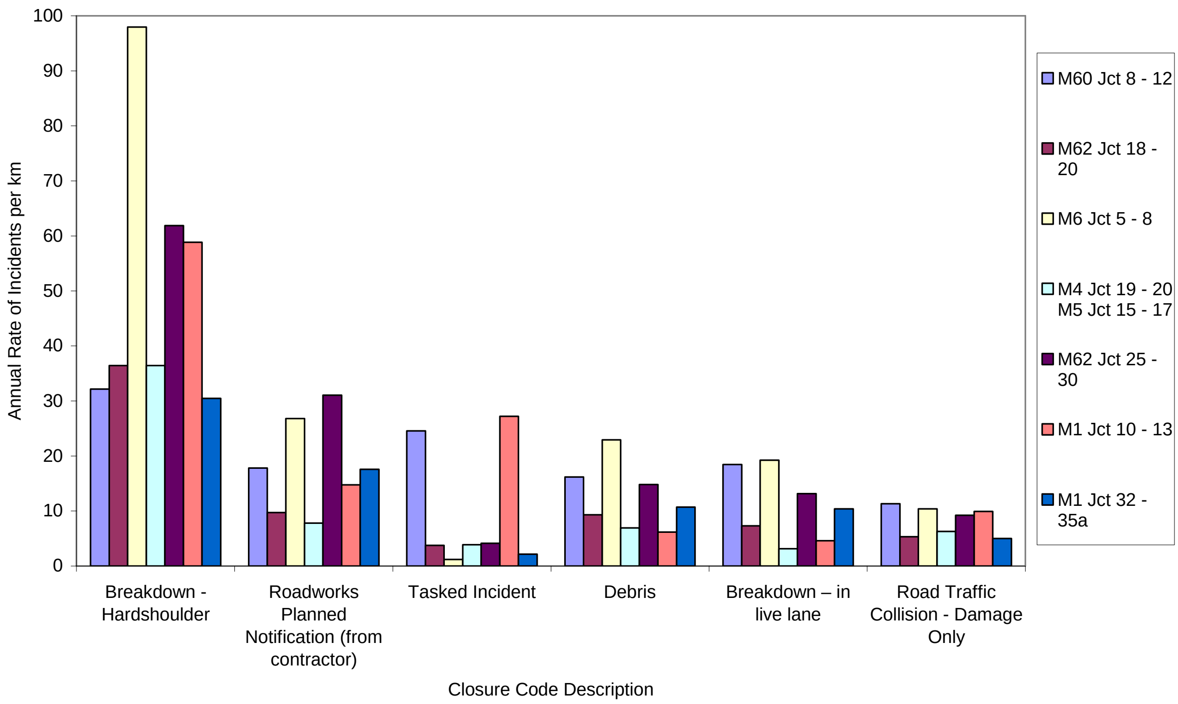

Figure 8: Rates of different incidents, sub-divided by type, for the different forthcoming MM schemes

From this analysis, it is evident that aside from breakdowns in the hard shoulder being the dominant incident type for all schemes, there are significant variations in incident type, which are chiefly attributed to:

Traffic Characteristics

For example, the high rates of breakdown on the hard shoulder on the M6: J5-8. From discussion with WMRCC staff, this high rate is attributed to a high number of vehicles running out of fuel. Although similar situations *may* be occurring on the M62: J25-30 and the M1: J10-13, discussion with the relevant RCC staff is required to establish the exact cause.

Effect of DHS construction programme

The large variations in road works illustrate the potential affects of the DHS construction programmes on the incident rates. The presence of such road works is likely to impact the incident pattern as vehicles travel at lower speeds. This in turn will affect the decision regarding when to take baseline incident records from which scheme safety performance is measured as well as affecting the inputs to the workload model.

Regional Practices

The large difference in rates of tasked incidents on the M60: J8-12 and M1: J10-13 compared with the other schemes suggests differences in operational practice between the RCCs regarding the use of incident classification codes.

Speed of detection

The speed of detection can affect the incident classification. For instance, a damage only incident which leaves debris in the road, would be classified as TC1 where initial reports relate to the vehicles, stopped either in the live lane or on the hard shoulder. However, where the vehicles leave the scene before the TO are alerted, a classification of OB1 may be assigned.

As part of the creation of the workload model, the incidents within each scheme have been classified by:

- final closure code
- weekend/ weekdays
- start time of incident (the incident have been classified into one of three groups of incident start times; 06:00-14:00, 14:00-22:00, or 22:00-06:00)

These have been submitted to IBI as part of the creation of the TOS resource workload model for the Managed Motorways Operations Group, and is provided in Appendix D.

4.7.3 Pre-MM implementation incident detection analysis on regional schemes

In order to provide an initial pre-DHS overview of incident detection for the various schemes, RIF data for the period 01/01/09 to 31/12/09 was analysed as illustrated in Figure 9. It should be noted that the following analysis and observations have been made without validatory discussion with the RCCs and hence should be treated with due consideration.

It is clear from Figure 9 that significant variations in incident types exist between schemes, with the most marked observations being:

- The relatively high rates of calls originating from Traffic Officers on routine patrols on M6: J5-8 and M1: J10-13.
- The relatively high rates of calls originating from HA Contractors M62: J25-30.
- The split between two groups of schemes, where certain schemes (i.e. M6: J5-8, M4: J19-20/ M5: J15-17, and M62: J25-30) yield greater rates of incidents originating from Emergency Radio and conversely lower rates of incidents originating from the Police.
- The scheme on the M6: J5-8 yields the greatest incident rates for five of the call origin types. From Figure 8 it is noted that many of these are Breakdowns on the Hardshoulder.
- The high rates of tasked incidents on M60: J8-12 and M1: J10-13.

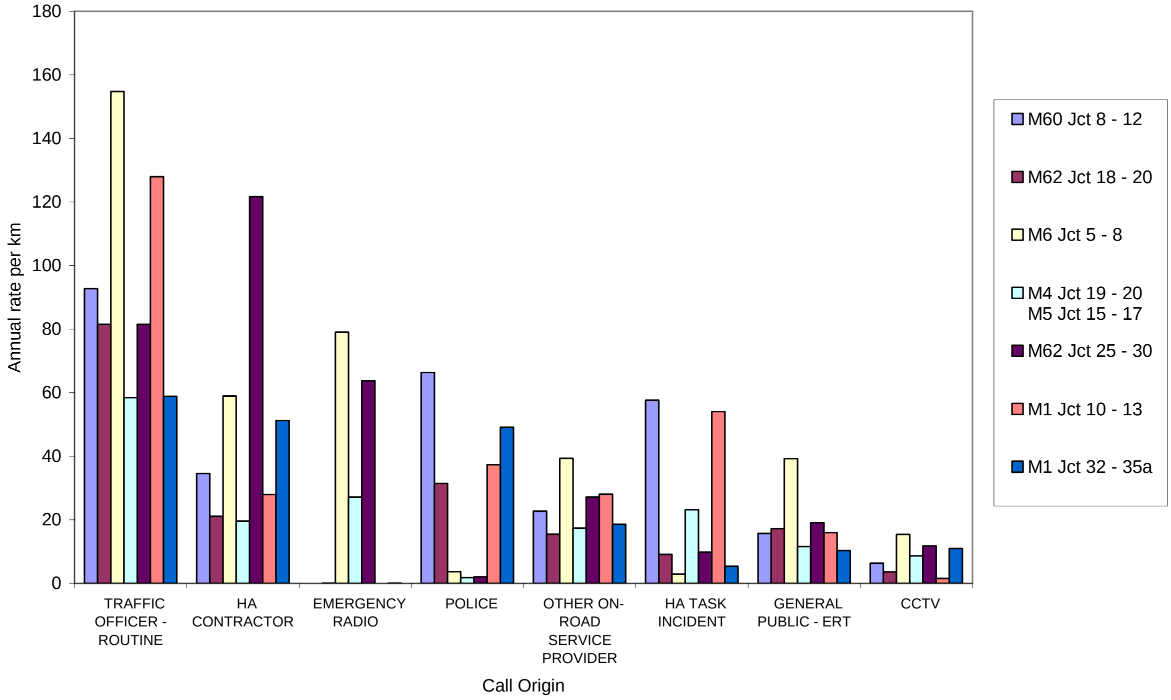

Figure 9: Rates of different incidents, sub-divided by call origin, for the different forthcoming MM schemes

From this analysis, it is evident that aside from the majority of calls originating from the TOS routine patrol, there are significant call origin variations between different motorway sections, which may be attributed to:

Usage of Codes

The marked differences between two groups of schemes in terms rates of incidents originating from Emergency Radio and those originating from the Police suggests differences in code usage between RCC/ outstations/ Police force boundaries. Observations in the WMRCC also revealed isolated examples of differences in code usage.

Regional Practices

RCCs may adopt slightly different practices as a result of differences in; network characteristics, traffic management technology and organisation preference. For instance, it may be observed that the greatest rates of HA contractors originated incidents occur on M62: J25-30.

Nature of Incidents

The nature of the incident may affect the call origin. For example, the high rates of incidents originating from the general public – ERTs occur in a section of the M6 where a relatively high number of vehicles run out of fuel, as discussed in section 4.3.1.

Detection Technology

The observed variations in the rates of incidents detected by CCTV coupled with known regional differences in the levels of functioning monitoring technology suggest that the level of technology will affect the mode and speed of incident detection as well as the workload to manage the incident. While the effect of monitoring technology on TOS workload is not part of this study, this aspect is significant. When considering the effect of DHS on incident characteristics and resulting TOS workload, the levels of existing functioning detection technology should be taken into account.

While these conclusions have been drawn from a relatively brief analyse of scheme incident data and observations from WMRCC, adequate scheme specific recommendations can only be made after:

- Details incident analysis
- Observation and discussion with the RCCs
- Scheme details are confirmed.

5. FURTHER WORK

The effects of MM implementation on incident management have been identified and these have been outlined in some detail in this report. Comment has been made throughout the report where further work is believed to be beneficial. Outputs from future work could include:

5.1 Incident access

This sub-task was concerned with assessing incident access for incident responders when Managed Motorways are operational (i.e. hard shoulder running is active). The concern was that responders to the incident will be impeded by slow moving or static traffic, with consequential detrimental effects on health and safety and congestion. While this task has clarified the risk based on the data available, further work is considered beneficial in two key areas:

5.1.1 Understanding of queue dynamics in relation to Red-X signals

As detailed in section 2.5, longer clearance times occur when the Red-X (STOP) signal is applied within 4 minutes of the incident being detected. While this *may* be attributed, in some part, to the presence of turbulent traffic flows within the section examined as traffic moves from 4 to 3 lane running, further analysis is required to verify this. Further analysis would take the form of both greater sample size, to add to statistical significance, and more in-depth study of the incident known to date. This may take the form of gaining further context, namely through C&C logs.

The benefits of this would be twofold:

1) Provide further confirmation that the risk of responder delay is negligible and that this would not adversely affect the health and safety of those involved in the incident.
2) Establish the mechanisms by which early responders are caught up in queuing traffic thereby informing future policy decisions resulting in reduced TOS response time and hence potential traffic delay.

5.1.2 The Effect of Staggered Red-X (STOP) signal implementation

As discussed in Section 2.8, the effect of staggered implementation of the Red-X (STOP) signal has been studied in some detail. However, the relationship between the Red-X signals and types of incidents and ERA utilisation (i.e. whether the incident vehicle uses the ERA or breaks down on the hard shoulder or live lane) has not been investigated within this report. It is possible that these two factors may have an effect on traffic behaviour, as breaking down on the live lane could potentially create a larger bottleneck on the carriageway being considered.

5.1.3 Gain stakeholder engagement

Although the analysis undertaken in section 2 suggests that the risk of responder delay due to DHS operation is negligible, it is recommended that these findings are presented and discussed with relevant stakeholders. The benefits of such engagement would either; 1) provide further confirmation that the risk of responder delay is negligible or 2) if the stakeholders have conflicting evidence, establish an evidence based argument to revise incident management procedures.

5.2 Incident type/ classification

This sub-task was principally concerned with identifying whether similar incidents require a different incident management approach if they occur on a Managed Motorway as opposed to a non-Managed Motorway. While, the work undertaken on this sub-task has identified several items where a revised incident management approach would be beneficial, a further item is also seen as beneficial for further investigation as detailed in section 5.2.1.

5.2.1 Effect of early detection and opportunity for ongoing monitoring

The increased quantity of monitoring equipment results in a greater number of incidents being detected, and arguable detected sooner. While the result of increased detection rates is to increase the number of incidents handled by the TOS, the effect of earlier detection is not fully understood. For instance, a damage only incident which leaves debris in the road would be classified as TC1 where detected early and initial reports relate to the vehicles, stopped either in the live lane or on the hard shoulder. However, where the incident is detected later, perhaps once the vehicles have left the scene, a classification of OB1 may be assigned. In this case, depending on the time of incident detection and available information at the time, the response grade may have ranged from immediate to routine. This variability in grading clearly affects TOS workload and resulting KPIs.

Due to organisational changes within the WMRCC on-road observations were not feasible within the timeframe available, therefore the effect of early detection has not been adequately investigated as part of the main works. This aspect is considered to yield potential benefits to the TOS through likely resulting changes in incident management procedures. Savings *may* be realised where ongoing monitoring of the incident prior to on-road TOS arrival provides additional information allowing the incident to be response grade downgraded.

5.3 Managing multiple incidents

This sub-task was concerned with evaluation of the potential impact on incident management as a result multiple Managed Motorway at one RCC. A number of RCCs will shortly need to extend their roles to encompass the seven forthcoming Managed Motorway schemes. While the work undertaken on this sub-task has identified the effect of DHS operations on incident rates and TOS workload, and provided pertinent considerations for subsequent schemes, a further item is also seen as beneficial for further investigation as detailed in section 5.3.1.

5.3.1 Establishing effects of patrol density on TOS performance

The sub-task has undertaken a brief analysis to ascertain a relationship between; patrol density, traffic flow and TOS performance in terms of TOS detected incidents and response times. While variations in performance have been observed, analysis to date does not reveal clear relationships therefore suggesting that further incident variables are required to be identified. Establishing a clear relationship between patrol density and TOS performance, coupled with the effect of MM implementation would allow:

3) Appropriate TOS resource allocation based on traffic characteristics
4) Appraisal of future MM schemes supported by evidence based TOS performance data

6. CONCLUSIONS

This task has provided consultancy support to evaluate the effect that the Managed Motorway programme will have on incident management. There were three sub-tasks within this task:

- Managed Motorways – Incident access
- Managed Motorways – Incident type / classification
- Managed Motorways – Incident handling with multiple Managed Motorways

Delivery of the task involved a two phase approach, commencing with a scoping report to; 1) determine the outline risks, presented by these effects, on the ATM pilot scheme (M42; J3a-7), and 2) identify appropriate methodologies to establish underlying relationships in order to effectively manage these risks for Dynamic Hard Shoulder Running (DHS) schemes progressed throughout the HA network until January 2013. The second phase of this task involved the main works of research as identified by the scoping report. The pertinent conclusions from each sub-task are present herein.

6.1 Incident access

This sub-task was concerned with assessing access for incident responders when Managed Motorways are operational (i.e. when DHS is active). The concern was that responders to the incident will be impeded by slow moving or static traffic, with consequential detrimental effects on health and safety and congestion. In order to evaluate this risk, several items of work have been undertaken with the key findings summarised below.

<u>DHS Incident characteristics</u>

- Traffic officers detect a much greater proportion of incidents on DHS sections.
- Traffic officer response times are generally lower on DHS sections.
- When traffic officer travel time is less than approximately 7 minutes, the time distribution suggests that non-DHS sections exhibit a reduced response time.

<u>Rate of incident related queue build up</u>

- Modelling through quRIUs found the introduction of DHS to reduce the corresponding rate of queue build up for a given scenario.
- Observations following an incident on the WMRCC network revealed an average rate of queue build up, as defined by MIDAS loops, approximately correlating with the relationship found in through the quRIUs model.

<u>Lane clearance following Red-X (STOP) signal illumination</u>

The majority of clearance times from the application of the Red-X (STOP) signal are less than 5 minutes (90th percentile is 4 minutes, 24 seconds).

The lane clearance element of the overall duration is longer if the Red-X (STOP) signal is set within 4 minutes of the incident being detected.

Lane clearance following incident detection

- A key factor in the time taken for vehicles to clear the hard shoulder following incident detection is the time interval after which the Red-X (STOP) signal is applied. This is an encouraging result and means that the sooner a Red-X (STOP) signal is set the sooner the lane is clear for use by the emergency services.

Lane clearance in relation to ES response

- A comparison of Red-X (STOP) signal clearance times with timings of when the police took control of incidents revealed that the Police taking control at least 3 minutes after a lane had been cleared. It should be noted that only 3 incidents during the period 01/04/07-31/03/08 required the police to lead during DHS operations.

Impact of DHS on incident related vehicle delay

- While the vehicle delay attributed to each incident has reduced by approximately 40%, the rate (per km) of delay-causing incidents is approximately 45% greater on the DHS. This may be somewhat expected as incidents which would have been dealt with on the hard shoulder (on the conventional 3 lane plus hard shoulder arrangement), now require a lane closure of LBS1, and hence result in vehicle delay.

Comments and Observations from RCC

- In relation to incident access, WMRCC staff reported that the lane with the Red-X (STOP) signal displayed immediately upstream of an incident always clear by the time the Emergency Services (ES) get to the scene.
- RCC staff felt that MM sections were safer than standard non-MM sections due to;
    1. the detection technology,
    2. the ability to communicate with motorists in the queue,
    3. and the ability to let traffic continue flowing past the incident in a controlled manner.
- This was corroborated by Bruce Nowell of Mouchel, an independent consultant, who found the intensively managed nature of the road has resulted in fewer serious incidents. This was attributed to the:
    1. ability to open the hard shoulder to clear traffic
    2. intensive nature of the signalling to close appropriate lanes allowing a faster detection, access and clear up than is possible on other motorways.

Applicability to future MM schemes

- It is recommended that verification is undertaken at an early stage to confirm the expected reduction in the rate of incidents requiring ES response as a result of DHS introduction.
- Given that a key factor in the time for vehicles to clear the hard shoulder following the introduction of the Red-X (STOP) signal is the time at which the Red-X (STOP) signal is applied, future schemes should focus on the speed of decision to apply Red-X (STOP) signal following an incident. Consideration will include;
    1. density and position of *functioning* detection equipment,
    2. work flows between desk staff,
    3. incident arrangements between the HA, ES and ISU, and
    4. potential co-location for incident management.

Recommendations for further work have been given in section 5.1.

6.2 Incident type / classification

This sub-task was principally concerned with identifying whether similar incidents require a different incident management approach if they occur on a Managed Motorway as opposed to a non-Managed Motorway. In order to evaluate this several items of work were undertaken, with the key findings summarised below.

<u>Requirements for additional incident classification</u>

- Incident analysis found a requirement for additional incident types to define breakdowns in the hard shoulder (LBS1) and those in the ERAs.
- Requirements for additional classifications to describe the management of DHS operations (e.g. opening/ closing sections) have been identified based on historic data analysis. Similar codes have been introduced in Autumn 2009.

<u>Effect of Early Detection</u>

- The increased quantity of monitoring equipment results in a greater number of incidents being detected. The effect of this earlier detection on KPIs and procedures is not fully understood and may benefit from further work.

<u>Effect of treating LBS1 as live lane overnight</u>

- The average desk times for both breakdowns in live lane and hard shoulder are less on the DHS section than the respective times on the non-DHS comparison sections.
- Breakdowns in the live lane have lower average desk times than the equivalent times for breakdowns on the hard shoulder.
- The effect of classifying all breakdowns in LBS1 as a breakdown in the live lane reduces the workload for the desk staff.
- Compared to breakdowns on the hard shoulder, breakdowns in the live lane occurring between 22:00-06:00 involve increases in on-road assignment time of an average of 40% on DHS section and 20% on non-DHS sections.

Recommendations for further work have been given in section 5.2.

6.3 Incident handling with multiple Managed Motorways Operating from a Single RCC

This sub-task was concerned with evaluating the potential impact on incident management as a result of multiple Managed Motorway implementation at one RCC. In order to evaluate this, several items of work were undertaken with the key findings summarised below.

<u>Effect on Incident rates</u>

- The introduction of DHS results in a much greater rate of incident detection with corresponding increases in incident rates. Notable increases are chiefly associated with three underlying causes:
    1. Change in classifications
    2. Improved detection
    3. DHS opening and closing procedures.

<u>Variation in incident characteristics between schemes</u>

- A comparison of incident characteristics has been undertaken between:

1. The M42 DHS pilot scheme and other comparative non-DHS sections
2. DHS introduction on the M6: J4-5

Good agreement between the two data sets for most incident types was found, except for large variations for certain incident types as given below.

- Variations for certain incident types may be classified into three groups:
  1. Stops in the Hard Shoulder
  2. Event / Incident (Off Network) – Unplanned
  3. No Trace.
- The chief reasons for these observations are not clear at this stage, but may include differences in traffic characteristics, seasonal effects and changes in operational policy.

Mode of Incident Detection

- The introduction of DHS significantly alters the mode of incident detection and is chiefly associated with increased concentration of detection technology and patrol densities.
- Although similar observations have been made in relation to DHS introduction on the M6: J4-5 on 30/11/09, the phased nature of changes in operational procedures, coupled with numerous road works, does not allow for a meaningful comparison during the period analysed.

Effect on TOS Workload

- The effect on TOS workload in terms of the distribution of timings for each stage in the incident process for each major incident type has been analysed for both DHS and non-DHS sections. These results have applied in the creation of the TOS resource workload model, being developed by IBI for the Managed Motorways Operations Group.
- The average timings for all incident stages are reduced under DHS. In addition, the majority of standard deviations also reduce, suggesting greater uniformity in incident processes.

- Early verification is seen to have two potential benefits;
  1. reduced travel time as the on-road staff have more definite locations and
  2. the need for on-road attendance is negated if RCC staff can verify the incident as non-attendance.
- In addition to the incident data supplied, the TOS resource workload model, being developed by IBI for the Managed Motorways Operations Group, will take into account factors such as the:
  1. Resource required to open/close DHS sections
  2. Effect of equipment faults on TOS workload
  3. Distribution of incident timings and occurrence throughout the week.

Effect on Performance

- For a given flow rate, the patrol densities on the DHS sections are lower in comparison with non-DHS sections of similar flow rate. Brief analysis to ascertain a relationship between; patrol density, traffic flow and TOS performance predictably found marked increases in response times where no patrols were present.

Considerations for National Schemes

- Aside from breakdowns in the hard shoulder being the dominant incident type for all schemes, there are significant variations in incident type, which are chiefly attributed to:
    1. Traffic Characteristics
    2. Effect of DHS construction programme
    3. Regional Practises
    4. Speed of detection

- From analysis of closure codes, it is evident that aside from the majority of calls originating from the TOS routine patrol, there are significant variations, which are chiefly attributed to; 1) usage of codes, 2) regional practices, 3) nature of incidents, and 4) detection technology.
- While these conclusions have been drawn from a relatively brief analysis of scheme incident data and observations from the WMRCC, adequate scheme specific recommendations can only be made after:
    1. Detailed incident analysis
    2. Observation and discussion with the RCCs
    3. Scheme details are confirmed.

Recommendations for further work have been given in section 5.3.

7. REFERENCES

McCormick, G, and Skelly, D. 'A Quick Queue Calculator for Use in Real Incidents', quRIUs Version 1.7.8, Highways Agency, May 2008.

Managed Motorways Delivery Office: Operations Group, 'Managed Motorways Operational Guidance', v1.0 - 2nd November 2009.

Task 029 (387), 'Investment Decision Model - Model Development', undertaken by the Highways Consultancy Group / Highways Research Group for Paul Hupton of Network Services. Final report due for publication in April 2010.

Task 766 (387), 'Consistency of Red X Signalling Final Report - Managed Motorway Compliance - Technical Consultancy', undertaken by the Highways Consultancy Group / Highways Research Group for Jamie Hassall of Network Operational Policy Team (NOPT). Final report due for publication in March 2010.

APPENDIX A
SCOPING REPORT

Highways Consultancy Group – Highways Research Group

Incident Policy for Managed Motorways

Scoping Report

Task Reference: 076(1308)
Project Sponsor: Andrew Vigrass
Report Date: December 2009

Highways Consultancy Group Highways Research Group

This report is prepared by the Highways Consultancy Group/Highways Research Group (HCG/HRG). HCG/HRG is a Consortium of four core suppliers, namely Mott MacDonald, Scott Wilson, Owen Williams and CIRIA, supported by an extensive supply chain.

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Issue and Revision Record

Rev	Date	Originator	Checker	Approver	Description
1.0	14/12/09	E Barker	B Meekums	B Meekums	Internal draft version
1.1	18/12/09	E Barker	B Meekums	B Meekums	Internal draft version
A	21/12/09	E Barker	B Meekums	B Meekums	Issued to client for approval

Executive Summary

Managed Motorway schemes aim to address congestion issues and improve Journey Time Reliability by utilising the existing road space and a set of advanced Intelligent Transport Systems applications. Under Managed Motorway operations, the hard shoulder is opened as a running lane during periods of congestion. It has been recognised that this could have an effect on the following:

1. Access of the 'first responder' to an incident
2. The assigned incident type / classification which determines the response grade of the RCC staff, traffic officers and maintenance contractors.
3. The ability of the RCC and Traffic Officers to manage one or more incidents at the same time as managing multiple Managed Motorways.

Mott MacDonald and Scott Wilson Ltd have been commissioned by the Highways Agency (HA) to undertake a scoping study aiming to; 1) determine the outline risks, presented by these effects, on the ATM pilot scheme (M42; J3a-7), and 2) identify appropriate methodologies to establish underlying relationships in order to effectively manage these risks for Hard Shoulder Running schemes progressed throughout the HA network until January 2013.

Key trends have primarily been identified through analysis of incidents handled by the West Midland Region Control Centre (WMRCC) during a 12 month period in 2008/09. Additional analysis regarding the compliance of drivers to Red-X (STOP) signals was assessed through correlation of MIDAS and HALOGEN data. Finally, ongoing discussion and observations with the WMRCC and other stakeholders within the HA was undertaken to provide both context to the data and develop suitable methodologies to undertaken detailed study. The work is being supported by Network Operations and appropriate Managed Motorways work stream leaders.

Incident Access

Preliminary findings suggests that while the implementation of HSR does cause the build up of queuing traffic in the hard shoulder which potentially impedes initial TO response when TO is close to the incident, it is not found to affect the overall ES/ISU response time. Additional, initial findings suggest that Emergency Services/Incident Support Unit (ES/ ISU) responders arriving at an incident are not generally delayed due to slow moving or static traffic. Further work is likely to be beneficial in the following areas; 1) Validation of preliminary findings, 2) Establish the applicability of initial findings to future HSR programmes, 3) Ascertain the effect of staggered signal implementation on queue clearance times.

Incident Classification

Initial findings suggest three notable differences between MM and Non-MM operations, these being; 1) The increased quantity of monitoring equipment results in a greater number of incidents being detected, 2) Breakdowns in the hard shoulder (LBS1) on MM Sections are treated as a breakdown in a live lane regardless of whether HSR is in operation or not. 3) There appears to be an overlap of usage between the classifications of BH and BL, where incidents which occur in LBS1 are either assigned BH or BL. In addition, there have been a number of the key operational changes that have occurred since the implementation of ATM in 2006. Further work is likely to be beneficial in the following areas; 1) Validation of preliminary findings, 2) Establish the effect of early detection on classification and hence policy, and 3) Ascertain requirements for additional Incident Classifications.

Managing Multiple Incidents

Initial findings suggest four notable differences between MM and Non-MM operations, these being; 1) Slightly longer desk times on MM Sections with corresponding higher rates of CCTV detected incidents. 2) Shorter travel time by on-road resource on MM Sections. 3) Greater clearance time durations on MM Sections, and 4) Greater rate of incidents at night on MM sections, primarily due to a greater proportion of breakdown in live lane being detected through monitoring technology at the RCC. Further work is likely to be beneficial in the following areas; 1) Validation of preliminary findings, 2) Assessment of effect of equipment faults, 3) Establishing outline relationships related to TOS task timings for input into the TOS workload model, 4) Incident analysis on future HSR schemes, and 5) Evaluation of new technologies on the network.

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Glossary of Terms

Average Vehicle Delay	an estimate of the average delay experienced by vehicles due to an incident (minutes per 10 vehicle miles)
Incident Creation Date	A time stamp which is created automatically when an RCC operator starts an incident log
Incident Start Date	A manual time entry which the operator can type in if the system is working offline. It defaults to the creation date if blank.
Incident Clearance Date	The time duration between the TO's arrival and restoring the carriageway.
Incident type code (opening code)	A code which is used to describe the first idea the RCC have about the incident which initiates the original response
Final classification code(s)	codes to indicate the main incident descriptions (e.g. breakdown, traffic collision) and sub-codes to provide further qualifiers (e.g. number of lanes closed, visibility).
Emergency Services	Fire, Ambulances and Police service.

List of Abbreviations

AADT	Annual Average Daily Traffic
ATM	Active Traffic Management
AVD	Average Vehicle Delay
C&C	Command and Control
CCF	Change Control Forms
CCTV	Closed Circuit Television
ERA	Emergency Refuge Areas
ERTs	Emergency Refuge Telephones
ES	Emergency Services
HA	Highways Agency
HALOGEN	Highways Agency Logging Environment
HATRIS	Highways Agency Traffic Information System
HCRC	Hazard Control Review Committee
HSR	Hard Shoulder Running
IDM	Investment Decision Model
ITIS	Integrated Transport Information Systems
ISU	Incident Support Unit
JTR	Journey Time Reliability
KPI	Key Performance Indicators
LBS	Lane Below Signal
LGV	Large Goods Vehicle
MIDAS	Motorway Incident Detection and Automatic Signalling
MTV	Motorway Traffic Viewer
NTCC	National Traffic Control Centre
PSA	Public Service Agreement
QuRIUS	Queuing Rapid Intelligence in Unplanned Situations
RCC	Regional Control Centre
RIF	Road Information Framework
RTC	Road Traffic Collision
TO	Traffic Officer
URN	Unique Reference Number
VMS	Variable Message Sign
WHIMS	Web-enabled Highways Information Management Systems

1. INTRODUCTION

The introduction and continued roll-out of Managed Motorways has had an impact on incident management policy and practice. A Managed Motorway will generally open the hard shoulder to traffic at peak flow times.

It has been recognised that the introduction of Managed Motorways could have an effect on:

- The access of the ‘first responder’ to an incident (i.e. where traffic jams have resulted and so the responder is not able to access via the hard shoulder).
- The assigned incident type / classification that determines the response grade of the RCC staff, traffic officers and maintenance contractors.
- The ability of the RCC and Traffic Officers to manage one or more incidents at the same time as managing multiple Managed Motorways.

This task relates to the provision of consultancy support to evaluate the effect that the Managed Motorway programme will have on incident management. There are three sub-tasks within this task:

- Managed Motorways – Incident access
- Managed Motorways – Incident type / classification
- Managed Motorways – Incident handling with multiple Managed Motorways

The first phase of this task is to undertake a scoping study to to; 1) determine the outline risks, presented by these effects, on the ATM pilot scheme (M42; J3a-7), and 2) identify appropriate methodologies to establish underlying relationships in order to effectively manage these risks for Hard Shoulder Running schemes progressed throughout the HA network until January 2013.

2. MANAGED MOTORWAYS: INCIDENT ACCESS

2.1 Introduction

This sub-task is concerned with assessing incident access for incident responders when Managed Motorways are operational (i.e. hard shoulder running is active). The concern is that responders to the incident will be impeded by slow moving or static traffic, with consequential detrimental effects on health and safety and congestion. In order to evaluate this risk several items of initial work have been undertaken, as detailed in section 2.2, with further work suggested in section 2.3.

2.2 Initial Work

The initial work undertaken involved a phased approach which involved an initial assessment of likely traffic flows and associated build up in queues for various scenarios of lane closure as detailed in section 2.2.1. Following this, the compliance of drivers to Red-X (STOP) signals was assessed through correlation of MIDAS and HALOGEN data as detailed in section 2.2.2. In addition, historic incidents handled by the WM-RCC during the period 1st April 2008 to 31st March 2009 were analysed to identify trends in incident access and the principal differences between the area of the MM and non-MM (Section 2.2.3). Finally, ongoing discussion and observations with the WM-RCC were undertaken to provide both context to the data and a dynamic preliminary validation of results as the work progressed, with further detail provided in section 2.2.4. It should be noted that an investigation of relevant research was undertaken relating to rates of access of emergency vehicles through queuing traffic. While the search was not exhaustive, it would appear that no published research is available through TRL, HA compendium or TRB.

2.2.1 QuRIUS

It is widely accepted that the time taken for responders to reach an incident will depend on the length of queuing traffic immediately upstream of an incident. In order to establish the magnitude of this effect, it was first necessary to assess rates of queue build-up for various scenarios covering different generic types of motorway network, different numbers of lanes blocked and under different flows.

To provide an initial picture of the relationships between these variables, the rate of queue build was assessed using the HA's QuRIUS model. The HA QuRIUS model contains 2008 flow and link data for the majority of the network.

This was undertaken through analysis of queue build up rates following various scenarios of lane blockage on different sections of the M1, M6 and M42. It should be noted that in order to maintain focus of the scoping phase, only 3 lane plus hard shoulder sections were considered. The relationship between flow rate and different lane blockages on 3 lane motorways were ascertained. For illustration, the relationship when 1 lane is blocked is given in Figure 1 below. The linearity of such relationships demonstrates the mathematical background of the QuRIUS model.

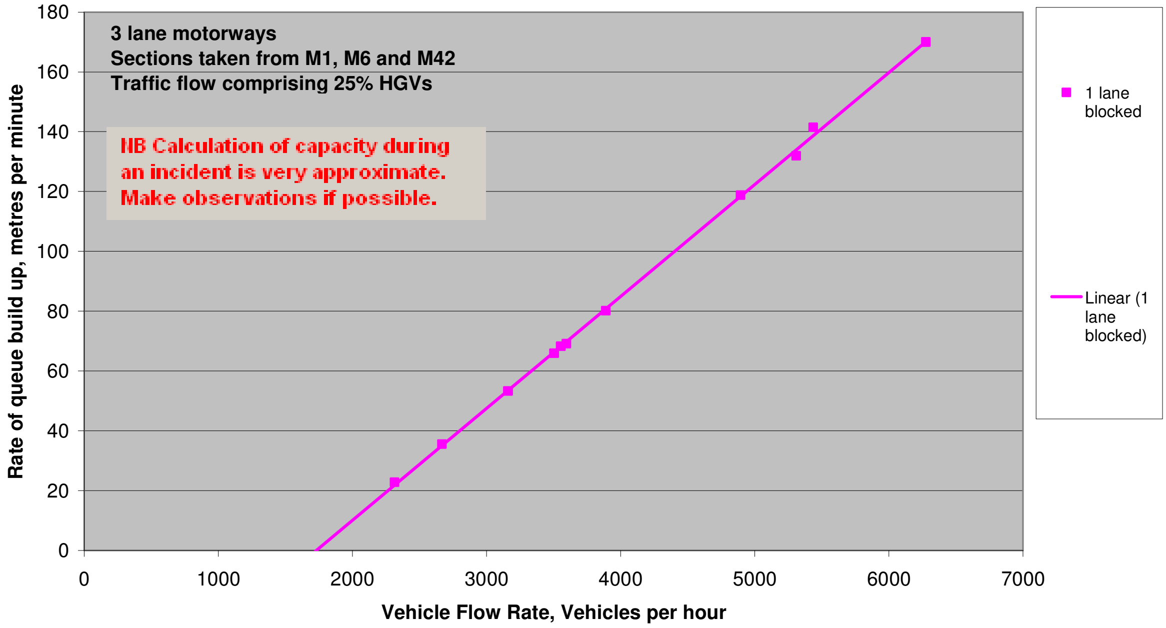

Figure 1 *Rate of Queue build up in relation to vehicular flow rate when one lane closed*

Once the outline relationship between vehicular flow rate and rate of queue build up had been established for 3 lane (plus hard shoulder) motorway, the effect of hard shoulder running was assessed as illustrated in Figure 2, below.

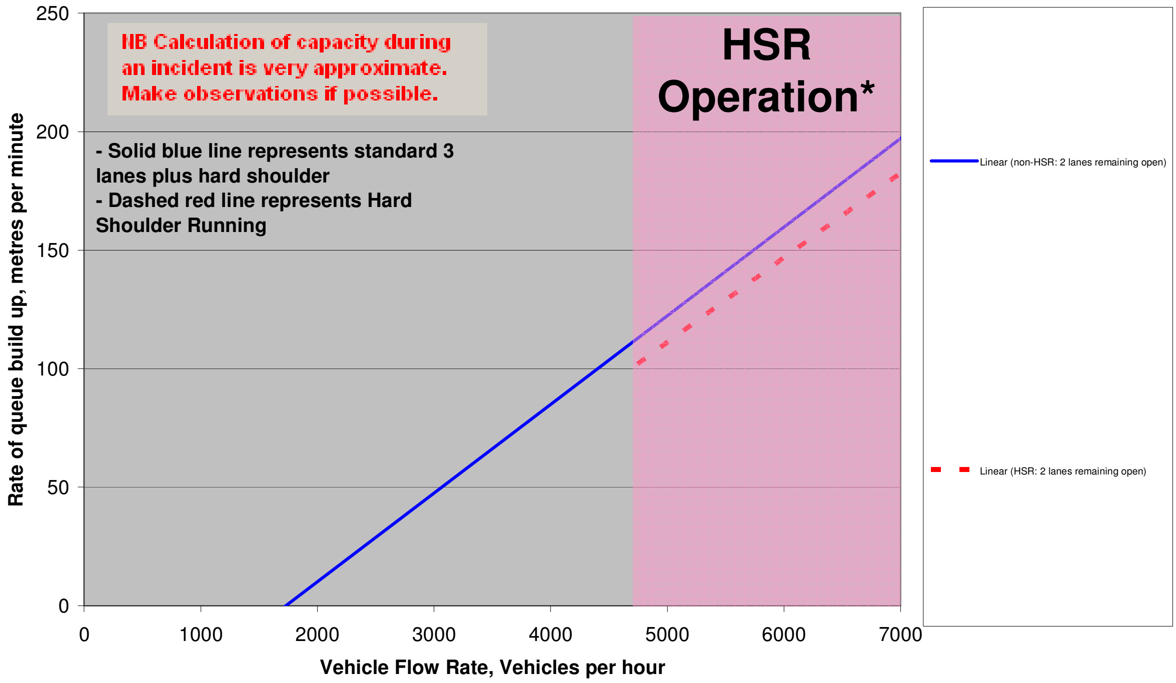

Figure 2 *Rate of Queue build up in relation to vehicular flow rate when one lane closed for both 3 lane plus hard shoulder, and 4 lane hard shoulder running sections*

From Figure 2, above, it is readily apparent that HSR has a marked effect on the rate of queue build up.

2.2.2 Red-X (STOP)

In addition to total queue length, the compliance of drivers to Red-X (STOP) gantry signs will effect the degree to which the emergency access route is kept clear and hence the travel time of the responders to reach an incident. The compliance of drivers to Red-X (STOP) gantry signs has been assessed during previous work (task 633) where HALOGEN and MIDAS data have been cross-correlated. The assessment concerned the compliance levels associated with a Red-X (STOP) gantry sign being activated immediately following an incident; i.e. how quickly does the traffic migrate from the hard shoulder to lane one, and how those remaining react to the responder vehicles.

In order to faciliate this, incident times and locations were identified according to the following criteria:

- Incident occurred between J3a-7 on M42
- Midweek days between 07:30-09:45 and 16:00-18:30
- Involved either ToS, ES and/or ISU

During the period, 1st April 2008 – 31st March 2009, a total of 194 no. incident were identified. These incidents were then assessed in terms of MTV plots to confirm that:

- HSR was in operation prior to the Red-X (STOP) signal being set

- Red-X (STOP) was introduced following the incident.

This process yielded approximately 100 no. incidents to be analysed, of which 20 no. (chosen at random) were analysed in greater detail to understand the best way to take this study forwards.

HALOGEN log data were downloaded/ processed to determine the time and location of where the Red-X (STOP) signals were implemented. MIDAS loop data were processed to understand how long it took for vehicles to clear the hard shoulder following the introduction of the Red-X (STOP) signal. The sample spreadsheet provided in the report (Appendix A) shows that the flow data are colour-coded according to their flow levels as other graphical representations (e.g. profiles, 3D) made it difficult to interpret the results. The results, detailed in the report in Appendix A, show that on average the hard shoulder was cleared after 3 minutes following the introduction of the first Red-X (STOP) signal. It should be noted that there is a reasonably large spread of clearance times; with further work detailed in section 2.3.1.

To understand the queue build-up following the clearance of the HS, speed profiles on LBS1 have been processed using MIDAS loop data and colour-coded according to their speed levels. Although preliminary results show that there is a deterioration in speed following an incident, this data has not been yet been looked at in detail, hence the magnitude of this problem is unknown.

2.2.3 RIF Data

Data analysis has been undertaken from the Timeline model (Task 633) to establish Traffic Officer response times (over the period 08/09) on Managed Motorway sections of the West Midlands region where hard shoulder running has been in place, and compared to a similar data set where hard shoulder running has not been in place. The initially data set comprised approximately 77,000 incidents across the WM-RCC region. These were filtered to approximately 3,000 incident requiring closure and 2,400 being initially classified as requiring an immediate response.

Initial analysis of this dataset has included the various elements of the first stages of the incident management process, namely incident detection and verification.

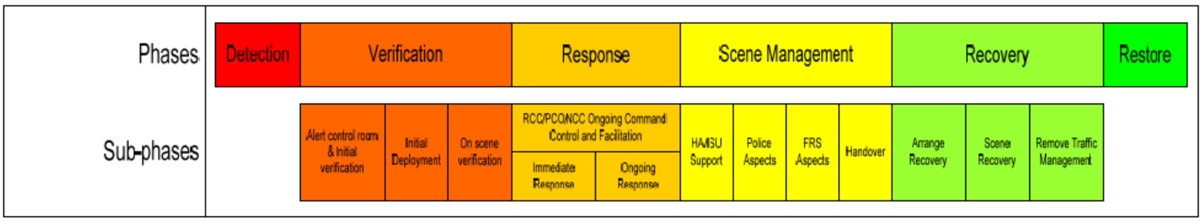

Figure 3 *Phases and sub-phases of the Incident Time line (Highways Agency Network Management Manual, Part 7 - Traffic Incident Management and Contingency Planning)*

In terms of detection, an initial look at the principal modes of detection on both the HSR section and the rest of the WM-RCC network reveals marked differences as illustrated in table 1, below.

Call Origin Description	**M42 J3a-7**	**All other Roads**
Traffic officer - routine	56%	35%
Fire	1%	14%
Police	1%	10%
CCTV	23%	2%
Other on-road service provider	3%	4%
General public - ERT	2%	4%
Contractor	2%	3%

Table 1 *Proportion of principal modes of incident detection in both MM and non-MM sections*

From an initial analysis of the above data it would appear that while traffic officers detect the majority of incidents on all sections, the proportion detected on the M42 between J3a-7 is much greater. Overall, the incidents which occur over the section of the M42 between J3a-7 are reported much less by; calls originating from Police, HA Contractors, and General public through ERTs; they are reported much more through traffic officers and CCTV.

Although this provides an indication of the changes in likely modes of detection between MM and non-MM, a question remains as to the time period between incident occurrence and detection.

In terms of initial deployment to on-scene verification, the effect on TO response times of incident related lane closures and associated queue build up was briefly analysed. This was undertaken through comparing response times of all immediate graded incidents where the call did not originate from the TO themselves, as illustrated in Figure 4, below.

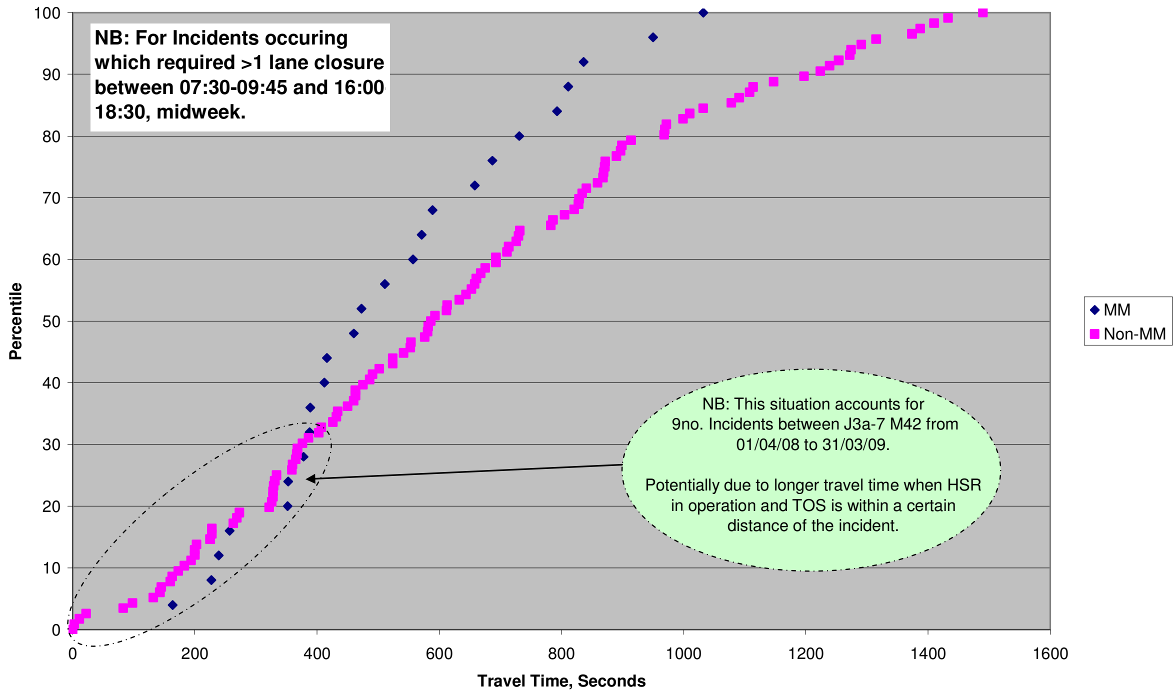

Figure 4 *Percentiles of TO response times to immediate graded incidents during peak hours where the call did not originate from the TO themselves and where >1 lane has closed*

Initial analysis of the above suggests that TO response times are generally lower for the section of M42 between J3a-7. However when TO travel time is less than approximately 7 minutes, the time distribution suggests that other sections of the network exhibit a reduced response time. Further discussion is provided in section 2.2.5 and considers this finding in the light of other information.

2.2.4 RCC Observations and Discussion

In order to provide both context to the data and a dynamic preliminary validation of results as the work progressed, observation and discussions with the West Midlands RCC (where Managed Motorways are operational), has been undertaken. Initial contacts and comments made are given below.

RCC Observations

Observations following an incident where one lane was blocked (LBS3) revealed an average rate of queue build up, as defined by MIDAS loops, of approximately 100 metres per minute for a flow rate of approximately 4,100 vehicles per hour. This approximately correlates with the relationship found in figure 1, section 2.2.1.

RCC Discussions

Chris Rushton – Tactical Analyst, West Midlands Intelligence Unit

A brief meeting was held with Chris on 05/11/09 where the limitations of RIF data and access protocol was discussed. Further discussion was held on 16/12/09 to discuss the potential for accessing data relating to the opening durations and closing durations of hard shoulder running in order to establish a statistically sound basis of timings distribution, as discussed in section 2.3.1.

Jodie Rowbottom - Service Development Manager, West Midlands RCC
Meetings were held with Jodie on 27/11/09 and 11/12/09 to discuss the emerging findings of the data analysis and provide further context and direction to the scoping study. In relation to incident access, she reported that the Red-X (STOP) lanes immediately up stream of an incident always clear by the time the Emergency Services (ES) get to the scene. She felt that MM sections were safer than standard Non-MM due to; the detection technology, the ability to communicate with motorists in the queue, and the ability to let traffic continue flowing past the incident in a controlled manner.

Bruce Nowell - Transport Operations and Technology, Mouchel
Following discussion with Jodie Rowbottom, written correspondence was held with Bruce Nowell of Mouchel who has been heavily involved in the development of operational policy relating to the ATM pilot on the M42 (J3a-7). Bruce's experience of ATM has resulted in the following comments:

- The intensively managed nature of the road has resulted in fewer serious incidents.
- The ability to open the hard shoulder to clear traffic and the intensive nature of the signalling to close appropriate lanes allows a faster detection, access and clear up than is possible on other motorways.

Andy Butterfield - Team Leader, West Midlands Intelligence Unit
Telephone conversations were held with Andy Butterfield on 30/11/09 and 14/12/09, regarding access to historic data, including C&C logs. The exact nature of what can be released by the HA for these study is yet to be clarified.

2.2.5 Concluding Summary

While it is known that the introduction of MM has reduced the rate of serious Road Traffic Collision (RTC) with no-fatal RTC occurring on the pilot section (M42 J3a-7) to date, the question remains as to whether the implementation of HSR has introduced new risks to traffic management. For the purposes of this study, these risks are only concerned with incident access.

Initial discussion with the RCC and preliminary investigation of the Red-X (STOP) compliance both suggest that a clear access path is created for the ES/ISU well before they arrive on the scene. Further work is required to establish a more statistical significant data set which validates this preliminary conclusion and to confirm that ES/ISU arrive well after the access path is cleared.

While the 'second phase' of response, by the ES, may not be adversely affected by the introduction of HSR, it would appear that there is a potential delay in 'initial response'. This is due to the presence of slow moving/ stationary traffic in all lanes immediately after an incident has occurred. The presence of such traffic being due to either delays in applying, or responding to, Red-X (STOP) signals. The underlying relationships of this potential delay in 'initial response' with TOS protocol are yet to be established since a question remains as to the time period between incident occurrence and detection. Further work is required to establish what effect any late 'initial' response has on the time interval between incident occurring and ES/ISU arriving.

2.3 Further Work

The preliminary scoping work suggests that the implementation of HSR:

1. Does not delay ES/ ISU responders arriving at an incident due to slow moving or static traffic
2. Potentially impedes initial TO response when TO is close to the incident
3. Does not affect the overall ES/ISU response time due to potentially impeded TO response

Further work is likely to be beneficial in the following areas:

1. Validation of preliminary findings
2. Secondary research
3. Applicability of initial findings to future HSR programmes
4. The effect of staggered signal implementation of queue clearance times.
5. Stakeholder Liaison

2.3.1 Validation

In order to provide the required degree of confidence to the initial findings, further validation would be required in the following areas;

Confirm HSR Operating

Analysis of HALOGEN data and observation undertaken at WM-RCC suggest that the initial assumptions regarding HSR operating times require further refinement. An initial assumption was made that HSR would be operating on all links between J3a-7 on the M42 between 07:30-09:45 and 16:00-18:45, midweek days.

Initial analysis of 194 no. incidents using Halogen found HSR to be in operation at just over half the incidents which occurred within these times. This finding is in agreement with RCC observations which found that between 35-75% of links were not open during peak times due to either insufficient traffic demand or equipment faults.

Confirm details of specific incidents

The nine occasions where response times between J3a-7 on the M42 were greater than that observed on the rest of the WM-RCC network would need to be validated. The most effective method would be interrogation of the C&C logs to ascertain:

- ES/ISU call time
- ES/ISU arrival time

In addition, the timing of the confirmation of HSR operation would verify that HSR was in operation during these nine incidents.

Further MIDAS/ HALOGEN Analysis

Although the 20no. incidents analysed to date have revealed an average LBS1 clearance time of 3 minutes, the distribution of LBS1 clearance times has ranged from 1-30 minutes. In order to establish the required confidence in the data current held, analysis of further incident is required. This is intended to establish the distribution of timings for lanes clearances. Where lengthy clearance times are indentified, further analysis through C&C may be required to identify the underlying causes. It is intended that such work involving MIDAS and HALOGEN will also confirm rates of queue build as indicated through QuRIUS and ascertain rates of queue dispersion.

Confirm ES/ISU Response times

The most effective method to confirm ES/ISU times without liaison with third parties would be interrogation of the C&C logs to ascertain the call times and arrival times of the ES/ ISU. Given that release of C&C logs potentially represents significant issues in terms of data protection, ongoing discussions are being undertaken with Andy Butterfield, Tom Kingaby and Bob Castleman.

2.3.2 Secondary Research

The following aspects will be considered;

- determining AVDs and JTR figures, where appropriate,
- KPIs relating to TOS/ES/ISU response times,
- environmental impact assessment.

2.3.3 Applicability of initial findings to future MM schemes

Although, the findings from the operational data for the section between J3a-7 on the M42 may conclude that responders to the incident may not be impeded by slow moving or static traffic, this *may* not be the case in future schemes. Key variations between HSR schemes include traffic flow and density of traffic monitoring and control devices. For instance, the rate of queue build up and subsequent dissipation may be affected by the spacing of signal gantries which is known to be generally increasing on future HSR schemes. The effect of this requires further analysis.

2.3.4 The effect of staggered signal implementation of queue clearance times

During analysis of MIDAS and HALOGEN data, it was observed that staggered implementation of the signal (i.e. Red-X (STOP) introduced on more than 2 consecutive gantries but at different times) appears to show different clearance times. This will need to be looked at in more detail as the analysis develops.

2.3.5 Stakeholder Liaison

Liaison with the Emergency Services Liaison Team (Rodney Brown) would be beneficial to confirm that the initial findings are in agreement with the experience of the West Midlands Emergency services.

3. MANAGED MOTORWAYS: INCIDENT TYPE/ CLASSIFICATION

3.1 Introduction

This task is principally concerned with identifying whether similar incidents require a different incident management approach if they occur on a Managed Motorway as opposed to a non-Managed Motorway.

For example, if a breakdown occurs in a live lane on a non-Managed Motorway section then the vehicle could be moved to the hard shoulder, with normal capacity quickly restored. However, if this occurs within a peak flow period (i.e. Managed Motorway in operational status) then a decision needs to be made as to whether to move the vehicle to the hard shoulder and so reduce capacity, or whether to physically remove the vehicle from the motorway or into ERA (i.e. tow – vehicle recovery option).

It should be noted that the definition for an immediate response grade is: ‘An obstruction on or related to the live carriageway that is likely to cause congestion or threaten safety’

Consequently, a breakdown on the hard shoulder of a Managed Motorway (in operational status) would be assigned a response grade of ‘immediate’. This sub-task concentrates on whether the mobilisation of resources and operational policy and practice of the TOSs, RCC and maintenance contractors needs to be tailored for Managed Motorways. In order to evaluate this several items of initial work have been undertaken, as detailed in section 3.2, with further work suggested in section 3.3.

3.2 Initial work

The initial work undertaken involved a phased approach which involved an initial assessment of historic incidents handled by the WM-RCC during the period 1st April 2008 to 31st March 2009. These were analysed to identify trends in incident type, response and classification at different times and on both HSR and non-HSR sections as detailed in section 3.2.1. Ongoing discussions and observations with the WM-RCC were undertaken to provide both context to the data and a dynamic preliminary validation of results as the work progressed, as detail in section 3.2.2. Finally, the Managed Motorway policies and associated amendments are details in section 3.2.3.

3.2.1 RIF Data

Statistical analysis of incident Timeline data on the 2 sets of data (Managed Motorway and non-Managed Motorway) has been undertaken. An initial analysis of all incidents in both MM and non-MM sections at different times of the day is presented in figure xx, below. For clarity of presentation, only the main incident types have been included. These account for over 80% of all recorded incidents.

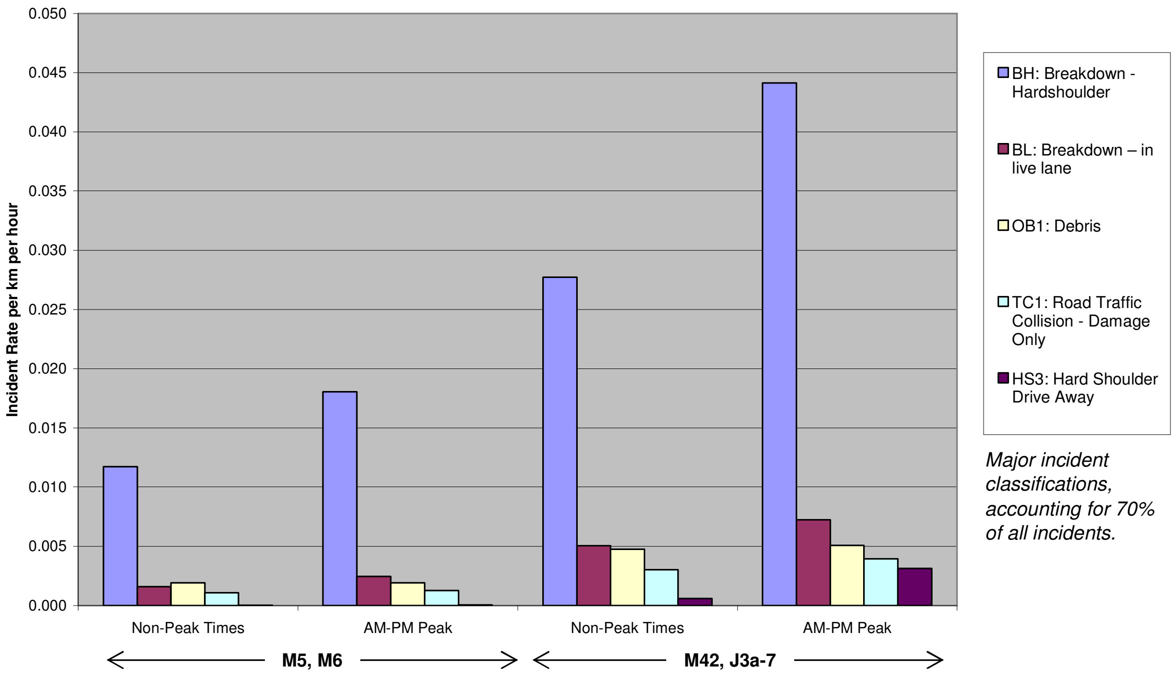

Figure 5 *Incident Rates for the top four incident classifications for both Non-MM and MM Sections during both peak and non-peak hours*

From the above figure, several observations may be made:

- Breakdowns on Hard Shoulder are dominant on both section types and at all times; being much greater in the MM sections.
- Breakdowns in the Live Lane are significantly greater on the MM sections, likely due to the classification of BL being assigned to any vehicle broken down in LBS 1-4. Further analysis is provided in section 3.2.1.2.
- While the rate of Debris in road is greater in the MM sections, the rates shown little variation with regards to time of day, and hence traffic flow.
- Road Traffic Collision - damage only; is greater in the MM sections, being greatest In peak times. It is of interest to note that the same difference between peak and off-peak hours are not observed in the non-MM sections. While the reasons for this are not immediately apparent, it should be born in mind that such collisions may be occurring throughout the network without being recorded.

- Hard Shoulder - Drive away; is significantly higher on MM sections, with over 60% of these incident being detected by CCTV or on-road patrol. It should be noted that over 60% of these incidents on MM section are not assigned an immediate response grade, suggesting that they are occurring in the ERAs.

Response Grades

In addition to the key differences in incident types between MM and non-MM sections, there are clear differences in response grades (see figure 6, below), as would be expected due to the differences in incident management policies. For clarity of presentation, only the main incident types have been included. These account for over 80% of all recorded incidents.

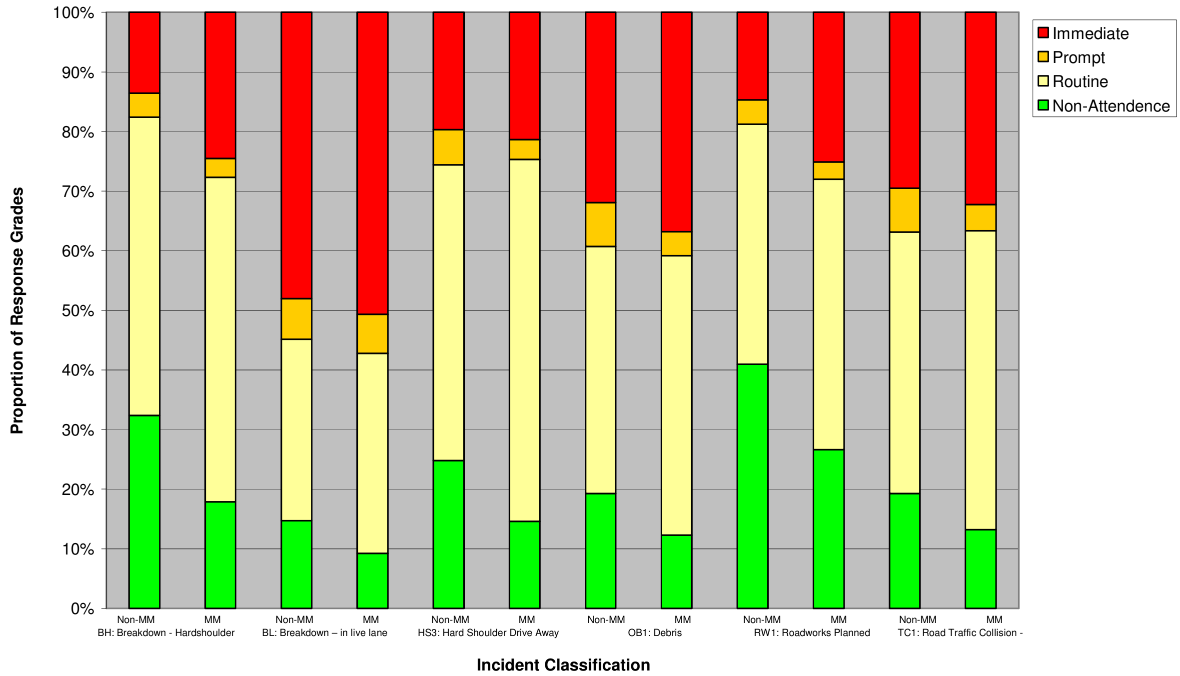

Figure 6 *Proportion of Incident Response Gradings for different incident classifications for MM and non-MM sections*

From the above figure, two main observations may be made. Firstly, the proportion of non-attendance grade responses are greater for Non-MM sections for all incident types, to varying degrees, with the high variances being for;

- breakdowns in the live lane
- breakdowns on the hard shoulder
- hard shoulder drive away incidents.

Secondly, the proportion of immediate grade responses are greater for MM Sections for all incident types, to varying degrees, being significantly greater for breakdowns on the hard shoulder. However, it should be noted that there is currently no distinction between breakdowns in LBS1 and breakdowns in an ERA. This is discussed further below.

Breakdown on Hard Shoulder and Live Lane

In order to further investigate the variation in breakdowns on the hard shoulder and a live lane, the total number of BH and BLs during midweek days on the section of the M42 between J3a-7 were plotted in terms of start times as illustrated in figure 7, below.

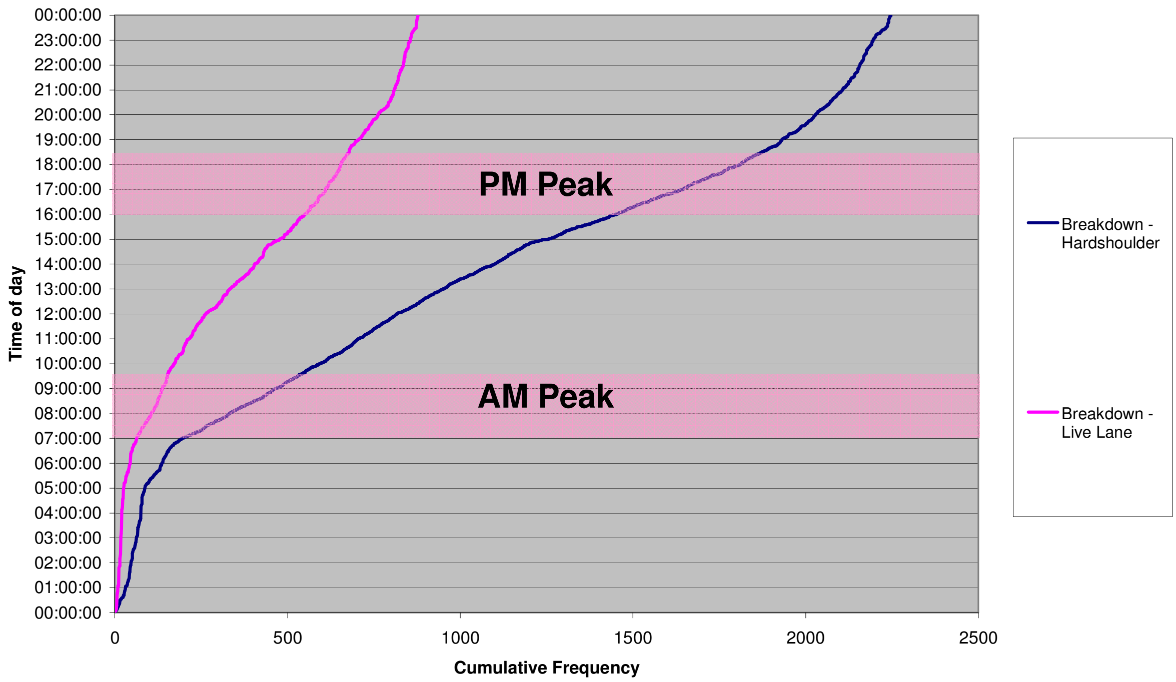

Figure 7 *Midweek Frequency of Live Lane and Hard Shoulder Breakdown Classifications on the section J3a-7, M42*

It would appear that while the rates of breakdown in the live lane and hard shoulder are somewhat proportional to traffic flow (as expected), they exhibit little variation with HSR operation. This would appear to suggest that classification practices of vehicles actually broken down in LBS1 remain consistent regardless of HSR operation. Further analysis has been undertaken into the incident locations for BH (breakdown in hard shoulder) classifications for midweek AM-PM hours between J3a-7 on the M42. Preliminary analysis suggests that over 70% of the incidents classified as BH actually occur in the ERAs, with the remainder occurring in a live lane or slip road. These would agree with figure 6 where non-attendance or routine graded responses accounted for just over 70% of the total number of BH incidents.

3.2.2 RCC Observations and Discussion

Observations and discussions with the West Midlands RCC were undertaken in order to gain an ‘on the ground view’ as to whether a different approach is generally adopted for Managed Motorways and non-Managed Motorways. Initial contacts and comments made are given below.

Jodie Rowbottom - Service Development Manager, West Midlands RCC
Meetings were held with Jodie on 27/11/09 and 11/12/09 to discuss the emerging findings of the data analysis and provide further context and direction to the scoping study. In relation to the findings in section 3.2.1, she confirmed that since the ERAs have detection devices, there is a greater rate of BH and HS incidents on MM sections compared to non-MM sections. In relation to the findings in section 3.2.1.2, she confirmed that the classification of BH, when used during HSR, may mean the incident is in the ERA or LBS1. This finding confirms her experience; with a need for an additional incident classification to be created specifically to describes incidents occurring in the ERA. Finally, Jodie confirmed the need for a BH classification on MM to be always dealt with as ‘immediate’ due to the elevated risk that HSR would need to be opened immediately if an incident occurred elsewhere; LBS1 has to be ready to run at all times. In addition, due to an elevated risk of a vehicle running in LBS1 even when closed for HSR, a breakdown on the hard shoulder is treated as a breakdown in a live lane with associated procedures regarding response times, and traffic management.

Jodie related some of the key operational changes that have occurred since the implementation of ATM in 2006. Further details were obtained from Bruce Nowell (Mouchel), these are detailed in section 3.2.3.

Bruce Nowell - Transport Operations and Technology, Mouchel
Following discussion with Jodie Rowbottom, written correspondence was held with Bruce Nowell of Mouchel who has been heavily involved in the development of operational policy relating to the ATM pilot on the M42 (J3a-7). Bruce confirmed that MM relies upon almost identical procedures to the National TO Manual for incident management.

3.2.3 Policy

During discussions with the WMRCC, Jodie Rowbottom related some of the key operational changes that have occurred since the implementation of ATM in 2006. Further details were obtained from Bruce Nowell (Mouchel) who detailed the main changes and the key drivers for these changes are detailed below.

Key Policy Changes

The key operational changes which resulted from operational experience are described below with further information provided in Appendix B1.

Links between HSM Subsystem, C&C and COBS

Development of automatic links from the HSM Subsystem into the Command and Control system to record the opening or closing of the hard shoulder which assists the operator and reduce the workload, since initially the operator had to log the details manually.

Debris checking regime

HCRC relaxed the requirement for a check to be undertaken within 60 minutes of *any* instance of hard shoulder opening to two checks per day.

Role of Second Operator

Since the 2nd Operator had intervened only rarely during the first two years of operation (i.e. on only one or two occasions), the role of the 2nd operator was therefore not clearly defined. The role of the second operator was more clearly defined as' to provide a competent resource to assist the first operator if an incident occurs while the hard shoulder is being opened.'

Role of Team Manager

The Procedures initially specified that the Team Manager should be consulted at a number of points in the opening and closing process. This was specified at the outset as an additional safety overlay. However, operational experience found that the experienced operator can make the decision themselves; with an additional check still deemed required at weekends when traffic flows are less well defined.

Advising NTCC of Hard Shoulder Opening

The RCC initially advised the NTCC when the hard shoulder was opened. This appeared to be unnecessary given that the NTCC could see traffic data from loops and CCTV cameras.

Drivers for Change

The implementation of ATM has required the introduction of number of specific operational procedures. Since the implementation of ATM in 2006, several drivers for the changes to the operational procedures have been identified, as detailed below.

- Firstly, it must be borne in mind that in 2006, this was the first use, in this country, of the hard shoulder as a dynamic running lane, and as such was approached with considerable caution. The arrangements put in place were deliberately designed to have a significant safety margin in the expectation that these could be reduced once a period of safe operation was demonstrated and operational experience gained. Mouchel ran an Operational Development Team in the WMRCC alongside the operators for nearly 18 months following implementation.

- The second driver for change was the WMRCC. As operational experience developed, it became clear that some requirements were overly onerous on their resources. This is related to the first driver for change as well. A review of some of these issues was undertaken in January 2007 – see Appendix B2.

- The third driver for change was some decisions about how ATM/MM should operate, in particular the decision to operate at 60mph and the decisions that gantries should be intervisible rather than at nominal 500m intervals and that MIDAS loops should be more widely spaced than on the pilot.

- The fourth driver for change was the development of additional sections of hard shoulder running, especially the implementation of the Birmingham Box Managed Motorways Phases 1 and 2 project, which doubles the amount of Managed Motorways controlled by the WMRCC. In conjunction with the WMRCC, we reviewed those activities that were resource intensive so that a single RCC could operate multiple sections of hard shoulder running. This review was documented at a number of meetings, and a set of minutes that best describes the desired changes is provided in Appendix B1.

These various drivers for change led to the development of several ATM Change Control Forms (CCF) which summarise the various changes requested. The process mirrors that used by the National Procedures User Group but uses the ATM Safety Management process. Thus the changes requested were tested against the original Safety Case/Report to ensure that safety was not compromised. Where there was a significant change, the Hazard Control Review Committee (HCRC) was asked to confirm the proposed course of action. Once all this had been done, and the WMRCC were content that the proposed changes met their requirements, the CCFs were submitted for implementation.

Most of these were submitted as a group on 28/01/09 with two following on later. All were implemented by 25/06/09. The specific ATM CCFs that cover changes affecting the operation of ATM/MM are provided in Appendix C1-12.

3.2.4 Concluding Summary

Statistical analysis of incident Timeline data on the 2 sets of data (Managed Motorway and non-Managed Motorway) initially highlighted several notable differences between MM and Non-MM operations. After discussion and observation with the WMRCC, there would appear to be three key differences, which may be summarised as:

- The increased quantity of monitoring equipment result in a greater number of incidents being detected. Under normal non-MM conditions these incidents, such as vehicles stopping on the hard shoulder, may not have been even detected. The effect of this earlier detection on KPIs and, potentially, procedures is not full understood and hence required further work as detailed in section 3.2.5.

- Breakdowns in the hard shoulder (LBS1) on MM Sections are treated as a breakdown in a live lane regardless of whether HSR is in operation or not. This is due to an elevated risk of vehicles running in LBS1 even when closed for HSR, with associated procedures regarding response times, and traffic management.

- There appears to be an overlap of usage between the classifications of BH and BL, where incident which occur in LBS1 are either assigned BH or BL. This finding suggests that there is a need for an additional incident classification to be created specifically to describe incidents occurring in the ERA as 70% of incidents classified as BH were actually occurring in LBS1 and hence required the classification BL. It is uncertain whether there are other such incidents which require specific code and, potentially, procedures; hence required further work as detailed in section 3.2.5.

There have been a number of the key operational changes that have occurred since the implementation of ATM in 2006. The key changes and drivers for them have been detailed to provide a background to the developments made to date.

3.3 Further Work

Further work is likely to be beneficial in the following areas:

- Validation of preliminary findings/ RCC observations and discussions
- Effect of early detection
- Ascertain requirements for additional Incident Classification

Validation of preliminary findings/ RCC observations and discussions
To date RCC observations/ discussions have been limited to control room and management staff only. In order to gain a representative picture of TO operations, it will necessary to undertake observations and discussion with on-road staff. Initial discussion with Jodie Rowbottom indicates that this should be possible. In addition to confirming findings from the data analysis, as detailed in section 3.2.4, an assessment would be undertaken to ascertain the degree to which operational policy is performed in practice.

Effect of early detection
While it has been established that the introduction of additional monitoring devices has increased the rates of incident detection, it is not fully known what effect this has on the incident classification. For instance, a damage only incident which leaves debris in the road, would be classified as TC1 where initial reports relate to the vehicles, likely to be stopped on the hard shoulder. However, were the vehicles leave the scene before the TO are alerted, a classification of OB1 may be assigned.

Ascertain requirements for additional Incident Classification
Investigation to ascertain whether further classification codes are necessary to capture the different duties of RCC/TOS, e.g. stops in ERA.

4. MANAGED MOTORWAYS: MANAGING MULTIPLE INCIDENTS

4.1 Introduction

Managed Motorways require a level of RCC and TO resource in terms of opening (CCTV and traffic officer sweeps), closing, sign and speed setting and on-going supervision. The seven RCCs distributed geographically throughout the network have different levels of technology (e.g. CCTV, loops, It is, etc.) and TO resource levels to support the incident management activities. The various regions also have their unique characteristics in terms of traffic flow, incident rates, incident types, TO outstation positioning and maintenance contractor out-station positioning.

A number of these RCCs will shortly need to extend their roles to encompass the seven forthcoming Managed Motorway schemes. It is understood that the HA wishes to investigate whether an additional level of resource is required in terms of RCC and TO staff for these regions that are ‘new’ to Managed Motorways. Naturally, the HA needs to negate any potential detrimental impact on incident management as a result of the Managed Motorway implementation.

There are several related ongoing work streams related to this subject and it has been necessary to interface with these work streams as part of this task. In order to evaluate the potential impact on incident management as a result of the Managed Motorway implementation, several items of initial work have been undertaken, as detailed in section 4.2, with further work suggested in section 4.3.

4.2 Initial work

Resource analysis (TO and RCC) of the West Midlands region has been undertaken to determine whether current incident management is adversely affected by Managed Motorway operations. This has been undertaken through two routes, i.) observation of the RCC and discussion with staff (Section 4.2.1), and ii.) a more quantitative approach achieved through analysis of incident timelines data sets for Managed Motorway and non-Managed Motorway network sections (Section 4.2.2). Finally, section 4.2.3 highlights characteristics of future schemes due for implementation in all seven RCC regions.

4.2.1 RCC Observations and Discussion

In order to provide both context to the data and a preliminary validation of results as the work has progressed, observation and discussions with the West Midlands RCC (where Managed Motorways are operational), has been undertaken. Initial contacts and comments made are given below.

Chris Rushton – Tactical Analyst, West Midlands Intelligence Unit
A brief meeting was held with Chris on 05/11/09 where the limitations of RIF data and access protocol were discussed. Further discussion was held on 16/12/09 to discuss the potential for accessing data relating to the opening durations and closing durations of hard shoulder running in order to establish a statistically sound basis of timings distribution.

Jodie Rowbottom - Service Development Manager, West Midlands RCC
Meetings were held with Jodie on 27/11/09 and 11/12/09 to discuss the emerging findings of the data analysis and provide further context and direction to the scoping study. In particular Jodie highlighted the ongoing trialling of new technologies to reduce HSR related workload. These are discussed further in section 4.3.6.

Andy Butterfield – Team Leader, West Midlands Intelligence Unit
Telephone conversations were held with Andy Butterfield on 30/11/09 and 14/12/09, regarding access to historic data, including HSR opening and closing timings. The exact nature of what can be released by the HA for these study is yet to be clarified.

Bruce Nowell - Transport Operations and Technology, Mouchel
Following discussion with Jodie Rowbottom, written correspondence was held with Bruce Nowell of Mouchel who has been heavily involved in the development of operational policy relating to the ATM pilot on the M42 (J3a-7). Bruce's experience of ATM has proved the following comments:

- The presence of MM should allow an RCC to deal with more incidents more expeditiously - although in reality there will be fewer incidents and those that occur will generally be less severe as the available evidence suggests that accident rates and severity are lower on a Managed Motorway.

RCC Observations
Observations of control room operations were undertaken in November and December 2009; with the following key observations during both the opening and running of HSR.

HSR Opening
HSR opening was found to be undertaken predominantly by one controller, with others assisting when required. Hard Shoulder sweeps were conducted at 90 minute intervals, commencing well before HSR would be required. Initiation of HSR is through traffic flow, monitored by MIDAS, and occurs when traffic flows reaches a predetermined level; this is in the region of 4,000-5,000 vph depending on average speed.

When opening a section of Hard Shoulder, the controller would follow a set procedure 'contingency plan' for each link. This contingency plan includes:

- checking the hard shoulder was clear
- checking all contractors logged into to work on the link through WHIMS had been logged out or contacted to verify position

- ensure all vehicles in ERA had received a safety briefing
- Ensuring VMS are working correctly
- Checking CCTV to ensure the hard shoulder is clear (approximately 5 seconds per camera when clear)

The observed duration of the opening procedure varied from 4-20 minutes per link and depended on the length of link (no. of CCTV cameras to check), and the issue encountered during opening. Typical issues observed included:

- Contacting contractors to ensure they were off the network
- Deployment of on-road resource to ensure VMS working
- Ensuring vehicle in ERA had received a safety briefing

During HSR

While the level of activity in the control room did reduce once HSR was in operation, the number of ERA alerts increased. An ERA alert occurs when a vehicle enters the ERA and triggers an alert to the RCC. While the number of ERA alerts increased significantly, this was not due to vehicles stopping in the ERA, rather the alert being triggered by vehicle travelling close to the ERA and initiating the sensor.

Dave Page (Performance Delivery Manager)

Discussions with Dave Page primarily revolved around a recent (17/11/08) resource bid. The bid's aim was to investigate, evidence and recommend the considerations required for WM-RCC to successfully manage and deliver 'Birmingham Box Managed Motorways' Phase 1 and phase 2 (BBMM 1&2), whilst sustaining existing performance and 'Journey Time Reliability' on the remaining heavily trafficked, and lightly trafficked links of the West Midlands motorway network.

From this bid, the operation regime in terms of patrol route, shifts times and RCC resource was ascertained with preliminary analysis detailed in section 4.2.3.1.

4.2.2 RIF Data

Data analysis has been undertaken from the Timeline model (Task 633) to determine whether current incident management is adversely affected by Managed Motorway operations. A quantitative approach has been achieved through analysis of incident timelines data sets for Managed Motorway and non-Managed Motorway network sections.

Initial analysis of this dataset has included various phases of the incident management process, namely desk time, travel time and deployment time.

An initial analysis of desk times on Managed- and non-Managed sections of motorway is presented in figure 8, below. The results suggest that the desk times are slightly longer for Managed Motorway sections when the desk time is less than 3 minutes. Further discussion is provided in section 4.2.4 and considers this finding in the light of other information.

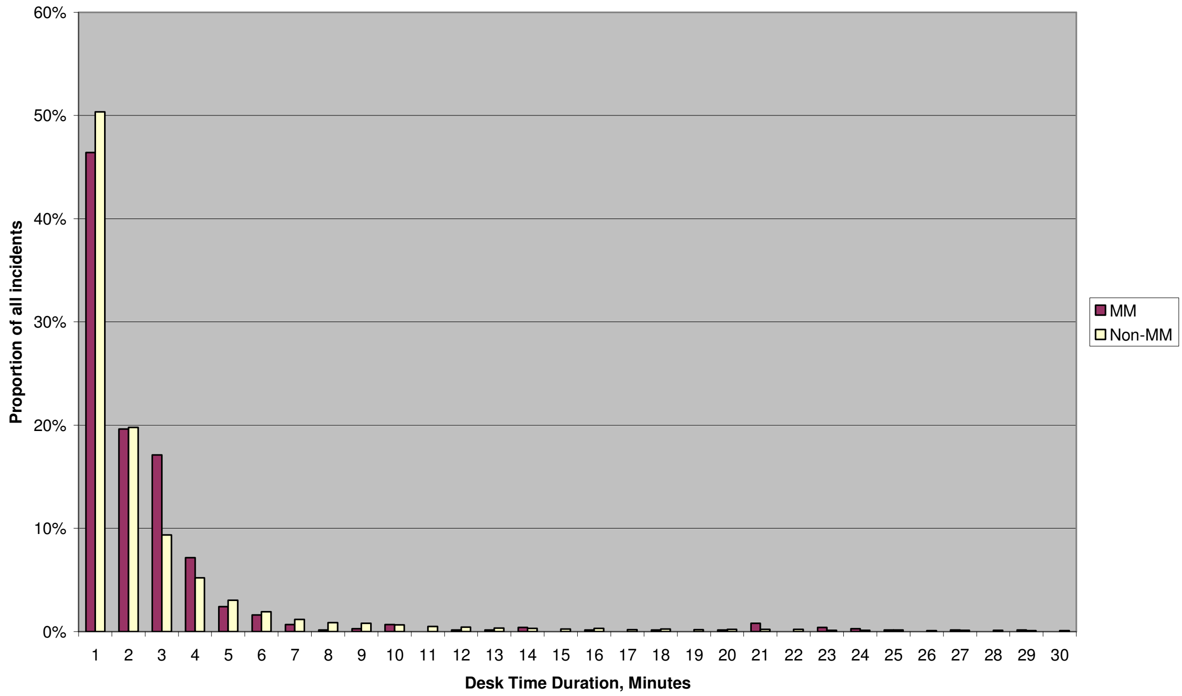

Figure 8 *Distribution of Desk Time duration for both Non-MM and MM sections*

An initial analysis of on-road travel is presented in figure 9. It should be noted that since between 35% (on non-MM) and 56% (on MM) of incidents are detect directly by the traffic officers during routine patrol, the analysis has only considered those events with travel time of greater than 20 seconds. Preliminary analysis indicates a marginally quicker response time for sections of Managed Motorway. This is especially marked when travel time is less than 5 minutes. While this result may be expected to some degree due to the greater density of patrol, as detailed in section 4.2.3.1, it must also be born in mind that traffic officer originated detection has been omitted. This omission results in approximately 65% of incidents being detected originally through the emergency services on non-managed sections, while CCTV accounts for over 70% detection on Managed Motorway. Therefore, although this provides an indication of the distribution of travel time between MM and non-MM, a question remains as to the time period between incident occurrence and detection. Further discussion is provided in section 4.2.4 and considers this finding in the light of other information.

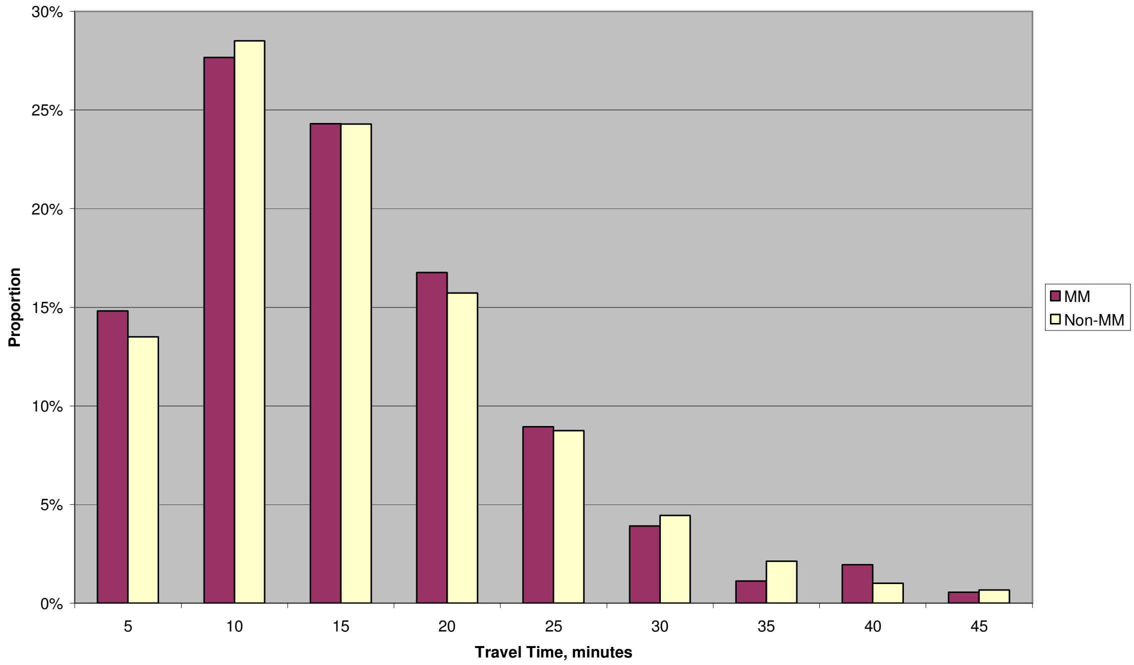

Figure 9 *Distribution of duration of TO Travel Time to Incident for both Non-MM and MM sections*

In terms of on-road deployment duration, figure 10 below suggests that a Non-MM exhibits a markedly greater proportion of durations less than 12 minutes, when compared to the MM section.

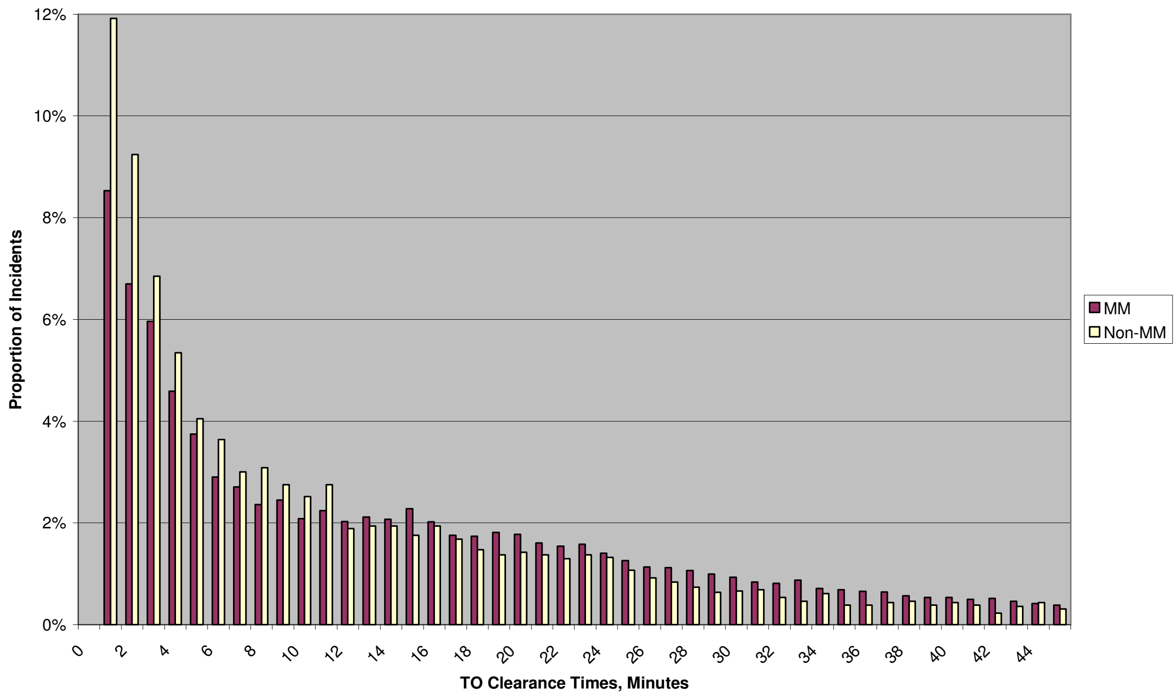

Figure 10 *Distribution of TO Clearance Time durations at Incident for both Non-MM and MM sections*

From a brief examination of the major incident types, as detailed in table 2, below, it may be observed that there is a much greater proportion of breakdowns in the live lane on the MM sections. As discussed in section 3, a 'breakdown – live lane' is assigned to all breakdowns in the MM section, except those occurring in the ERAs. A breakdown in a live lane as opposed to a break down in the hard shoulder is subject to various differences in policy, including; response grade and traffic management.

Closure Code Description	Proportion of Incidents	
	Non-MM	MM
Breakdown – Hardshoulder	44%	40%
Debris	15%	12%
Breakdown – in live lane	12%	27%
Road Traffic Collision - Damage Only	8%	6%
No Trace	7%	3%
Totals	**87%**	**89%**

***Table 2** Major incident types for both non-MM and MM sections*

In terms of average interval between incidents per carriageway km, figure 11 below, shows that while both MM and Non-MM sections reduce the number of incidents per hour over night, the diurnal variation is much lower on MM sections than Non-MM section. This highlights the increased rates of detection afforded by the installed monitoring technology. It should be noted that the majority of incidents over night on MM Sections are classified as breakdowns in the live lane.

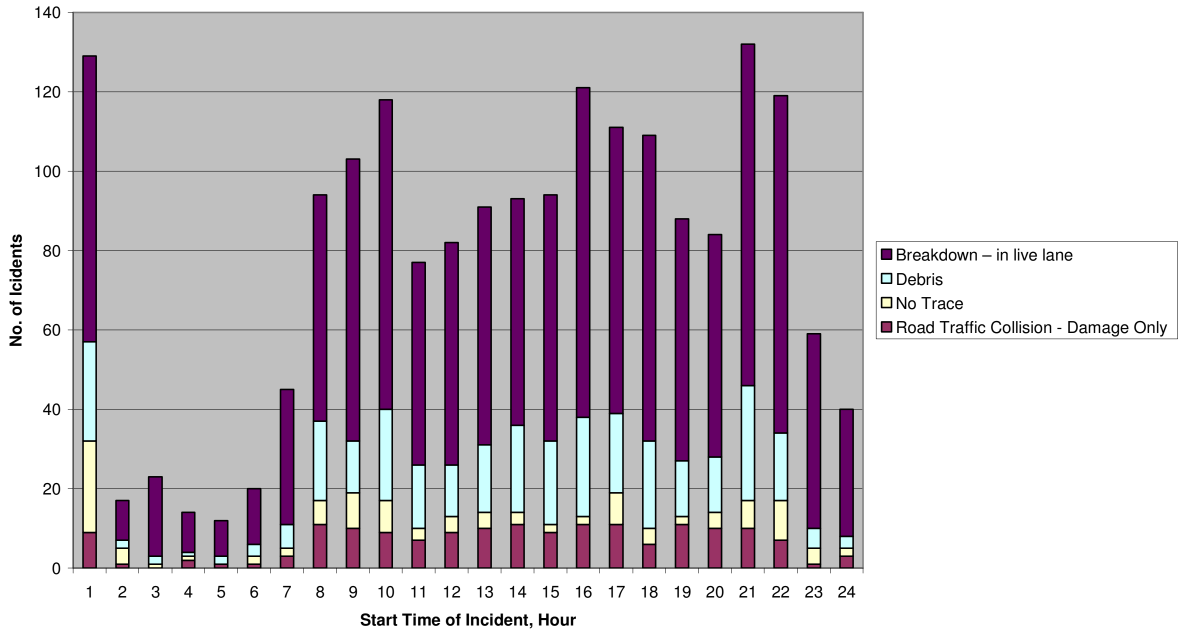

***Figure 11** Distribution of incidents by major incident classification with respect to start time for MM sections*

The On-road function of WMRCC are based at one of five outstations as detailed on figure 12. In terms of multiple concurrent incidents, Figure 13 shows that Quinton outstation (which manages the majority of HSR) exhibits predominantly moderate levels of multiple incidents compared with Quinton and Hilton Park. However, it is noted that the number of multiple incidents increases disproportionately in the Longbridge area around; 04:00-06:00 and 21:00-22:00. These are times just outside the am/pm peak patrolling where only one (night) patrol is presented per outstation area. Therefore, this is likely to be a result of the reduced rate of detection on the non-MM where the number of patrols has halved.

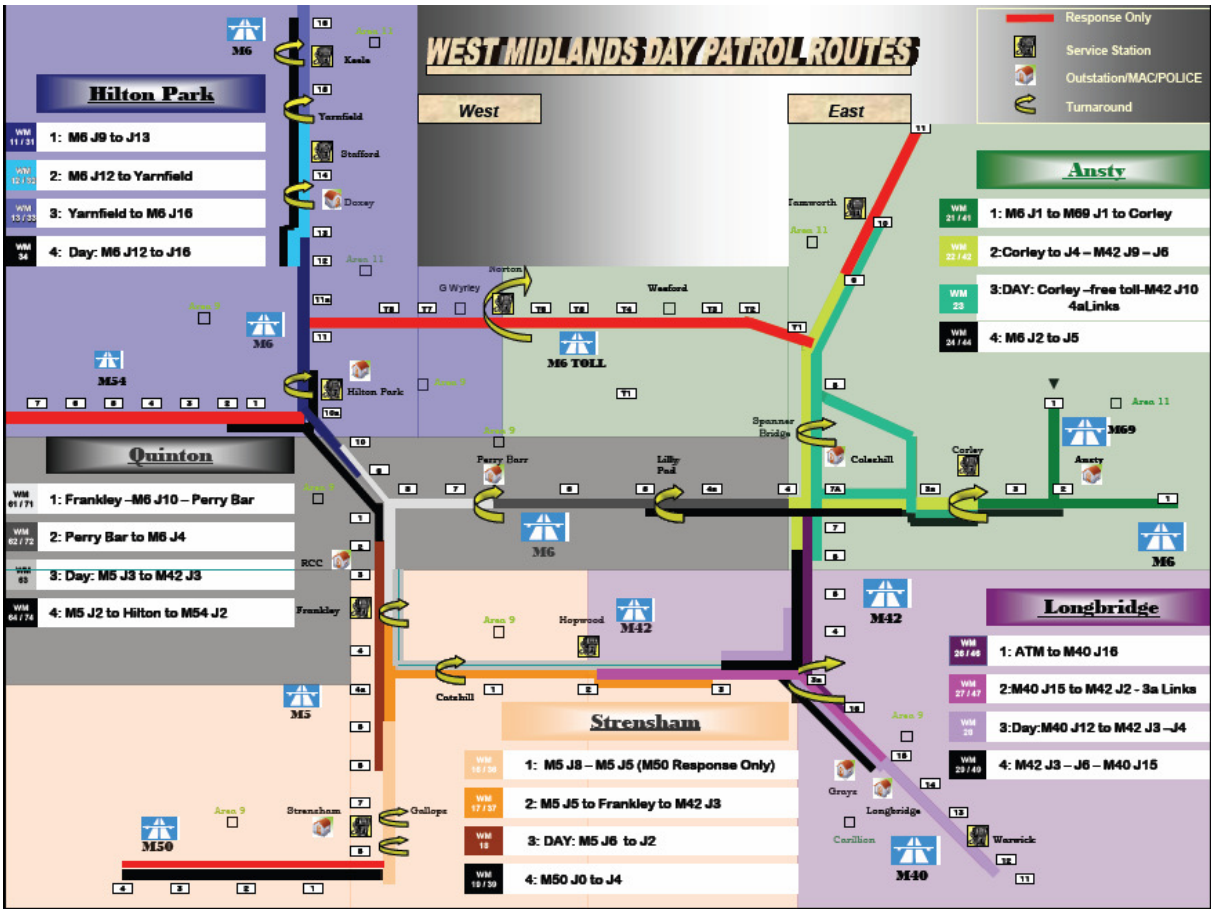

Figure 12 *Plan of West Midlands on-road day patrols*

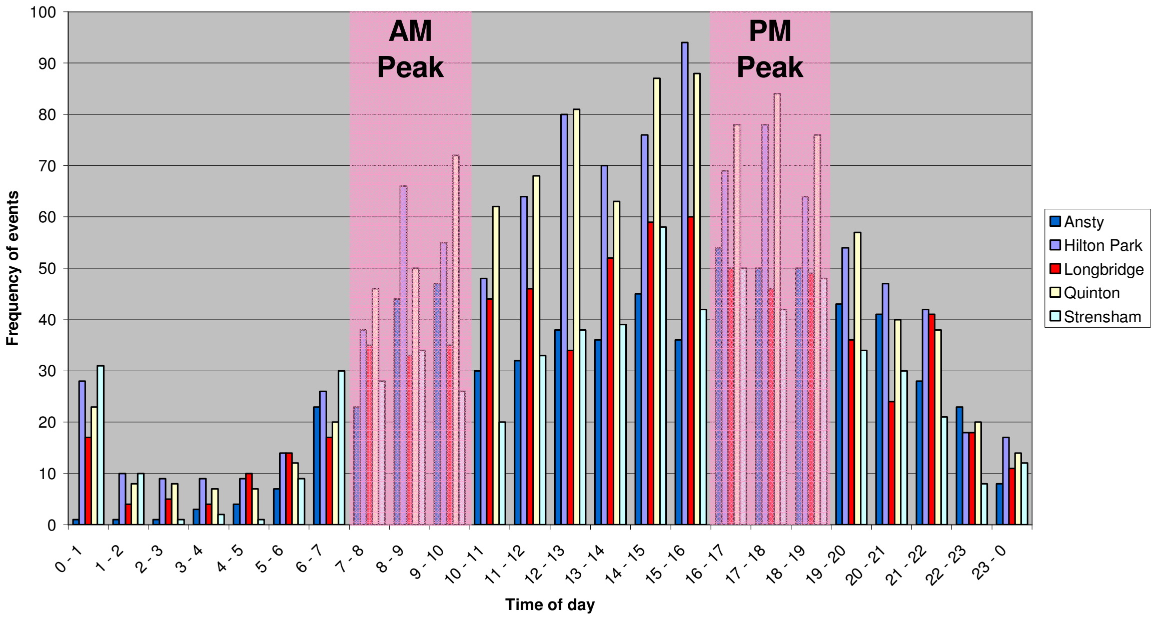

Figure 13 *Distribution of incidents with respect to start time when more than one incident is occurring for each outstation. NB: The MM section is predominantly resourced by Longbridge outstation*

4.2.3 National Schemes

The seven forthcoming Managed Motorway schemes as detailed in Table 3 below will require further analysis as detailed in section 4.3.3.

Month	Region	Scheme	From	To	Length, km
Nov 2011	NW	M60 Jct 8 - 12	12	19.7	7.7
Nov 2011	NW	M62 Jct 18 - 20	56.5	68.4	11.9
Jan 2012	WM	M6 Jct 5 - 8	178.1	191.2	13.1
Jul 2012	SW	M4 Jct 19 - 20	181.8	186.7	4.9
Jul 2012	SW	M5 Jct 15 - 17	131.8	141.5	9.7
Oct 2012	NE	M62 Jct 25 - 30	95.2	120.3	20.8
Dec 2012	E	M1 Jct 10 - 13	48.7	72.8	24.1
Jan 2013	NE	M1 Jct 32 - 35a	252.4	267.9	15.5

Table 3 *Outline details of the seven forthcoming Managed Motorway schemes*

WM-RCC M42 Pilot
(*based on document entitled, 'Resource Bid Birmingham Box ATM', dated 17/11/09*)
The following description of Control Centre and on-road resource has been extracted from the document entitled, 'Resource Bid Birmingham Box ATM', dated 17/11/09.

- The On-road function comprises of five outstations each with 3 Team Managers, managing a total of 137 Traffic Officers. This compliment allows the region to deploy 15 patrols in total, compromising of each outstation deploying x2 Early Patrols: 06:00-14:00, x1 day patrol: 11:00-19:00 and x2 late Patrols: 14:00 – 22:00.

- The Regional Control Centre function comprises of six Teams, each with a Team Manager managing a total of 48 Operators. Each team is accountable for resourcing two radio desks, three call handling desk, two desks for setting signals and a Team Managers desk. Radio desks are responsible for managing the on-road resources and deploying them appropriately and timely, call handling desks make and receive all calls into and out of the Regional Control Centre, these include Emergency Roadside Telephone calls. The signals desk is responsible for managing congestion, strategic incident management, opening and closing of ATM, diversion routes and setting signals for roadworks.

Grade	Current Number, Heads	Current Number, FTE	Baseline, FTE	FTE against, Baseline	Live Staff Request, Forms	Turnover, Heads	Starters, Heads
PB8	1	1	1	100%	0		
PB5	1	1	1	100%	0		
PB4	1	1	0	0%	0		
PB3	4	3.3	1	330%	0		
PB2	0	0	1	0%	0		
TM3	7	6.8	6	113%	1		
TM2	27	27	26	104%	1	0	0
TM1A	48	45.8	51	90%	5	2	1
TM1B	137	137	130	105%	3	1	2

Table 4 *West Midlands Traffic Officer Headcount in November 2008*

From knowledge of the patrol routes, as illustrated in figure 12 (section 4.2.2 - page 27), and resource information, the analysis has been undertaken to determine the density of patrol over different parts of the network as outlined in figure 14, below. The figure illustrates the density of patrols on the network between 11:00-19:00 when the day and evening shifts are in operation. It should be noted that the Pilot section between J3a-7 on the M42 received some of the highest densities of patrol in terms of no. of available patrols per km.

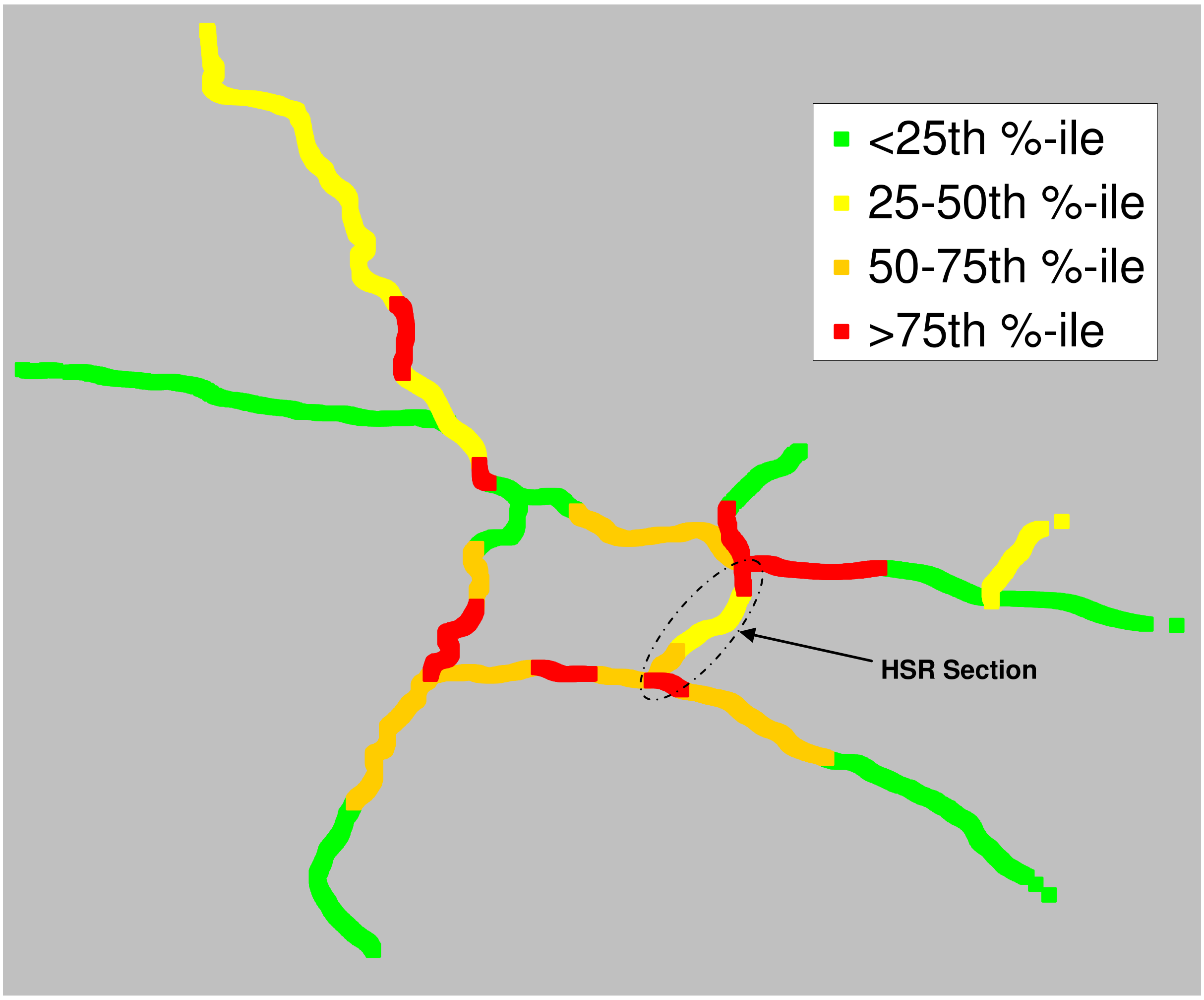

Figure 14 *Density of patrols on the network between 11:00-19:00 when the day and evening shifts are in operation*

4.2.4 Concluding Summary

A preliminary analysis of data taken from the Timeline model (Task 633) suggests:

- Slightly longer desk times on MM Sections with corresponding higher rates of CCTV detected incidents. Initial observations suggest that early indication of incidents through monitoring technology such as MIDAS or CCTV result in slightly longer desk times as the control room staff have to ascertain the location of the incident, and in many cases can do so themselves with the use of CCTV. While this may lengthen desk times, it is likely to reduce the use of on-road resources through better targeting of deployment in terms of:
    1. whether on-road resource is actually required, and
    2. more accurate locating of incidents thereby reducing the need for on-road resource to locate the incident.

- Shorter travel time by on-road resource on MM Sections. This is likely to be function of greater patrolling density on the MM sections and better initial locating of incident by the control room staff.

- Greater deployment durations on MM Sections, likely due to the higher proportion of breakdown in live lanes experienced on MM Sections, with this classification requiring more time input from on-road resource due to policy requirements.

- Greater rate of incidents at night, primarily due to a greater proportion of breakdown in live lane being detected through monitoring technology at the RCC.

While these initial findings require further validation, they provide a platform on which to undertake further analysis which relates Traffic Flow and Patrol densities with intermediate performance measures, including timings, which would lead to more end user performance measures such as AVDs, as detailed in section 4.3.

4.3 Further Work

The preliminary scoping work has highlighted a number of outline trends on the MM Sections. Further work is likely to be beneficial in the following areas:

- Validation of preliminary findings
- Assessment of effect of equipment faults
- Incident analysis on future HSR schemes
- On-road observation
- Stakeholder Liaison/ Input into workload model
- Consider New Technologies

4.3.1 Validation of preliminary findings

In order to provide the required degree of confidence to the initial findings, further validation would be required in the following areas;

Confirm HSR Operating
Analysis of HALOGEN data and observations undertaken at WMRCC suggest that the initial assumptions regarding that HSR operating times require further refinement; with between 35-75% of links not being open during peak time due to either insufficient traffic demand or equipment faults.

Timings of Opening/ Closing Procedures
A more detailed analysis of timings of contingency plans would provide a statistically sound basis of timings distribution. Discussions with Jodie Rowbottom and Chris Rushton suggest that this data would be accessible from RIF. In addition, the effect on operator workload of the following may be assessed; errant WHIMS bookings (see section 4.2.1) and breakdowns in LBS1 and ERAs (section 3.2.1).

4.3.2 Assessment of effect of equipment faults

During observations it was found that a significant rate of equipment failure either:

- Prevented any attempt to open HSR
- Prevented the completion of HSR opening
- Required on-road intervention to complete HSR opening

Through analysis of both the National Faults Database and timings of opening codes, the effect on RCC and TO work load may be established.

4.3.3 Incident analysis on future HSR schemes

As detailed in Section 4.2.3, there are a number of HSR schemes being implemented in the near future. Analysis of their characteristics will be undertaken, in terms of length of Managed Motorway (Controlled and HSR sections), traffic flow (i.e. magnitude and % LGVs), lit versus unlit and any geographic factors. The study will, provide high level indicators relating to the probable level of resource required to maintain adequate incident management.

4.3.4 Input into Workload Model

Following discussions with Pete Martin and Gareth Tyler an analysis of incident on all prospective HSR schemes will be required. This analysis will include:

• Incident Type	debris (no rolling road block) debris (rolling road block) breakdown damage only incident Injury incident (divided into “slight/serious/killed” if possible) Other Incident Type - (as much breakdown of type as is possible)
• Day of week	Mon, Tue, etc….
• Time of Incident	Start time, finish time
• Carriageway location	Hard shoulder, live lane
• Time for TO to arrive	## min
• Time of TO attendance	## min
• TO required to tow to off network	Yes/No
• Emergency Services in attendance	Yes/No
• ISU in attendance	Yes/No

4.3.5 On-road Observation

To date RCC observation/ discussion have been limited to control room and management staff only. In order to gain a representative picture of TO operations, it will necessary to undertake observations and discussion with on-road staff. Initial discussion with Jodie Rowbottom indicates that this should be possible. In addition to confirming findings from the data analysis, it is hoped that an assessment is undertaken of the effect on the incident timeline should an incident occur when opening/ closing HSR.

4.3.6 Consider New Technologies

A number of trials of new technology are being planned/ undertaken within the WC-RCC region. An outline assessment of these technologies would be beneficial in terms of their effect on:

- the incident timeline
- TO work load
- Potential resource savings if current protocol/ procedures were revised.

APPENDIX B
RED-X (STOP) FURTHER INVESTIGATION OF COMPLIANCE DURING INCIDENTS

Safe roads, Reliable journeys, Informed travellers

HIGHWAYS AGENCY

Highways Consultancy Group – Highways Research Group

Incident Policy for Managed Motorways

WP 2002 - Red-X (STOP) Further Investigation of Compliance during Incidents

Task Reference: 076(1308)

Project Sponsor: Andrew Vigrass

Report Date: March 2010

Highways Consultancy Group Highways Research Group

This report is prepared by the Highways Consultancy Group/Highways Research Group (HCG/HRG). HCG/HRG is a Consortium of four core suppliers, namely Mott MacDonald, Scott Wilson, Owen Williams and CIRIA, supported by an extensive supply chain.

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A	March 2009	MJ Ogawa	AJ Poole	RJ Meekums	First Issue

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Executive Summary

Within Managed Motorway schemes, the hard shoulder is opened as a running lane during periods of congestion, and it has been recognised that this could have an effect on the following:

- Access of the 'first responder' to an incident
- The assigned incident type / classification which determine the response grade of the RCC staff, traffic officers and maintenance contractors.
- The ability of the RCC and Traffic Officers to manage one or more incidents at the same time as managing multiple Managed Motorways.

WP 2000 of this framework task is concerned with the assessment of incident access for incident responders when managed motorways are operational.

WP 2002 is a sub-task within WP2000, and aims to review incident response times on existing ATM/Managed Motorway schemes to assess the compliance levels associated with a Red-X (STOP) signal being activated immediately following an incident. This will be achieved by addressing the following objectives:

1. Determining the time at which the Red-X (STOP) signal was implemented following an incident
2. Quantifying how quickly traffic migrates from the hard shoulder to lane one
3. The level of congestion resulting so the responder is not able to access the incident quickly via the hard shoulder.

Objectives 1 and 2 have been addressed in a report issued in December 2009. This report summarises the key findings from objective 3, with a concluding discussion on how the findings can be applied to future managed motorway schemes.

The key findings from this report are summarised below:

- The hard shoulder was cleared within 10 minutes for 80% of the 102 incident days considered.
- However, there is often a time lag between the actual incident time and time the incident was reported to the RCC. Actual incident times were identified for 32 out of the 102 incidents studied. The hard shoulder cleared within 12 minutes from the actual incident time for 80% of these 32 incident days.
- 80% of the 102 incidents cleared within 4 minutes from the time at which the Red-X (STOP) signal was implemented, indicating that the implementation of the signal has a noticeable effect on the hard shoulder clearance times.

- The relationship between hard shoulder clearance times and traffic demand has been studied, however did not show clear correlation.
- The staggered implementation of the Red-X (STOP) (i.e. Red-X introduced on 2 or more consecutive gantries but at different times) has been studied in more detail to identify any differences from non-staggered implementation of the signal, however, no clear difference between the two datasets was observed.

It is to be noted that this study was limited to the M42-ATM section between the periods April 2008 and March 2009, where the original Managed Motorway design (i.e. lane gain/drop arrangement at junctions) was in place. Therefore it is important to consider the following factors when considering other Managed Motorway schemes:

- Type of operational regime
- Gantry spacing
- Distance between Emergency Refuge Areas (ERAs)
- Traffic demand and flow profiles
- Road geometry

The relationship between the Red-X signals and types of incidents and ERA utilisation (i.e. whether the incident vehicle uses the ERA or breaks down on the hard shoulder or live lane) has not been investigated within this report. It is possible that these two factors may have an effect on traffic behaviour, as breaking down on the live lane could potentially create a larger bottleneck on the carriageway.

1 Introduction

1.1 Background

Managed Motorway schemes aim to address congestion issues and improve Journey Time Reliability by utilising the existing road space and a set of advanced Intelligent Transport Systems applications. Under Managed Motorway operations, the hard shoulder is opened as a running lane during periods of congestion. It has been recognised that this could have an effect on the following:

- Access of the 'first responder' to an incident.
- The assigned incident type / classification which determine the response grade of the RCC staff, traffic officers and maintenance contractors.
- The ability of the RCC and Traffic Officers to manage one or more incidents at the same time as managing multiple Managed Motorways.

1.2 Objectives

WP 2000 of this framework task is concerned with the assessment of incident access for incident responders when Managed Motorways are operational.

WP 2002 is a sub-task within WP2000, and aims to review incident response times on existing ATM/Managed Motorway schemes to assess the compliance levels associated with a Red-X (STOP) signal being activated immediately following an incident. This will be achieved by addressing the following objectives:

1. Determining the time at which the Red-X (STOP) signal was implemented following an incident
2. Quantifying how quickly traffic migrates from the hard shoulder to lane one
3. The level of congestion resulting so the responder is not able to access the incident quickly via the hard shoulder.

Objectives 1 and 2 have been addressed in a report issued in December 2009 [Ref 1]. This report summarises the key findings from objective 3, with a concluding discussion on how the findings can be applied to future Managed Motorway schemes.

1.3 Site Description

Figure 1.1 shows the Managed Motorway schemes which are found near Birmingham. This study covers the M42 Active Traffic Management (ATM) section which was introduced by the Highways Agency (HA) in September 2006 on the M42 between Junctions 3A and 7. The Birmingham Box Managed Motorway Phase 1 scheme was introduced on the M6 between Junctions 4 to 5 in 30th November 2009; however this is not within the scope of this study.

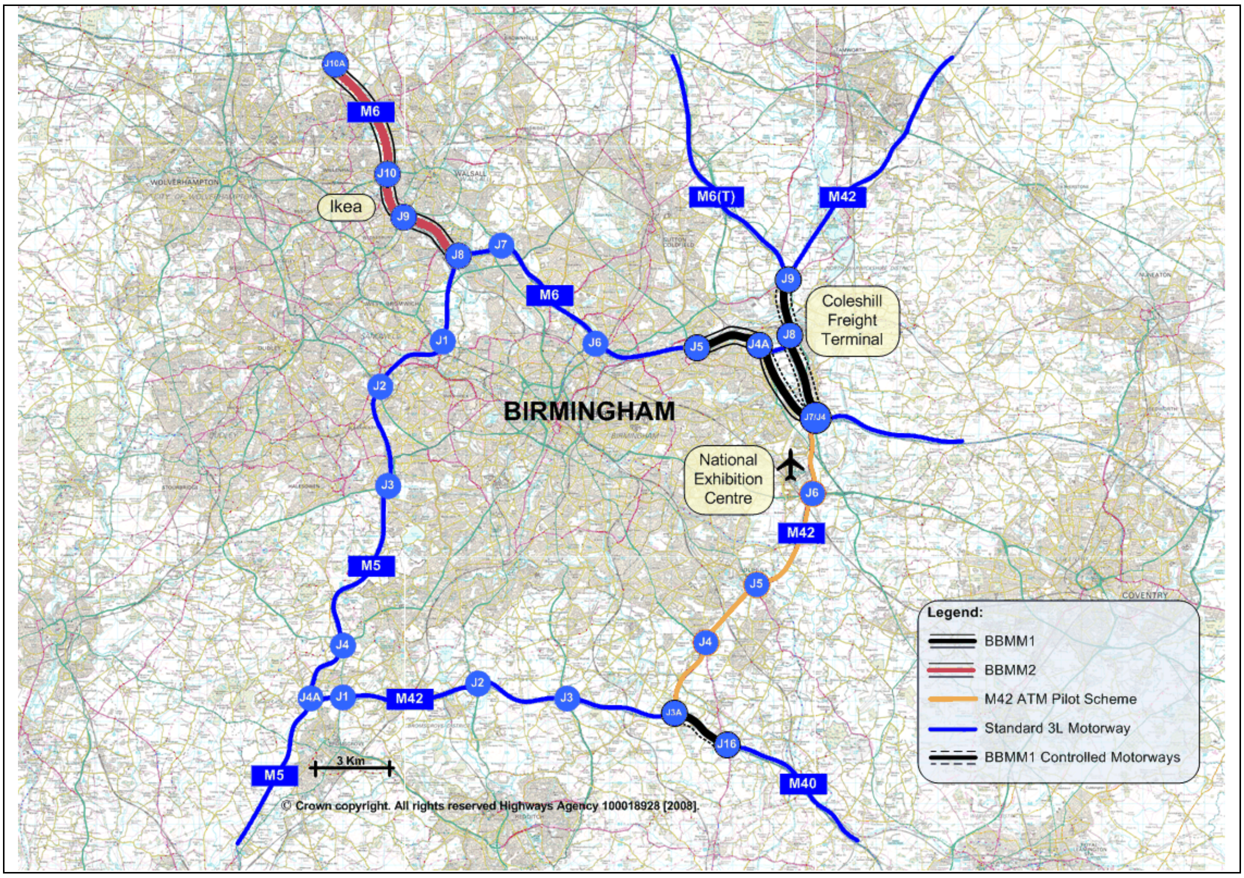


Figure 1.1: Managed Motorway Sites near Birmingham

2 Evaluation Approach

2.1 Dataset

An assessment of the traffic conditions during incidents recorded between April 2008 and March 2009 has been carried out. Following the assessments undertaken within WP2001, a list of incidents covering this period was derived. The list identifies incidents which occurred on the M42-ATM section on weekdays causing lane closures between 07:30-09:45 and 16:00-18:45 which also involved emergency services and/or Incident Support Units (ISU) attending the scene.

To undertake the analysis, the 102 incident days studied within a previously issued report [Ref 1] were considered. These days were filtered from the available dataset based on the following criteria:

- Hard shoulder running (HSR) was in operation prior to the Red-X (STOP) signal being introduced
- A Red-X (STOP) signal was implemented following the incident

Table A.1 in **Appendix A** lists the days which were used for the assessment of this study.

2.2 Assessment Indicators

Minute-by-minute speed and flow data were processed from MIDAS loop data for each lane, and the following parameters were studied to form this report:

- Frequency of hard shoulder clearance times
- Effect of 15 minute traffic flows on hard shoulder clearance times
- Effect of staggered implementation of the Red-X(STOP) signal (i.e. Red-X introduced on 2 or more consecutive gantries but at different times) to clearance times

3 Data Analysis

3.1 Frequency Analysis of Hard Shoulder Clearance Times

A frequency analysis of hard shoulder clearance times has been undertaken to understand how quickly the hard shoulder is clear of traffic from:

- the recorded time of incident
- the time of incident
- the time the Red-X (STOP) signal(s) was implemented

As identified in the previous report [Ref 1], the average hard shoulder clearance times from the recorded time of incidents was 7 minutes. **Figure 3.1** presents the frequency of hard shoulder clearance times from the recorded time of incident. The hard shoulder was cleared within 10 minutes for 80% of the incident days.

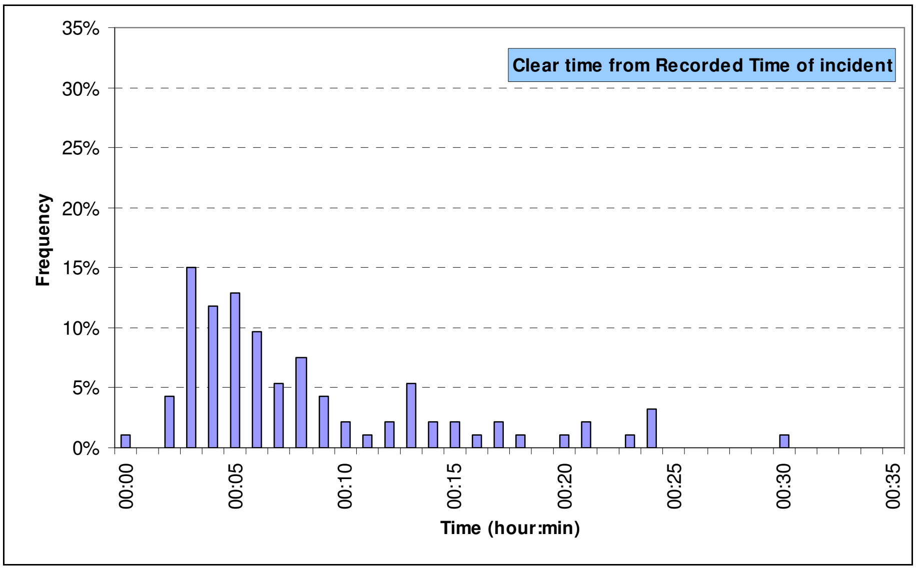


Figure 3.1: Frequency of Clearance Time from Recorded Time of Incident

However, it has been recognised that there is often a time lag between the actual incident time and time the incident was reported to the RCC (this is discussed further in **Section 3.4)**. Of the 102 incidents which were studied within this report, the actual incident times were identified for 32 incident days. From this dataset, the average time difference between the actual time of incident and recorded time of incident was found to be 3 minutes.

Figure 3.2 presents the frequency of hard shoulder clearance times from the actual time of incident, for the 32 incidents where the actual incident times were identified. The figure shows hard shoulder clearance times are longer when compared to the findings in **Figure 3.1**, with the hard shoulder clearing within 12 minutes for 80% of the 32 incidents considered.

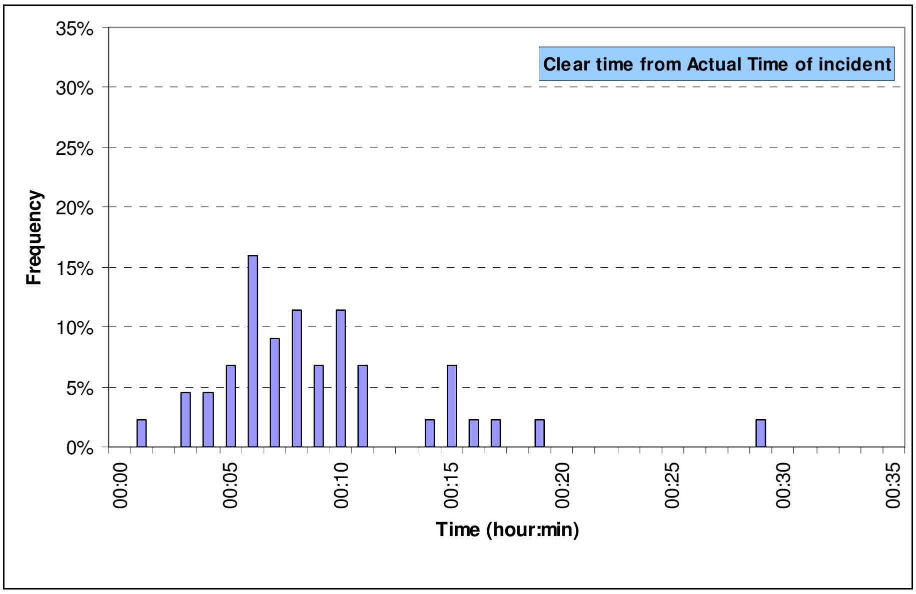


Figure 3.2: Frequency of Clearance Time from Actual Time of Incident

Figure 3.3 presents the frequency of hard shoulder clearance times from the time of Red-X (STOP) implementation for the 102 incident days considered. The result shows that 80% of the 102 incidents were cleared within 4 minutes from the time at which the Red-X (STOP) signal was implemented. This indicates that the implementation of the signal has a noticeable effect on the hard shoulder clearance times, regardless of their clearance times from the time of incident.

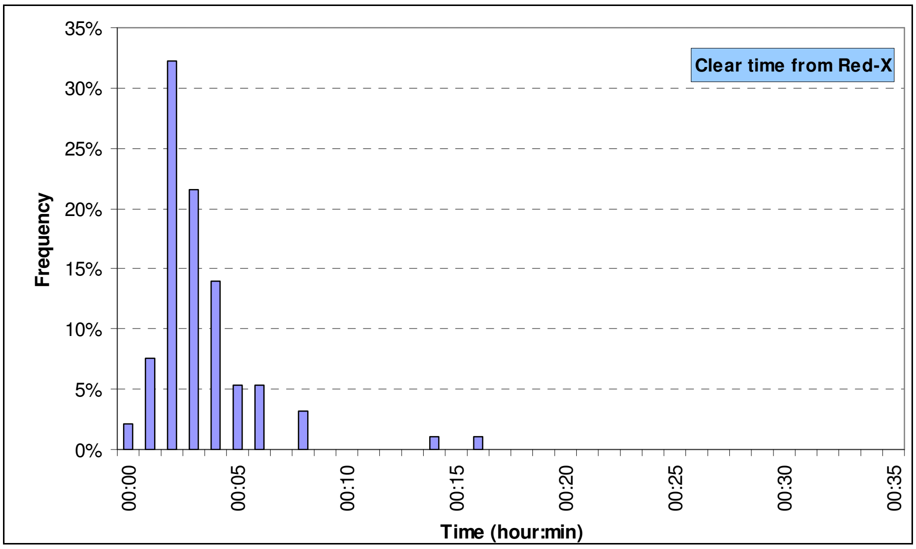


Figure 3.3: Frequency of Clearance Time from Time of Red-X(STOP) Implementation

However, there may be other factors which have an influence on this result, as there were also a number of days within the dataset which showed that the hard shoulder was not cleared during the time of incident and therefore not included within the figures above.

3.2 15 minute traffic flows prior to the incident

It has been recognised that the operation of HSR could have an effect on the access of the 'first responder' to an incident. Deterioration in speed and/or flow breakdown is typically observed following the occurrence of an incident, hence there is a concern that responder vehicles may not be able to access the scene via the hard shoulder.

The relationship between hard shoulder clearance times and traffic demand has been studied to see whether there was a relationship between the traffic demand and hard shoulder clearance times following the occurrence of an incident. The results are presented in the figures below:

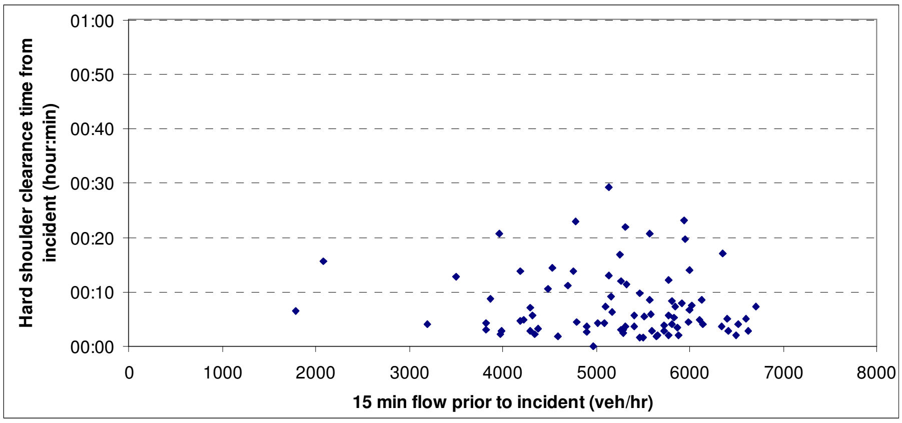


Figure 3.4: Hard shoulder clearance time from recorded time of incident vs. 15 min carriageway flow (veh/hr) prior to incident

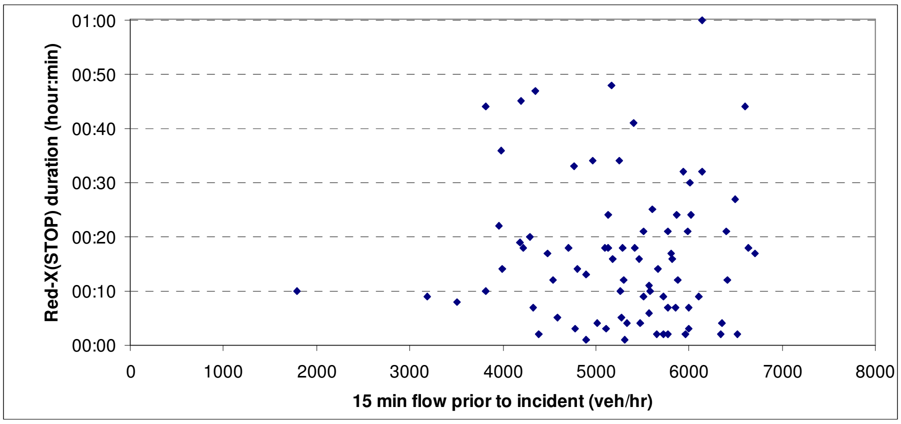


Figure 3.5: Red-X duration vs. 15 min carriageway flow (veh/hr) prior to incident

The data does not show any clear correlation between flow and clearance times.

3.3 The effect of staggered implementation on hard shoulder clearance times

The staggered implementation of the Red-X (STOP) (i.e. Red-X introduced on 2 or more consecutive gantries but at different times) has been studied in more detail as such incidents appeared to have a longer Red-X duration when compared to incidents with non-staggered implementation (i.e. Red-X signals introduced only on one gantry or on 2 or more consecutive gantries simultaneously) of the signal.

The 15 minute traffic flows prior to the time of an incident studied within **Section 3.2** were examined as a part of this analysis, by further classifying the data into staggered and non-staggered implementation of the Red-X (STOP) signal.

Figure 3.6 presents the relationship between the hard shoulder clearance times from the recorded time of incident against 15 minute flows prior to the incident for the two cases. Non-staggered implementation of the Red-X (STOP) signal shows a larger variation in hard shoulder clearance times from the recorded time of incident when compared to the staggered case. However, the data does not show any clear difference between the two datasets overall when considering the 15 minute flows observed prior to the occurrence of an incident.

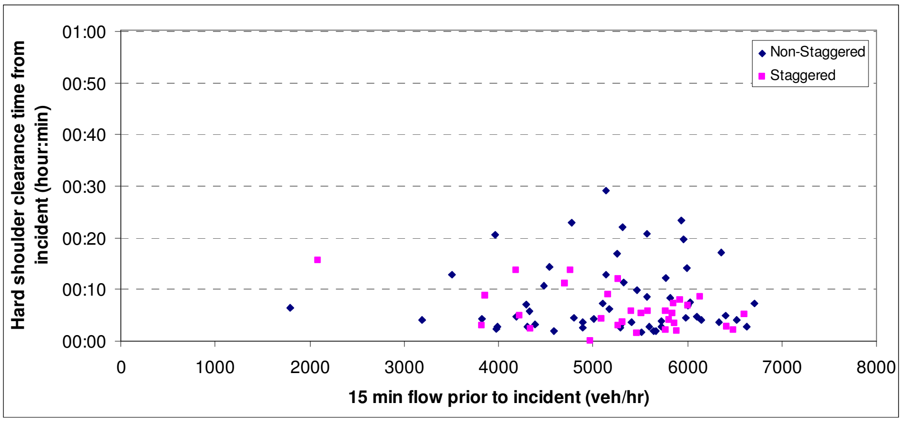


Figure 3.6: Hard shoulder clearance time from recorded time of incident vs.15 min flows [non-staggered/staggered]

Figure 3.7 presents the relationship between Red-X (STOP) duration and 15 minute flows prior to the recorded time of incident. The results show that staggered implementation required a longer duration of the Red-X (STOP) to be displayed, as identified in the previous report [Ref 1]. This is likely to be due to changes during the incident that required additional Red-X (STOP) signals to be set. However, similar to the hard shoulder clearance times from the recorded time of incident shown in **Figure 3.6**, the data does not show any clear difference between the two datasets when considering the 15 minute flows observed prior to the occurrence of an incident.

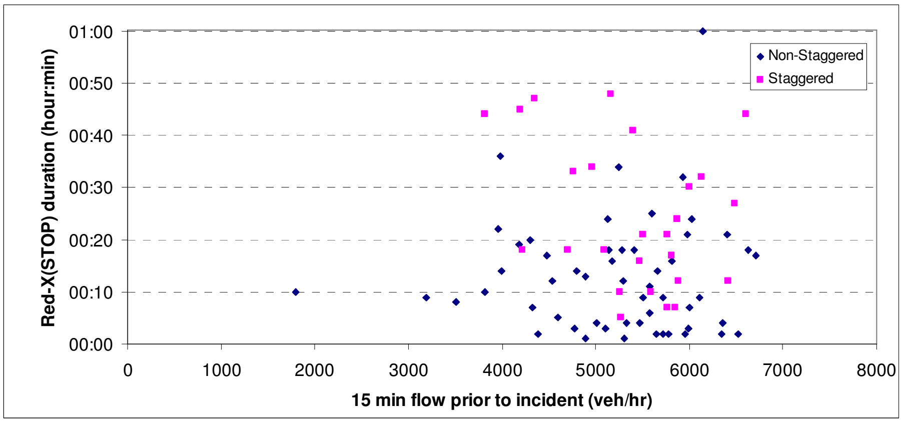


Figure 3.7: Red-X duration vs. 15 min flows [non-staggered/staggered]

Staggered implementation of the Red-X (STOP) may also be due to a number of other factors, none of which have been studied in this report, including:

- Incident type
- Complexity of incident (e.g. if a vehicle needs to be moved from the live carriageway to a safe place on the hard shoulder or ERA)
- Changes in traffic conditions during an incident

3.4 Other Findings

3.4.1 Incident Detection

It has been recognised that there is often a time lag between the actual incident time and time the incident was reported to the RCC. Determining the actual time of incident was done within a separate task [Ref 2] by studying lane-by-lane speed and flow profiles along the M42-ATM section. It was considered that a noticeable drop in speed and/or flow would be observed following an incident.

Of the 102 incidents which were studied within this report, the actual incident times, based on the methodology above, were identified for 32 days. From this dataset, the average time difference between the actual time of incident and recorded time of incident was found to be 3 minutes.

Although the occurrence of an incident was identifiable for a number of incident days, this was not necessarily the case for all incidents due to the following reasons:

- Not all incidents had an impact on the carriageway flow or speed.
- The M42 was already experiencing queue conditions prior to the incident (e.g. congestion, other incidents downstream, etc).
- Speed restrictions were put in place, however, the reasons for its implementation are not always known. Hence it was not possible to distinguish whether this was due to an incident or simply in response to the traffic demand.

3.4.2 Congestion created by the closure of a lane(s) during an incident

The time taken for traffic speeds to recover following an incident was examined. However, during some incidents, the queue appears to propagate upstream with time, therefore the impact of the incident is not limited to the location at which it occurred. A more in-depth study is required to understand this issue.

4 Discussion

4.1 Summary of Results

Further analysis has been undertaken on 102 incident days to gain a better understanding of hard shoulder clearance times following the occurrence of an incident. The key findings from this report are summarised below:

- The hard shoulder was cleared within 10 minutes for 80% of the 102 incident days considered.
- However, there is often a time lag between the actual incident time and time the incident was reported to the RCC. Actual incident times were identified for 32 out of the 102 incidents studied. The hard shoulder cleared within 12 minutes from the actual incident time for 80% of these 32 incident days.
- 80% of the 102 incidents cleared within 4 minutes from the time at which the Red-X (STOP) signal was implemented, indicating that the implementation of the signal has a noticeable effect on the hard shoulder clearance times.
- The relationship between hard shoulder clearance times and traffic demand has been studied, however did not show clear correlation.
- The staggered implementation of the Red-X (STOP) (i.e. Red-X introduced on 2 or more consecutive gantries but at different times) has been studied in more detail to identify any differences from non-staggered implementation of the signal, however, no clear difference between the two datasets was observed.

4.2 Limitation to this study and recommendations

It is to be noted that this study was limited to the M42-ATM section between the periods April 2008 and March 2009, where the original Managed Motorway design (i.e. lane gain/drop arrangement at junctions) was in place. Therefore it is important to consider the following factors when considering other Managed Motorway schemes:

- Type of operational regime: The introduction of new operational regimes such as Through Junction Running and Through Merge Running may have an effect on lane utilisation and its impact to incidents is yet unknown.
- Gantry spacing: The average spacing between gantries on the M42-ATM section is 500 m; however, future Managed Motorway schemes will have gantries with greater spacings. This may have an effect on how road users respond to the Red-X (STOP) signal.

- Distance between Emergency Refuge Areas (ERAs): Similar to gantries, the average spacing between ERAs on the M42-ATM section is 500 m; however, future Managed Motorway schemes will have ERAs with greater spacings. This may possibly have an effect on how road users utilise the hard shoulder during an incident.

- Traffic Demand: Other roads may have very different traffic demand and flow profiles compared to the M42, which may have an impact on the operation of Managed Motorway schemes.

- Road Geometry: Although flow levels did not appear to be a contributing factor within this study, hard shoulder utilisation may vary from one site to another as other roads may have different link lengths, horizontal and vertical alignments.

The relationship between the Red-X signals and types of incidents and ERA utilisation (i.e. whether the incident vehicle uses the ERA or breaks down on the hard shoulder or live lane) has not been investigated within this report. It is possible that these two factors may have an effect on traffic behaviour, as breaking down on the live lane could potentially create a larger bottleneck on the carriageway being considered.

5 References

1. Mott MacDonald (2009). *Incident Policy for Managed Motorways: WP2002 – Red-X (STOP) Compliance during Incidents*, Task Ref: 076(1308), December 2009.

2. Mott MacDonald (2010). *Investment Decision Model: Occurrence to Detection using MIDAS Data,* Task Ref: (029(1308)MOTT), March 2010.

Appendix A List of Incident Days

Date	Time Incident Recorded (hour:min)	Geo Ref	Direction	A/B/J/K/L/M	Link/Jct
09/04/2008	09:03	6408	NB	A	J5/6
11/04/2008	08:38	--	SB	L	J4
15/04/2008	16:50	6449	SB	B	J7
16/04/2008	08:15	6410	NB	A	J5/6
17/04/2008	08:28	6362	NB	A	J4/5
17/04/2008	16:29	6364	SB	B	J5
17/04/2008	16:59	6398	NB	A	J5/6
17/04/2008	17:27	--	SB	B	
21/04/2008	07:42	6302	SB	B	J4/3A
21/04/2008	17:24	6300	SB	B	J4/3A
24/04/2008	17:19	6440	NB	A	J6/7
25/04/2008	09:08	6347	NB	A	J4/5
06/05/2008	17:46	6377	NB	A	J5/6
14/05/2008	09:20	6410	NB	A	J5/6
15/05/2008	17:14	6409	SB	B	J6/5
15/05/2008	17:16	6402	SB	B	J6/5
18/06/2008	18:14	6306	NB	A	J3A/4
19/06/2008	08:13	6434	NB	A	J6/7
25/06/2008	18:15	6395	SB	B	J6/5
27/06/2008	08:00	6343	NB	A	J4/5
02/07/2008	09:08	6401	NB	A	J5/6
10/07/2008	18:06	6435	NB	A	J6/7
11/07/2008	07:52	6343	NB	A	J4/5
15/07/2008	09:18	6309	SB	B	J4/3A
17/07/2008	08:17	6352	NB	A	J4/5
18/07/2008	16:12	6315	NB	A	J3A/4
21/07/2008	17:12	6421	NB	A	J6
29/07/2008	08:36	6381	SB	B	J6/5
30/07/2008	07:57	6322	NB	A	J3A/4
30/07/2008	08:07	6331	NB	A	J4
01/08/2008	16:18	6347	SB	B	J5/4
04/08/2008	08:41	6352	NB	A	J4/5
04/08/2008	17:19	6354	SB	B	J5/4
12/08/2008	17:56	6442	NB	A	J6/7
14/08/2008	18:27	6450	SB	B	J7
21/08/2008	17:46	6437	SB	B	J7/6
03/09/2008	17:42	6440	NB	A	J6/7
04/09/2008	16:19	6360	SB	B	J5/4
09/09/2008	09:08	6359	NB	A	J4/5
10/09/2008	16:17	6305	SB	B	J4/3A
17/09/2008	08:22	6449	NB	A	J6/7
19/09/2008	07:53	6389	NB	A	J5/6
26/09/2008	16:26	6307	SB	B	J4/3A
26/09/2008	18:21	6373	NB	A	J5
01/10/2008	08:36	6315	SB	B	J4/3A
09/10/2008	17:11	6316	NB	A	J3A/4
09/10/2008	17:41	6357	SB	B	J5/4
14/10/2008	17:09	6306	SB	B	J4/3A
16/10/2008	07:44	6404	SB	B	J6/5
17/10/2008	17:47	6412	SB	B	J6/5
21/10/2008	09:07	6319	SB	B	J4/3A
21/10/2008	17:01	6356	SB	B	J5/4
22/10/2008	18:13	6357	SB	B	J5/4
24/10/2008	08:29	6339	NB	A	J4
24/10/2008	09:01	6399	NB	A	J5/6
24/10/2008	18:02	6399	SB	B	J6/5
03/11/2008	18:04	6357	SB	B	J5/4
04/11/2008	18:21	6312	NB	A	J3A/4
05/11/2008	18:03	6356	NB	A	J4/5
05/11/2008	18:08	6345	SB	B	J5/4
06/11/2008	07:54	6317	SB	B	J4/3A
06/11/2008	18:18	6344	NB	A	J4/5
13/11/2008	09:04	6434	NB	A	J6/7
13/11/2008	16:25	6441	SB	B	J7/6
14/11/2008	16:42	--	NB	K	J4
14/11/2008	18:09	6346	SB	B	J5/4
14/11/2008	18:15	6357	SB	B	J5/4
17/11/2008	18:39	6411	NB	A	J5/6
18/11/2008	18:14	6388	SB	B	J6/5
26/11/2008	16:13	6351	SB	B	J5/4
27/11/2008	18:29	6452	NB	A	J6/7
28/11/2008	16:21	6312	SB	B	J4/3A
03/12/2008	18:03	6318	SB	B	J4/3A
04/12/2008	17:27	6401	SB	B	J6/5
05/12/2008	16:26	6406	NB	A	J5/6
05/12/2008	16:33	6410	NB	A	J5/6
11/12/2008	17:54	6354	SB	B	J5/4
18/12/2008	16:05	6441	NB	A	J6/7
08/01/2009	16:22	6341	SB	B	J5/4
09/01/2009	09:29	6414	NB	A	J5/6
15/01/2009	17:02	--	SB	L	J4
15/01/2009	18:36	--	SB	M	J6
16/01/2009	16:32	6413	SB	B	J6/5
21/01/2009	16:46	6443	SB	B	J7/6
22/01/2009	08:20	6306	SB	B	J4/3A
26/01/2009	09:37	6395	NB	A	J5/6
28/01/2009	08:46	6351	NB	A	J4/5
30/01/2009	08:03	6418	NB	A	J6
04/02/2009	08:03	6314	SB	B	J4/3A
04/02/2009	16:20	--	NB	K	J6
09/02/2009	17:45	6339	NB	A	J4
19/02/2009	18:17	6357	SB	B	J5/4
23/02/2009	08:02	6341	NB	A	J4/5
24/02/2009	08:52	6450	NB	A	J6/7
10/03/2009	09:26	6351	SB	B	J5/4
13/03/2009	08:17	6340	NB	A	J4/5
19/03/2009	16:01	6435	NB	A	J6/7
20/03/2009	16:20	6377	NB	A	J5/6
26/03/2009	16:37	6404	NB	A	J5/6
26/03/2009	18:30	6358	SB	B	J5/4
30/03/2009	16:58	6416	NB	A	J5/6
30/03/2009	17:50	6407	NB	A	J5/6

Table A.1: List of Incident Days

APPENDIX C
TOS INCIDENT RELATED WORKLOAD ANALYSIS FOR M42 DHS PILOT SECTION AND COMPARISON SECTIONS

The data used for the timings analysis herein is taken from RIF data for the period, 01/04/08-31/03/09 in the West Midlands region. The section from J3a-7 on the M42 was compared with Hard Shoulder plus 3 lane sections with similar AADTs (Annual Average Daily Traffic), namely; M42: J7-9 both carriageways, and M6: J2-3, J4a-5, J6-8, J10-10a both carriageways.

The data was further sorted by closure code description and the frequency distribution of the following timings ascertained; desk time, travel time, response time and clearance time.

The timings for the frequency distribution analysis were grouped into 60 second intervals for between 0 - 40,020 seconds (i.e. 11 hours, 7 minutes). NB: There are a small number of incidents with reported times greater than 40,020 seconds, these have not been used for this analysis.

The following incident types have been analysed for use in the TOS resource workload model.

- BH: Breakdown - Hard shoulder
- BL: Breakdown – in live lane
- HS1 : Hard Shoulder - Medical Emergency
- HS2 : Hard Shoulder - Tacho Break (HGV)
- HS3 : Hard Shoulder - Drive Away
- HS4 : Hard Shoulder - Other Non Legal use
- NT : No Trace
- OB1: Debris
- OI : Observation - infrastructure problem
- OP : Observation - police/ VOSA intelligence.
- PR : Police Response
- TC1: Road Traffic Collision - Damage Only
- TC2 : Road Traffic Collision - Minor Injury
- TC3 : Road Traffic Collision - Serious Injury

For purposes of illustration, the distribution of pertinent timings for incident types BH, BL, OB1 and TC1 have been included in the figures herein. These four incident types account for approximately 73% and 64% of all incidents reported on the M42:J3a-7 and comparison sections, respectively.

Figure C1: Distribution of Desk Times for Breakdowns in the Live Lane

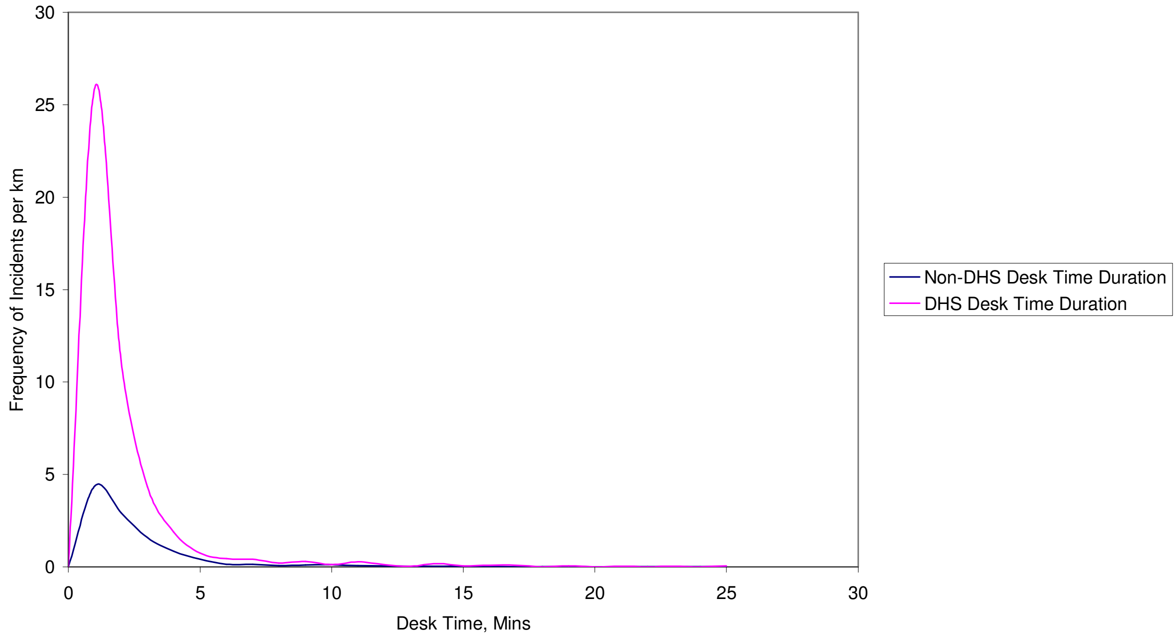


Figure C2: Distribution of Travel Times for Breakdowns in the Live Lane

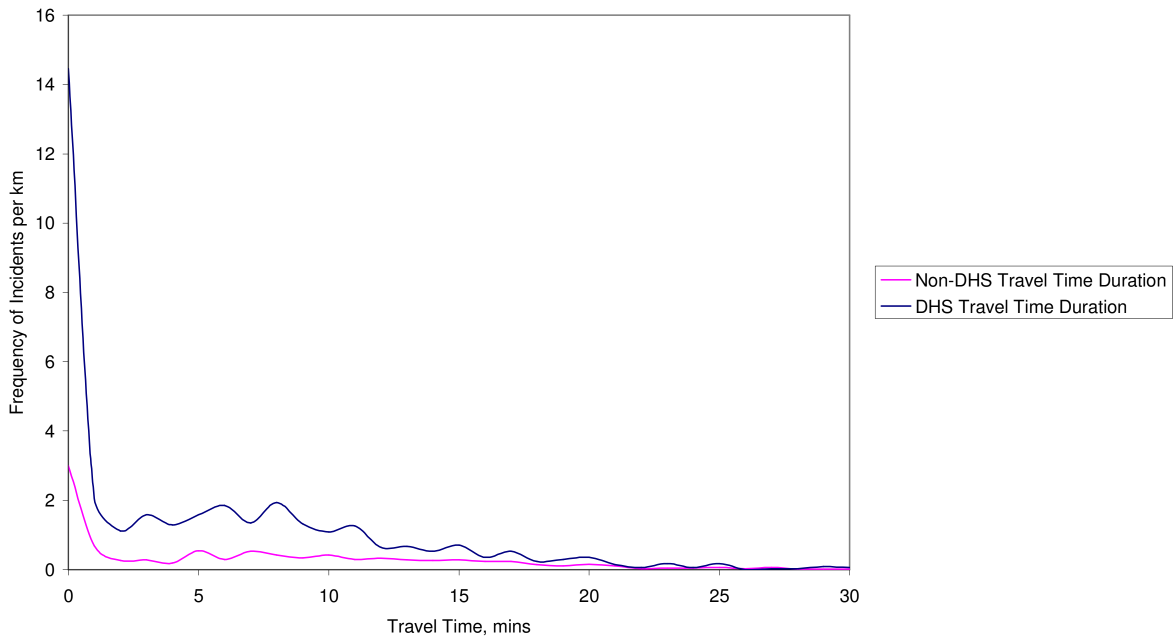


Figure C3: Distribution of Clearance Times for Breakdowns in the Live Lane

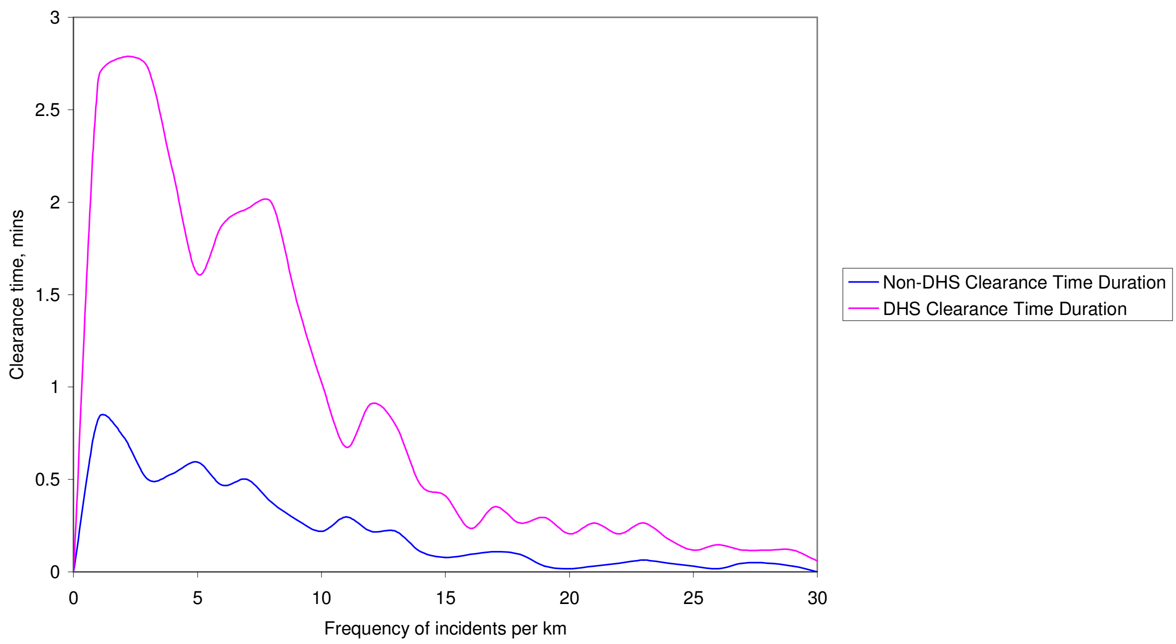


Figure C4: Distribution of Desk Times for Breakdowns on the Hard Shoulder

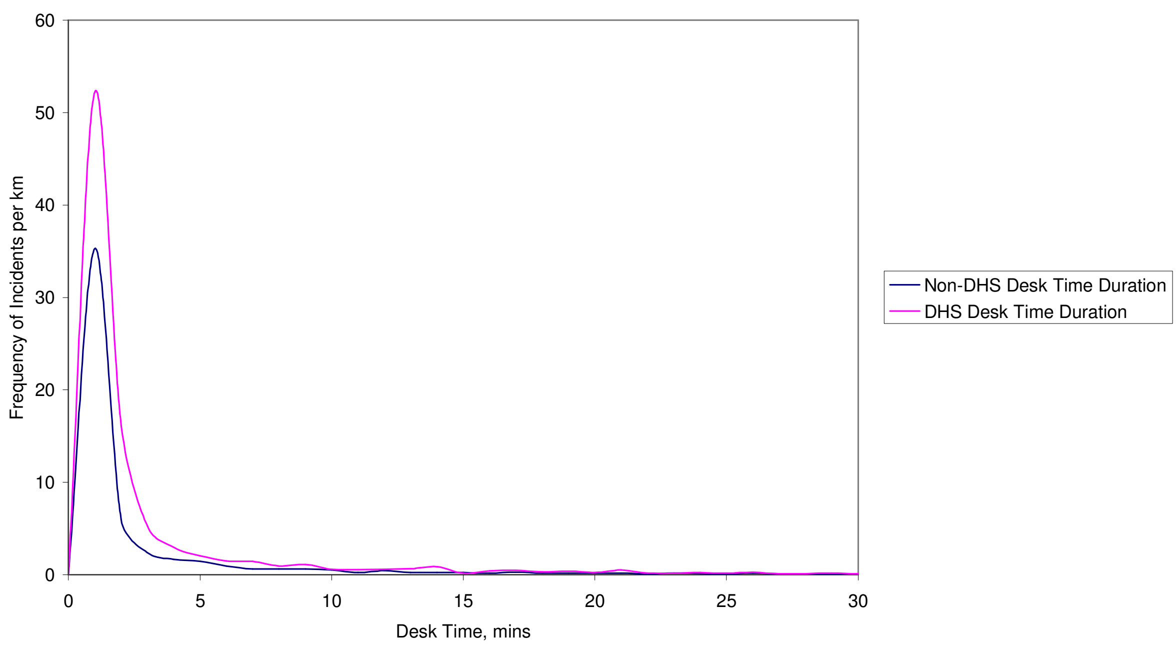


Figure C5: Distribution of Travel Times for Breakdowns on the Hard Shoulder

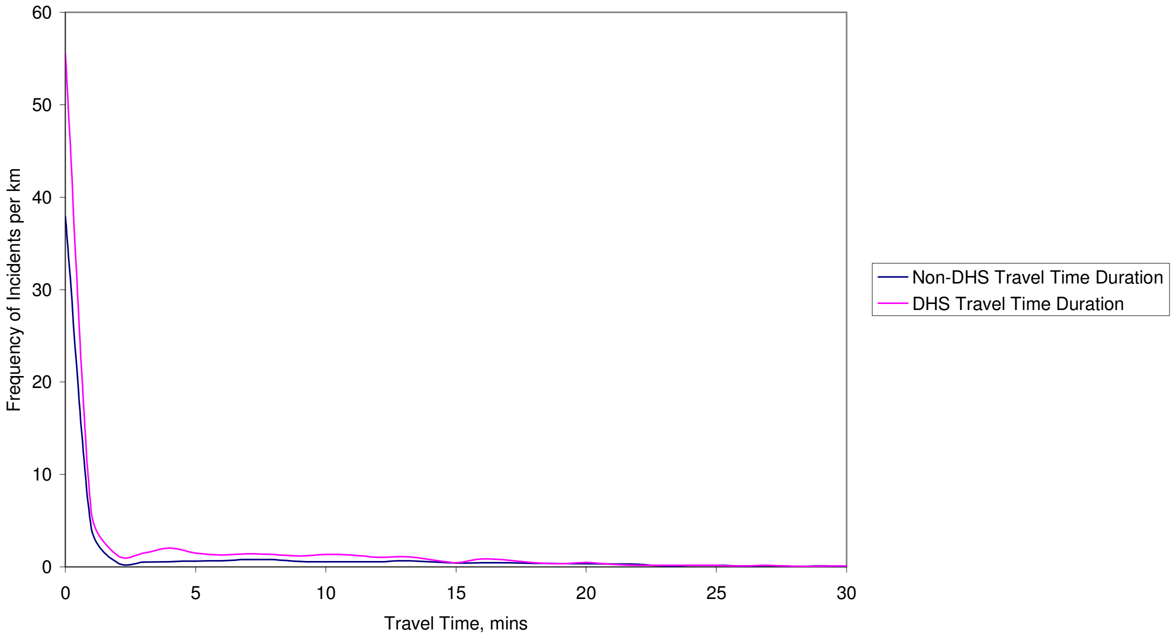


Figure C6: Distribution of Clearance Times for Breakdowns on the Hard Shoulder

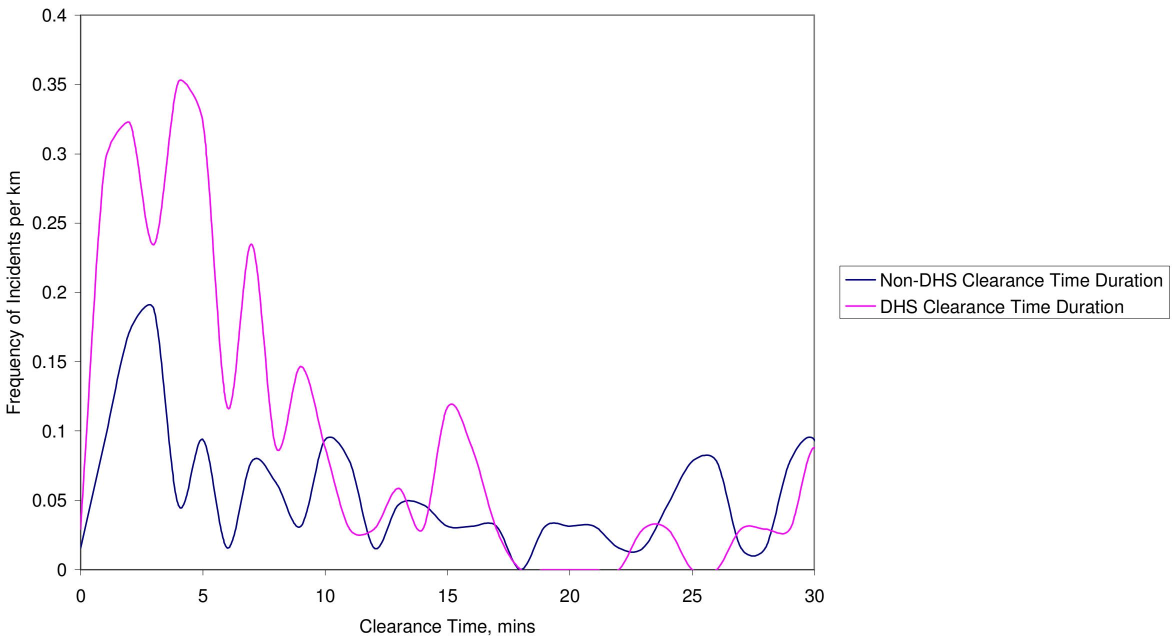


Figure C7: Distribution of Desk Times for Debris

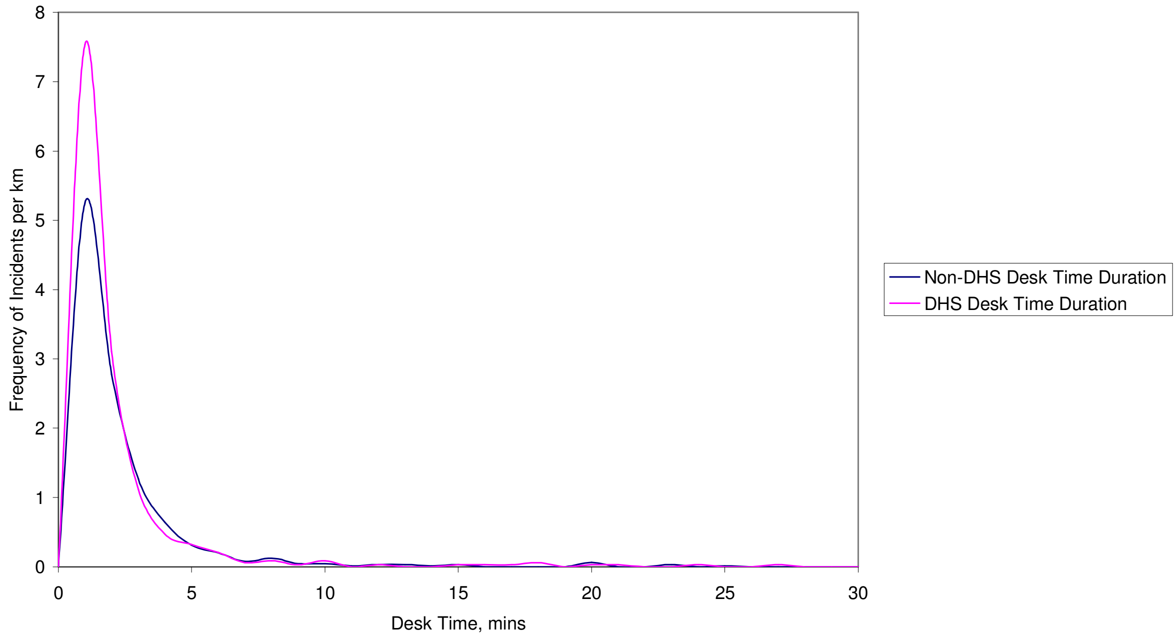


Figure C8: Distribution of Travel Times for Debris

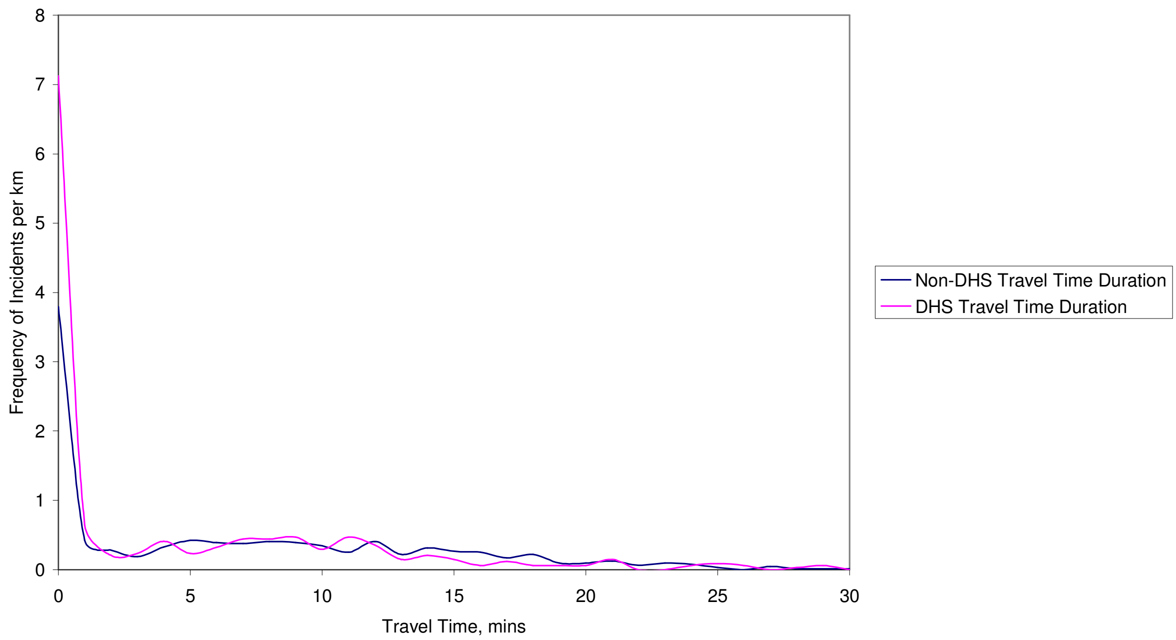


Figure C9: Distribution of Clearance Times for Debris

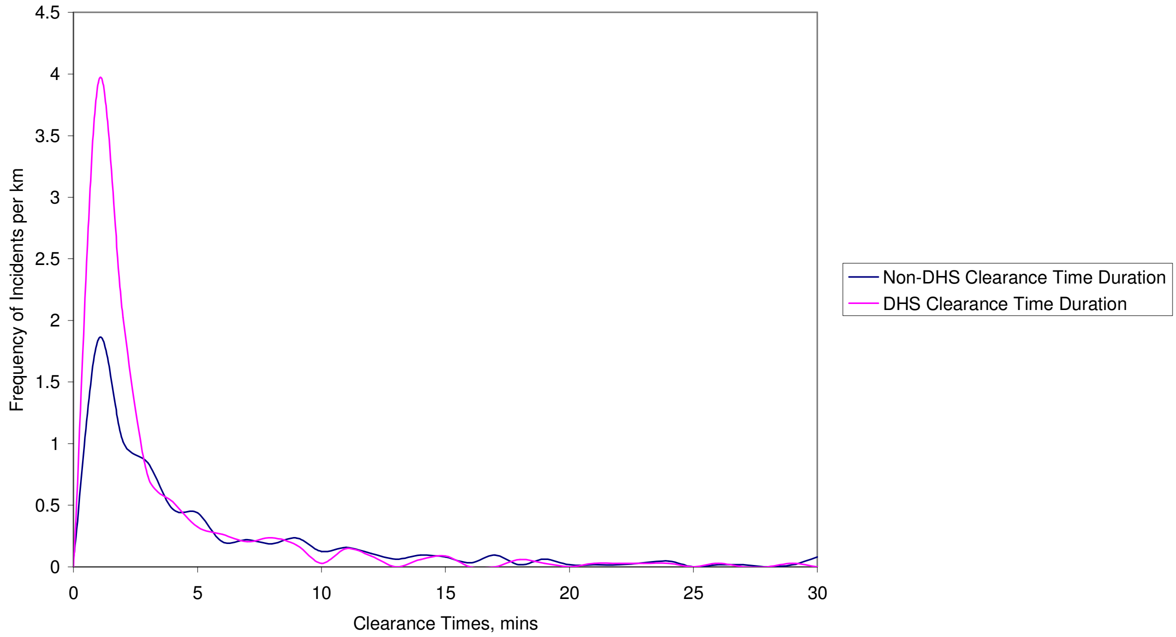


Figure C10: Distribution of Desk Times for Road Traffic Collision - Damage Only

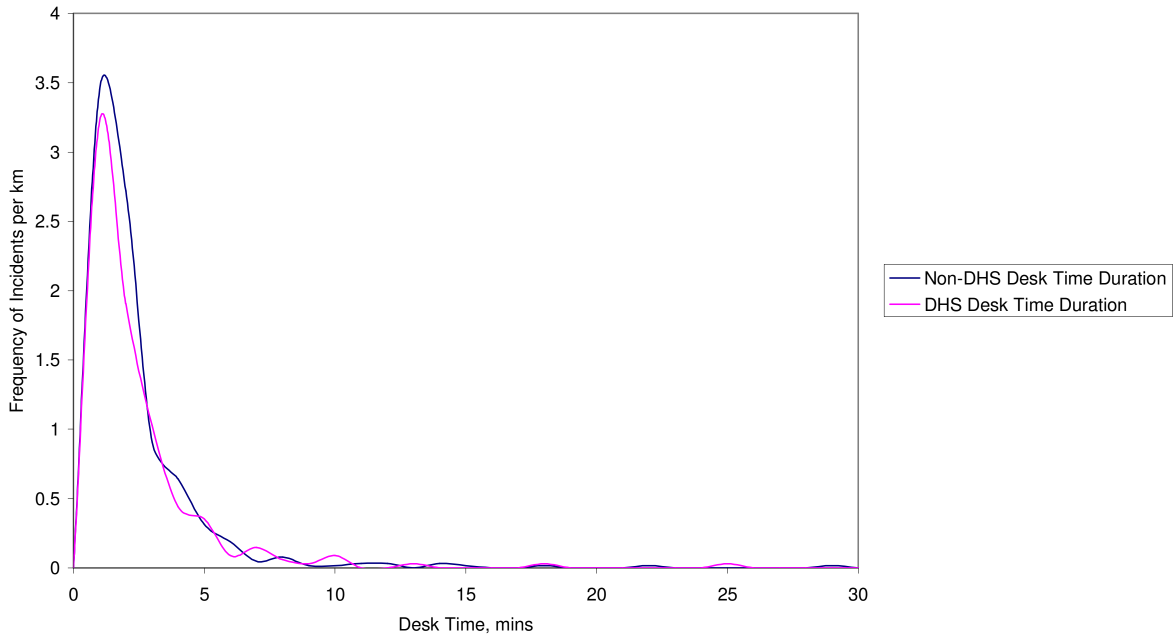


Figure C11: Distribution of Travel Times for Road Traffic Collision - Damage Only

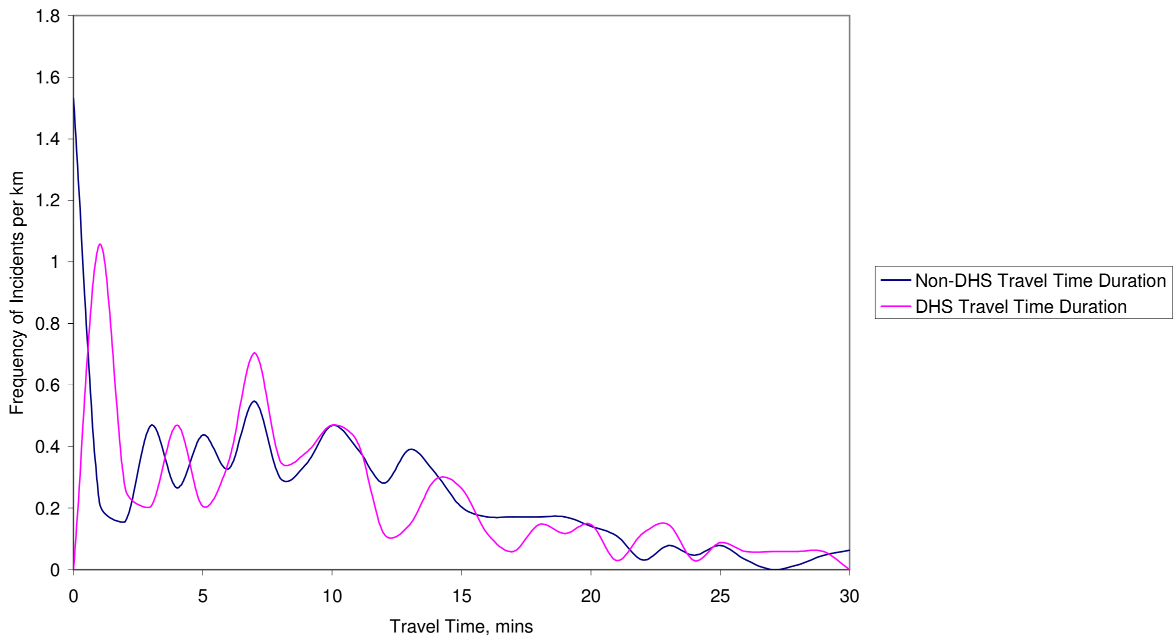
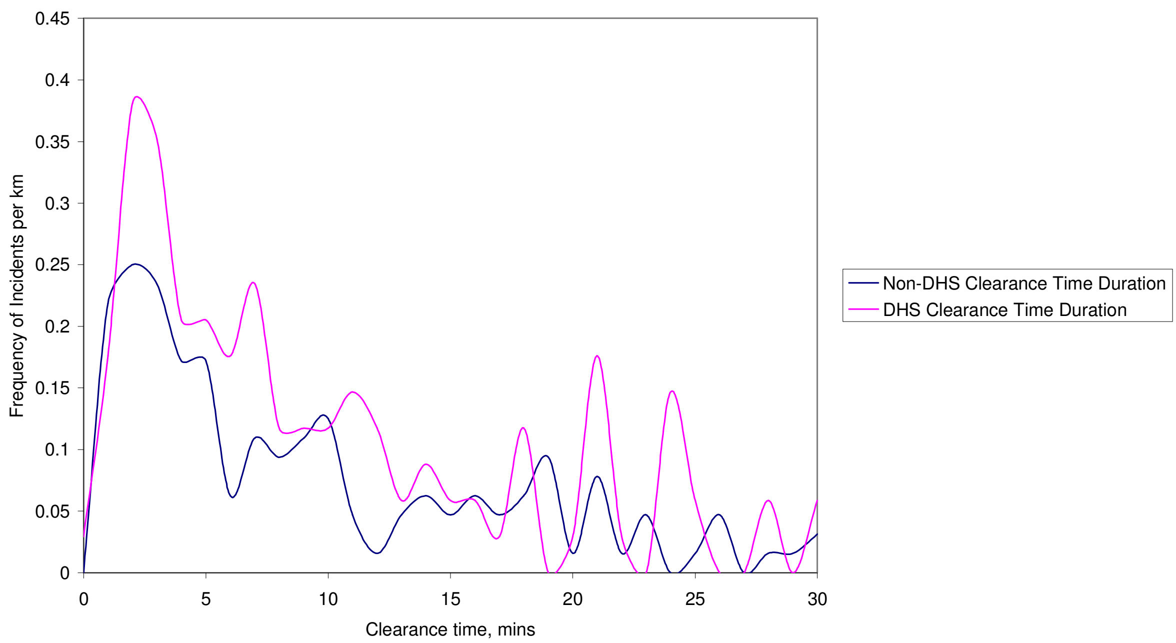


Figure C12: Distribution of Clearance Times for Road Traffic Collision - Damage Only



APPENDIX D
INCIDENT ANALYSIS FOR THE SEVEN INITIAL MM SCHEMES

The data used for the timings analysis herein is taken from RIF data for the period, 01/01/09-31/12/09 from the seven forthcoming national schemes:

- M60 Jct 8 - 12
- M62 Jct 18 - 20
- M6 Jct 5 - 8
- M4 Jct 19 - 20/ M5 Jct 15 - 17
- M62 Jct 25 - 30
- M1 Jct 10 - 13
- M1 Jct 32 - 35a

The incidents on each section have been classified by:

- final closure code
- all 7 days of the week/ weekdays
- start time of incident (the incident have been classified into one of three groups of incident start times; 06:00-14:00, 14:00-22:00, or 22:00-06:00)

The figures in the following tables are the number of incidents of the incident classifications as listed in the first two columns, per shift given in the second row and for the specific scheme given the first row.

The units for figures in the tables herein are 'number of incidents per shift.'

Scheme	M60 Jct 8 - 12			M62 Jct 18 - 20			M6 Jct 5 - 8			M4 Jct 19 - 20/ M5 Jct 15 - 17			M62 Jct 25 - 30			M1 Jct 10 - 13			M1 Jct 32 - 35a		
Final Closure Code	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00
AL1 : Abnormal Load - Unescorted	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.011	0.008	0.000	0.003	0.003	0.000	0.008	0.005	0.000
AL2 : Abnormal Load - Escorted	0.003	0.000	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.005	0.000	0.016	0.003	0.005	0.005	0.011	0.000	0.005	0.022	0.025
AN : Animal on network	0.022	0.027	0.019	0.068	0.033	0.011	0.022	0.008	0.000	0.016	0.019	0.000	0.066	0.038	0.019	0.041	0.025	0.011	0.022	0.014	0.014
AV1 : Abandoned Vehicle - Not Suspicious	0.003	0.011	0.011	0.003	0.014	0.008	0.011	0.019	0.003	0.019	0.016	0.011	0.044	0.060	0.025	0.033	0.049	0.036	0.027	0.008	0.014
AV2 : Abandoned Vehicle - Suspicious	0.000	0.003	0.000	0.003	0.000	0.003	0.000	0.000	0.003	0.003	0.000	0.000	0.003	0.011	0.000	0.000	0.003	0.003	0.003	0.000	0.003
BH : Breakdown - Hardshoulder	0.507	0.737	0.112	0.997	1.123	0.255	2.707	3.444	0.879	1.151	1.526	0.236	3.005	3.310	0.737	3.085	3.671	1.014	1.074	1.288	0.225
BH1 : Breakdown – offside tyre change	0.049	0.063	0.003	0.088	0.068	0.027	0.005	0.016	0.005	0.027	0.019	0.003	0.241	0.208	0.044	0.274	0.244	0.082	0.121	0.104	0.011
BH2 : Breakdown – vulnerable person present	0.011	0.025	0.005	0.014	0.016	0.005	0.008	0.016	0.000	0.000	0.008	0.000	0.047	0.107	0.019	0.036	0.063	0.014	0.025	0.044	0.008
BH3 : Breakdown - out of fuel	0.022	0.060	0.025	0.058	0.093	0.030	0.011	0.027	0.005	0.011	0.036	0.003	0.153	0.208	0.033	0.112	0.189	0.085	0.055	0.082	0.025
BL : Breakdown – in live lane	0.279	0.441	0.058	0.211	0.222	0.041	0.537	0.690	0.153	0.099	0.148	0.003	0.608	0.805	0.082	0.244	0.282	0.082	0.353	0.463	0.063
C : Congestion	0.003	0.027	0.000	0.008	0.003	0.000	0.003	0.014	0.003	0.307	0.195	0.000	0.003	0.003	0.000	0.011	0.011	0.003	0.005	0.003	0.000
C1 : Non-incident congestion	0.008	0.008	0.000	0.003	0.000	0.000	0.003	0.000	0.000	0.156	0.096	0.000	0.016	0.008	0.000	0.008	0.003	0.003	0.019	0.019	0.003
C2 : Incident-related congestion	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.008	0.008	0.000	0.000	0.008	0.000	0.005	0.003	0.000	0.003	0.005	0.000
D10 : Infrastructure defect	0.005	0.008	0.011	0.008	0.008	0.000	0.011	0.008	0.008	0.005	0.005	0.003	0.003	0.003	0.000	0.019	0.022	0.003	0.003	0.003	0.003
E10 : Event (Off Network) Planned	0.003	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.003	0.000	0.000	0.000	0.000	0.008	0.000
E20 : Event (Off Network) - Unplanned	0.030	0.025	0.003	0.005	0.008	0.005	0.041	0.055	0.003	0.000	0.005	0.000	0.110	0.118	0.044	0.011	0.022	0.008	0.096	0.099	0.016
F10 : Vehicle Fire	0.003	0.011	0.000	0.003	0.014	0.003	0.016	0.022	0.014	0.014	0.014	0.000	0.022	0.041	0.005	0.022	0.041	0.008	0.038	0.014	0.005
F20 : Off road fire (e.g. verge fire)	0.003	0.003	0.000	0.000	0.005	0.000	0.008	0.008	0.000	0.000	0.000	0.000	0.003	0.008	0.000	0.000	0.003	0.000	0.000	0.011	0.000
FP : Found Property	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
H99 : Emergency Assistance required	0.000	0.003	0.003	0.000	0.000	0.000	0.016	0.003	0.003	0.003	0.003	0.000	0.000	0.000	0.003	0.000	0.005	0.000	0.000	0.000	0.000
HS1 : Hard Shoulder - Medical Emergency	0.003	0.003	0.000	0.003	0.003	0.000	0.019	0.041	0.003	0.011	0.000	0.003	0.027	0.022	0.005	0.022	0.025	0.011	0.005	0.019	0.003
HS2 : Hard Shoulder - Tacho Break (HGV)	0.000	0.000	0.000	0.011	0.000	0.000	0.005	0.030	0.005	0.000	0.003	0.000	0.011	0.005	0.005	0.011	0.016	0.019	0.016	0.014	0.000
HS3 : Hard Shoulder - Drive Away	0.003	0.005	0.000	0.005	0.003	0.003	0.011	0.022	0.000	0.016	0.016	0.005	0.085	0.079	0.027	0.003	0.014	0.000	0.055	0.027	0.014
HS4 : Hard Shoulder - Other Non Legal use	0.019	0.025	0.005	0.038	0.033	0.014	0.058	0.112	0.014	0.008	0.030	0.011	0.285	0.290	0.055	0.134	0.175	0.052	0.153	0.167	0.025
I : Incident Other (unspecified)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
I10 : Insecure Load	0.000	0.003	0.000	0.000	0.003	0.000	0.003	0.005	0.000	0.003	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.005	0.003	0.000
I30 : Abortive ERT call	0.003	0.000	0.000	0.008	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.003	0.011	0.011	0.003	0.000	0.000	0.003
I40 : Suicide / Attempted suicide	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000
I50 : Anti Social Behaviour with Vehicle	0.000	0.003	0.000	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.005	0.014	0.000	0.016	0.036	0.022	0.005	0.000	0.000
I70 : Immediate Despatch of ISU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000
I80 : Assistance to Other Agencies	0.014	0.005	0.008	0.014	0.011	0.000	0.003	0.005	0.000	0.016	0.000	0.000	0.025	0.038	0.005	0.016	0.003	0.000	0.016	0.019	0.005
I90 : Near Miss	0.000	0.005	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.003	0.003	0.000	0.003	0.000	0.000	0.000
JR : Joint Resolution	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.003	0.000	0.000	0.000	0.000	0.000
NT : No Trace	0.003	0.033	0.019	0.008	0.008	0.003	0.104	0.110	0.036	0.011	0.036	0.003	0.003	0.000	0.000	0.025	0.033	0.033	0.000	0.000	0.000
OB1 : Debris	0.337	0.290	0.055	0.296	0.238	0.071	0.868	0.600	0.178	0.282	0.214	0.058	0.868	0.627	0.195	0.408	0.329	0.077	0.479	0.340	0.088
OB2 : Hazardous Spillage	0.003	0.005	0.000	0.003	0.005	0.000	0.003	0.000	0.000	0.003	0.003	0.000	0.014	0.003	0.000	0.005	0.005	0.003	0.011	0.003	0.003
OB3 : Non Hazardous Spillage	0.016	0.000	0.000	0.003	0.003	0.000	0.005	0.000	0.000	0.003	0.000	0.000	0.000	0.003	0.000	0.003	0.008	0.000	0.000	0.000	0.000
OB4 : Shed Load	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.003	0.000	0.003	0.005	0.000	0.011	0.000	0.000	0.003	0.005	0.000
OB6 : Other obstruction (excl breakdown)	0.000	0.000	0.000	0.000	0.000	0.003	0.003	0.000	0.000	0.003	0.000	0.005	0.036	0.033	0.011	0.066	0.085	0.019	0.016	0.008	0.014
OI : Observation – infrastructure problem	0.014	0.019	0.016	0.038	0.041	0.014	0.071	0.049	0.025	0.044	0.030	0.014	0.151	0.077	0.044	0.159	0.088	0.030	0.041	0.044	0.008
OP : Observation – police/ VOSA intelligence.	0.027	0.022	0.000	0.025	0.011	0.005	0.036	0.060	0.030	0.030	0.019	0.019	0.079	0.096	0.052	0.121	0.142	0.088	0.096	0.175	0.041
OV : Oncoming vehicle	0.003	0.000	0.005	0.000	0.000	0.000	0.000	0.003	0.005	0.005	0.000	0.000	0.008	0.005	0.008	0.003	0.003	0.000	0.003	0.005	0.000
PN : Pedestrian on network	0.096	0.164	0.107	0.047	0.101	0.071	0.068	0.151	0.082	0.063	0.090	0.066	0.151	0.219	0.134	0.148	0.195	0.090	0.071	0.134	0.077
PR : Police Response	0.003	0.003	0.000	0.000	0.003	0.000	0.008	0.008	0.005	0.000	0.008	0.000	0.008	0.000	0.005	0.008	0.008	0.003	0.000	0.003	0.003
RW1 : Roadworks Planned Notification	0.058	0.537	0.156	0.082	0.452	0.099	0.378	1.022	0.523	0.025	0.521	0.077	0.858	2.375	0.304	0.025	1.422	0.501	0.326	0.932	0.236
RW2 : Roadworks Unplanned	0.000	0.005	0.000	0.000	0.000	0.003	0.008	0.003	0.008	0.000	0.003	0.000	0.003	0.003	0.000	0.005	0.003	0.000	0.003	0.005	0.005
SI : Secondary Incident	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.003	0.000
SV : Stopping Vehicles	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.003	0.003	0.003	0.000	0.000	0.000	0.000	0.008	0.000	0.003	0.000	0.000
TA1 : Tasked Incident	0.312	0.696	0.027	0.096	0.118	0.030	0.027	0.041	0.016	0.178	0.123	0.008	0.126	0.266	0.079	1.447	1.578	0.567	0.085	0.068	0.030
TC1 : Road Traffic Collision - Damage Only	0.192	0.252	0.033	0.123	0.192	0.030	0.290	0.384	0.071	0.222	0.247	0.033	0.452	0.545	0.052	0.578	0.553	0.178	0.173	0.205	0.047
TC2 : Road Traffic Collision - Minor Injury	0.019	0.025	0.011	0.014	0.047	0.011	0.055	0.041	0.008	0.025	0.025	0.016	0.036	0.055	0.014	0.071	0.058	0.014	0.047	0.016	0.003
TC3 : Road Traffic Collision – Serious Injury	0.014	0.008	0.003	0.008	0.003	0.003	0.022	0.022	0.003	0.008	0.011	0.005	0.025	0.022	0.003	0.036	0.049	0.016	0.025	0.014	0.005
TC4 : Road Traffic Collision - Fatal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.003	0.005	0.000	0.000	0.000	0.003	0.000	0.000	0.003
WC1 : High Wind	0.003	0.000	0.003	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.008	0.000	0.000	0.000	0.000	0.003	0.000
WC2 : Heavy rain	0.005	0.000	0.000	0.003	0.000	0.000	0.005	0.003	0.000	0.011	0.003	0.005	0.003	0.008	0.000	0.003	0.000	0.000	0.003	0.003	0.005
WC3 : Snow Frost Ice	0.003	0.000	0.003	0.003	0.005	0.005	0.000	0.003	0.000	0.000	0.000	0.008	0.005	0.005	0.000	0.005	0.005	0.005	0.000	0.003	0.000
WC4 : Flooding	0.008	0.000	0.003	0.005	0.005	0.000	0.005	0.019	0.003	0.000	0.005	0.000	0.000	0.005	0.003	0.003	0.005	0.003	0.000	0.000	0.000
WC6 : Poor Visibility - Fog	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.005	0.011	0.008	0.011	0.000	0.000	0.000	0.000	0.000	0.005
WC7 : Poor Visibility - Other	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Totals	**2.107**	**3.567**	**0.704**	**2.310**	**2.904**	**0.762**	**5.474**	**7.068**	**2.099**	**2.803**	**3.496**	**0.605**	**7.638**	**9.789**	**2.049**	**7.266**	**9.507**	**3.090**	**3.501**	**4.411**	**1.036**

Table D1: Number of incidents per shift for each Tranche 1 Managed Motorway Scheme over a 7 day per period

Scheme	M60 Jct 8 - 12			M62 Jct 18 - 20			M6 Jct 5 - 8			M4 Jct 19 - 20/ M5 Jct 15 - 17			M62 Jct 25 - 30			M1 Jct 10 - 13			M1 Jct 32 - 35a		
Final Closure Code	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00	06:00-14:00	14:00-22:00	22:00-06:00
AL1 : Abnormal Load - Unescorted	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.011	0.000	0.000	0.004	0.000	0.011	0.008	0.000
AL2 : Abnormal Load - Escorted	0.000	0.000	0.000	0.000	0.004	0.004	0.000	0.000	0.000	0.000	0.008	0.000	0.023	0.004	0.008	0.008	0.011	0.000	0.008	0.027	0.031
AN : Animal on network	0.015	0.027	0.011	0.069	0.034	0.011	0.019	0.004	0.000	0.023	0.023	0.000	0.054	0.034	0.023	0.031	0.023	0.011	0.019	0.011	0.011
AV1 : Abandoned Vehicle - Not Suspicious	0.004	0.015	0.011	0.004	0.019	0.008	0.011	0.011	0.000	0.011	0.015	0.008	0.031	0.057	0.011	0.038	0.042	0.034	0.023	0.008	0.015
AV2 : Abandoned Vehicle - Suspicious	0.000	0.004	0.000	0.004	0.000	0.004	0.000	0.000	0.004	0.004	0.000	0.000	0.004	0.011	0.000	0.000	0.004	0.000	0.004	0.000	0.000
BH : Breakdown - Hardshoulder	0.517	0.805	0.107	1.100	1.107	0.238	2.889	3.421	0.793	1.157	1.533	0.218	3.222	3.429	0.782	3.126	3.391	0.969	1.123	1.303	0.215
BH1 : Breakdown – offside tyre change	0.057	0.061	0.004	0.103	0.073	0.023	0.004	0.019	0.008	0.034	0.011	0.004	0.268	0.238	0.038	0.307	0.272	0.088	0.111	0.107	0.011
BH2 : Breakdown – vulnerable person present	0.015	0.027	0.000	0.008	0.015	0.008	0.011	0.015	0.000	0.000	0.011	0.000	0.050	0.080	0.011	0.031	0.054	0.011	0.023	0.050	0.011
BH3 : Breakdown - out of fuel	0.031	0.050	0.011	0.054	0.088	0.027	0.008	0.031	0.008	0.011	0.038	0.004	0.138	0.211	0.023	0.119	0.176	0.061	0.057	0.065	0.023
BL : Breakdown – in live lane	0.299	0.479	0.046	0.230	0.249	0.027	0.590	0.789	0.130	0.103	0.172	0.004	0.705	0.935	0.073	0.276	0.280	0.073	0.383	0.456	0.073
C : Congestion	0.004	0.034	0.000	0.008	0.004	0.000	0.004	0.019	0.004	0.372	0.245	0.000	0.004	0.004	0.000	0.015	0.015	0.004	0.008	0.004	0.000
C1 : Non-incident congestion	0.004	0.011	0.000	0.004	0.000	0.000	0.004	0.000	0.000	0.218	0.123	0.000	0.011	0.011	0.000	0.008	0.000	0.004	0.019	0.023	0.004
C2 : Incident-related congestion	0.000	0.004	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.008	0.011	0.000	0.000	0.008	0.000	0.004	0.004	0.000	0.004	0.004	0.000
D10 : Infrastructure defect	0.008	0.008	0.004	0.008	0.008	0.000	0.008	0.008	0.004	0.008	0.008	0.004	0.000	0.000	0.000	0.027	0.019	0.004	0.000	0.004	0.000
E10 : Event (Off Network) Planned	0.004	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.008	0.000
E20 : Event / Incident (Off Network) - Unplanned	0.031	0.023	0.000	0.004	0.008	0.000	0.042	0.061	0.004	0.000	0.008	0.000	0.123	0.107	0.042	0.008	0.027	0.011	0.111	0.107	0.015
F10 : Vehicle Fire	0.004	0.015	0.000	0.000	0.008	0.004	0.019	0.019	0.019	0.008	0.011	0.000	0.027	0.038	0.008	0.019	0.042	0.008	0.034	0.019	0.008
F20 : Off road fire (e.g. verge fire)	0.004	0.000	0.000	0.000	0.008	0.000	0.008	0.008	0.000	0.000	0.000	0.000	0.004	0.008	0.000	0.000	0.004	0.000	0.000	0.011	0.000
FP : Found Property	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000
H99 : Emergency Assistance required	0.000	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.000	0.000	0.000	0.000	0.004	0.000	0.008	0.000	0.000	0.000	0.000
HS1 : Hard Shoulder - Medical Emergency	0.004	0.004	0.000	0.004	0.000	0.000	0.027	0.038	0.004	0.011	0.000	0.004	0.008	0.023	0.004	0.023	0.027	0.011	0.008	0.011	0.000
HS2 : Hard Shoulder - Tacho Break (HGV)	0.000	0.000	0.000	0.015	0.000	0.000	0.008	0.038	0.000	0.000	0.004	0.000	0.015	0.008	0.008	0.015	0.019	0.015	0.019	0.015	0.000
HS3 : Hard Shoulder - Drive Away	0.004	0.008	0.000	0.004	0.004	0.000	0.011	0.015	0.000	0.019	0.019	0.008	0.092	0.077	0.019	0.004	0.000	0.000	0.061	0.019	0.008
HS4 : Hard Shoulder - Other Non Legal use	0.023	0.027	0.000	0.042	0.023	0.015	0.046	0.111	0.008	0.011	0.031	0.004	0.287	0.314	0.050	0.142	0.142	0.065	0.169	0.176	0.023
I : Incident Other (unspecified)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
I10 : Insecure Load	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.004	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.008	0.004	0.000
I30 : Abortive ERT call	0.004	0.000	0.000	0.008	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.015	0.000	0.000	0.000	0.004
I40 : Suicide / Attempted suicide	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000
I50 : Anti Social Behaviour with Vehicle	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.008	0.000	0.019	0.034	0.023	0.008	0.000	0.000
I80 : Assistance to Other Agencies	0.015	0.004	0.011	0.011	0.015	0.000	0.004	0.008	0.000	0.011	0.000	0.000	0.019	0.031	0.000	0.019	0.004	0.000	0.015	0.011	0.008
I90 : Near Miss	0.000	0.008	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004	0.000	0.004	0.000	0.000	0.000
JR : Joint Resolution	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.004	0.000	0.000	0.000	0.000	0.000
NT : No Trace	0.000	0.034	0.019	0.011	0.011	0.004	0.130	0.123	0.046	0.011	0.038	0.004	0.004	0.000	0.000	0.019	0.031	0.034	0.000	0.000	0.000
OB1 : Debris	0.391	0.330	0.050	0.330	0.276	0.069	1.027	0.655	0.203	0.314	0.261	0.065	0.939	0.670	0.199	0.464	0.360	0.080	0.563	0.379	0.100
OB2 : Hazardous Spillage	0.000	0.008	0.000	0.004	0.004	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.019	0.004	0.000	0.004	0.008	0.004	0.011	0.004	0.004
OB3 : Non Hazardous Spillage	0.019	0.000	0.000	0.004	0.004	0.000	0.004	0.000	0.000	0.004	0.000	0.000	0.000	0.004	0.000	0.004	0.011	0.000	0.000	0.000	0.000
OB4 : Shed Load	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.000	0.004	0.008	0.000	0.008	0.000	0.000	0.004	0.008	0.000
OB6 : Other obstruction (excl breakdown)	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.004	0.000	0.004	0.038	0.038	0.011	0.080	0.103	0.023	0.015	0.008	0.015
OI : Observation – infrastructure problem	0.011	0.023	0.019	0.038	0.031	0.015	0.080	0.038	0.031	0.034	0.031	0.011	0.157	0.088	0.050	0.195	0.088	0.038	0.050	0.054	0.004
OP : Observation – police/ VOSA intelligence.	0.023	0.019	0.000	0.031	0.015	0.008	0.038	0.073	0.031	0.038	0.019	0.019	0.084	0.119	0.057	0.126	0.130	0.092	0.100	0.199	0.042
OV : Oncoming vehicle	0.004	0.000	0.004	0.000	0.000	0.000	0.000	0.004	0.004	0.000	0.000	0.000	0.008	0.004	0.008	0.004	0.004	0.000	0.000	0.004	0.000
PN : Pedestrian on network	0.077	0.161	0.088	0.038	0.096	0.061	0.077	0.134	0.073	0.061	0.092	0.069	0.165	0.207	0.103	0.157	0.218	0.084	0.069	0.138	0.046
PR : Police Response	0.000	0.004	0.000	0.000	0.004	0.000	0.011	0.008	0.008	0.000	0.008	0.000	0.011	0.000	0.004	0.004	0.004	0.000	0.000	0.000	0.000
RW1 : Roadworks Planned Notification	0.077	0.636	0.192	0.111	0.563	0.126	0.494	1.295	0.674	0.034	0.663	0.096	1.176	3.019	0.330	0.031	1.805	0.644	0.433	1.153	0.261
RW2 : Roadworks Unplanned	0.000	0.008	0.000	0.000	0.000	0.004	0.011	0.004	0.008	0.000	0.004	0.000	0.000	0.000	0.000	0.008	0.004	0.000	0.000	0.000	0.008
SV : Stopping Vehicles	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.004	0.000	0.000	0.000	0.000	0.011	0.000	0.004	0.000	0.000
TA1 : Tasked Incident	0.280	0.847	0.031	0.119	0.115	0.038	0.027	0.042	0.015	0.215	0.157	0.008	0.138	0.307	0.080	1.533	1.674	0.567	0.100	0.073	0.023
TC1 : Road Traffic Collision - Damage Only	0.165	0.295	0.046	0.146	0.226	0.027	0.345	0.475	0.065	0.249	0.287	0.027	0.502	0.655	0.050	0.582	0.621	0.172	0.192	0.257	0.050
TC2 : Road Traffic Collision - Minor Injury	0.015	0.031	0.015	0.015	0.057	0.008	0.061	0.042	0.008	0.023	0.023	0.023	0.042	0.073	0.011	0.073	0.054	0.011	0.050	0.015	0.000
TC3 : Road Traffic Collision – Serious Injury	0.008	0.011	0.004	0.011	0.004	0.000	0.031	0.019	0.000	0.004	0.015	0.008	0.027	0.023	0.004	0.034	0.046	0.019	0.027	0.011	0.004
TC4 : Road Traffic Collision - Fatal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WC1 : High Wind	0.004	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.011	0.000	0.000	0.000	0.000	0.004	0.000
WC2 : Heavy rain	0.008	0.000	0.000	0.004	0.000	0.000	0.008	0.000	0.000	0.011	0.000	0.008	0.004	0.011	0.000	0.004	0.000	0.000	0.004	0.004	0.008
WC3 : Snow Frost Ice	0.000	0.000	0.004	0.004	0.004	0.004	0.000	0.004	0.000	0.000	0.000	0.008	0.004	0.008	0.000	0.004	0.008	0.000	0.000	0.004	0.000
WC4 : Flooding	0.008	0.000	0.004	0.008	0.008	0.000	0.004	0.015	0.004	0.000	0.000	0.000	0.000	0.008	0.000	0.004	0.008	0.004	0.000	0.000	0.000
WC6 : Poor Visibility - Fog	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.008	0.008	0.008	0.015	0.000	0.000	0.000	0.000	0.000	0.004
WC7 : Poor Visibility - Other	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Totals	**2.134**	**4.031**	**0.686**	**2.559**	**3.096**	**0.743**	**6.080**	**7.556**	**2.157**	**3.042**	**3.877**	**0.621**	**8.448**	**10.923**	**2.046**	**7.598**	**9.805**	**3.172**	**3.847**	**4.766**	**1.027**

Table D2: Number of incidents per shift for each Tranche 1 Managed Motorway Scheme during weekdays only