

Managed Motorways – All Lanes Running

Generic Safety Report

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Name	Role
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Approvals Sheet for Managed Motorways – All Lanes Running, Generic Safety Report

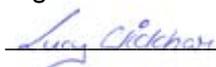
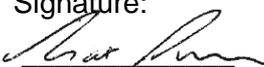
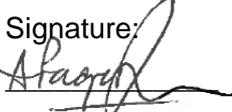
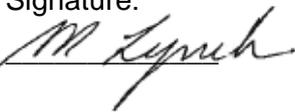
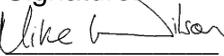
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Name: Max Brown Date: 23/03/2012 Signature: 	MM-ALR Design Workstream (NetServ Project Sponsor)	<ul style="list-style-type: none">• the scope and content of the attached deliverable are correct and fit for purpose given the current stage of the project.• the attached deliverable complies with the requirements of the relevant Work Instructions for Project Safety Risk Management.
Name: Andrew Page-Dove Date: 23/03/2012 Signature: 	Network Delivery & Development (MM-ALR Senior User)	I accept that in relation to the project operating regime the scope and content of the attached deliverable are correct and fit for purpose given the current stage of the project.
Name: Andrew Page-Dove Date: 23/03/2012 Signature: 	Traffic Management (MM-ALR Senior User)	I accept that in relation to the project operating regime the scope and content of the attached deliverable are correct and fit for purpose given the current stage of the project.
Name: Martin Lynch Date: 23/03/2012 Signature: 	Network Services (Safe Roads & Casualty Reduction Group Manager)	I approve that in relation to project safety: <ul style="list-style-type: none">• the scope and content of the attached deliverable are correct and fit for purpose given the current stage of the project• the attached deliverable complies with the requirements of the relevant Work Instructions for Project Safety Risk Management.
Name: Mike Wilson Date: 23/03/2012 Signature: 	MM-ALR Senior Responsible Owner	I approve that in relation to project safety & the PCF: <ul style="list-style-type: none">• the attached Project Safety Deliverable complies with the requirements of the relevant Work Instructions for Project Safety Risk Management .

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Executive summary

Introduction

This document is the Generic Safety Report for Managed Motorways – All Lanes Running (MM-ALR). The objective of the document is to demonstrate that the appropriate level of safety management has been undertaken to assess the expected safety performance for the implementation of Managed Motorways – All Lanes Running.

The key challenges for Managed Motorways –All Lanes Running are:

- Adequate Guidance that produces the required level of compliant driver behaviour
- Road Worker Safety
- Road User Safety
- Operating and Maintenance Regimes
- Mitigations for top scoring hazards

Conclusion

The information presented in this report demonstrates that:

A safety objective has been set for the scheme and is likely to be achieved

- A generic safety baseline and generic safety objectives have been agreed for MM-ALR schemes, as define in IAN 161 [1]. These cover road users and road workers.

Road user safety baseline:

Validated STATS19 Personal Injury Accident (PIA) data covering the scheme extent, including entry and exit slips is used to determine the road user safety baseline. The road user safety baseline used to demonstrate meeting the safety objective must be the number (averaged per annum) of all fatal and weighted injury (FWI) casualties and the rate of FWIs per billion vehicle miles per annum averaged for the three years prior to the installation of any element of MM-ALR.

FWI is defined as: (number of fatalities) + 0.1 x (number of serious casualties) + 0.01 x (number of slight casualties).

For the purposes of this report, the safety baseline assumes prior to the implementation of any element of managed motorways (including Motorway Incident Detection And Signalling (MIDAS)).

Road user safety objective:

A MM-ALR scheme will satisfy the road user safety objective if it is demonstrated for a period of three years after becoming fully operational that:

- the average number of Fatal and Weighted Injuries (FWI) casualties per year is no more than the safety baseline, and
- the rate of FWIs per billion vehicle miles per annum is no more than the safety baseline,

- no population (e.g. car drivers, pedestrians, HGV drivers and motorcyclists) is adversely affected in terms of safety.

Road worker safety:

There is no numerical objective or target for road worker accidents on MM-ALR schemes and the risk must be managed in accordance with SFAIRP (So Far As Is Reasonably Practicable). The Highways Agency's "Aiming for Zero" strategy must be applied for further positive action to reduce the risk to road workers during maintenance and operation. One part of the strategy aims to eliminate all fatalities and serious injuries to road workers maintaining the Highways Agency's road network.

- The methodology used to demonstrate whether the safety objective can be achieved is based on the methodology used successfully for the M42 Managed Motorways (MM) and Birmingham Box Managed Motorways Phase 1&2 (BBMM1&2) Schemes. Results from the "M42 MM Monitoring and Evaluation Three year Safety Review" [2] have been used to provide some evidential basis for the likely safety performance of the MM-ALR generic scheme. Further evidence has been provided from a review of the safety performance of the All purpose trunk road network [7] and a review of the likely impact of MM-ALR on driver compliance and understanding [8].
- The "Demonstration of Meeting the Safety Objective Report" [5] (based on the use of a MM-ALR generic hazard log) shows that the safety objective for road users is likely to be achieved due to:
 - A reduction in risk for a significant number (15) of the highest scoring existing motorway hazards (20), due to a controlled environment being provided through a combination of regularly spaced mandatory speed signals, speed enforcement, and comprehensive CCTV coverage
 - One highest scoring new MM hazard is introduced (E08/S08 and above) is introduced (Vehicle recovered from Emergency Refuge Area (ERA))
 - Three high-scoring existing hazards increase in risk
 - The impact of the new hazards, and increase in risk of some existing hazards is expected to be countered by the decrease in risk of other existing highest scoring hazards
 - Anti-log calculations show that the total risk score for 'after' represents approximately a reduction of risk of 15% when compared with the safety baseline (no MIDAS).
- With regard to meeting the safety objective for specific users, MM-ALR reduces the risk of a number of existing hazards for these groups and introduces a number of new hazards. On balance the safety objective is likely to be achieved for Pedestrians, Motorcyclists, HGV Drivers, On Road Resources (ORR), Emergency Services, Recovery Organisations, and Disabled drivers or passengers.
- With regard to Maintenance Workers, improvements are required in the frequency and implementation of maintenance activities before it can be concluded that the safety objective is likely to be achieved or that the risk is managed So Far As Is Reasonably Practicable (SFAIRP). However there are

indications that the hazards and risks identified can be either eliminated or mitigated so as to be as low as reasonably practicable resulting in the residual risks associated with the operations and maintenance of the MM-ALR layout being no more onerous than for a D3M layout.

An appropriate Safety Management Process has been selected for MM-ALR and has been applied

- MM-ALR has been classified as ‘Type B’. This represents a ‘medium’ level of safety management.
- The assessment had been carried out by persons with the required level of competency.

Hazards are well managed

- An appropriate risk assessment methodology consistent with the M42 MM and BBMM1&2 Schemes and Highways Agency Guidance has been applied for MM-ALR.
- The MM generic hazard log has been used as the starting point to develop a list of hazards applicable to MM-ALR.
- All identified scheme hazards have then been assessed and the risk level they present has been determined.
- Evidence has been used where relevant to support the hazard assessment
- A list of appropriate safety requirements has been produced.

Summary

It can be concluded from the information summarised in this Safety Report that the objective of the report to “demonstrate that the appropriate level of safety management has been undertaken to assess the expected safety outcome for the implementation of MM-ALR has been met. MM-ALR is likely to meet the safety objective for road users. With regard to road workers further work is required to demonstrate that safety of this group has been managed So Far As Is Reasonably Practicable. However, there are indications that the hazard and risk identified can be either eliminated or mitigated so as to be low as reasonably practicable resulting in the residual risks associated with the operations and maintenance of the MM-ALR layout being no more onerous than for a D3M layout.

1 Introduction

1.1 Background

Managed Motorways (MM) is a programme to tackle congestion on the motorway network, whether caused by high volumes of traffic or disruptive incidents. Managed Motorways uses innovative ways to maximise capacity whilst providing a safe and informed environment for the travelling public and on-road resources. It incorporates operationally led solutions that utilise combinations of active traffic management elements (such as Controlled Motorways (CM), Dynamic use of the Hard Shoulder (DHS) and Access Management (AM)) to optimise network performance.

Each traffic management element is defined by the operational regime, equipment and technology available. It is expected that these will evolve over time as new equipment and functionality becomes available and policy is developed. Each of the elements is supported, as appropriate, by operator inputs through Regional Control Centres (RCC) and the Traffic Officer Service (TOS). Such elements range from existing approaches that have been in place for several years on the UK motorway network (e.g. Triple Package [TP]¹), to more recent Pilot schemes (e.g. Active Traffic Management [ATM]).

Varying safety studies have been undertaken on each traffic management element to determine their impact on the safety of the motorway network. When establishing the impact of MM on safety a number of items need to be defined:

- Safety Baseline – against which the safety objective will be measured
- Safety Objective – the level of safety that the scheme is aiming to achieve
- Level of safety benefit / impact achievable and mitigation measures required

This report summarises the safety impact (beneficial and detrimental) of one version of Managed Motorways known as MM-ALR.

1.2 MM-ALR

MM-ALR is as described in DMRB IAN 161 “Managed Motorways – All Lanes Running” [1]. The outline design for MM-ALR is shown in Figure 1-1. Key features include:

- a. The hard shoulder on the main line is permanently converted to a controlled running lane. This includes the main line intra-junction subject to assessment.
- b. Refuge areas provided at a maximum of 2500m intervals. Refuge areas may either be bespoke facilities (an emergency refuge area (ERA)) or converted from an existing facility, for example a wide load bay, a motorway service area (MSA), the hard shoulder on an exit slip/link road or hard shoulder intra-junction.
- c. Variable mandatory speed limits (VMSL)

¹ MIDAS Queue Protection, Motorway Signals and fibre optic cabling

-
- d. Lane specific signalling only provided at the 'gateway signals and VMS' location and where necessary at intermediate locations. At all other signal locations, verge mounted carriageway signalling must be provided
 - e. Driver information, including mandatory speed limits, are provided at intervals not less than 600m and not exceeding 1500m.
 - f. Queue protection system
 - g. Comprehensive low-light pan-tilt-zoom (PTZ) CCTV coverage
 - h. Emergency roadside telephones (ERTs) are only provided in all dedicated refuge areas (except MSAs), e.g. ERAs, intra-junction (where Though Junction Running is not required and a suitable hard shoulder is present).
 - i. No non-essential infrastructure or technology.
 - j. The avoidance wherever practicable the positioning of infrastructure in the central reserve.

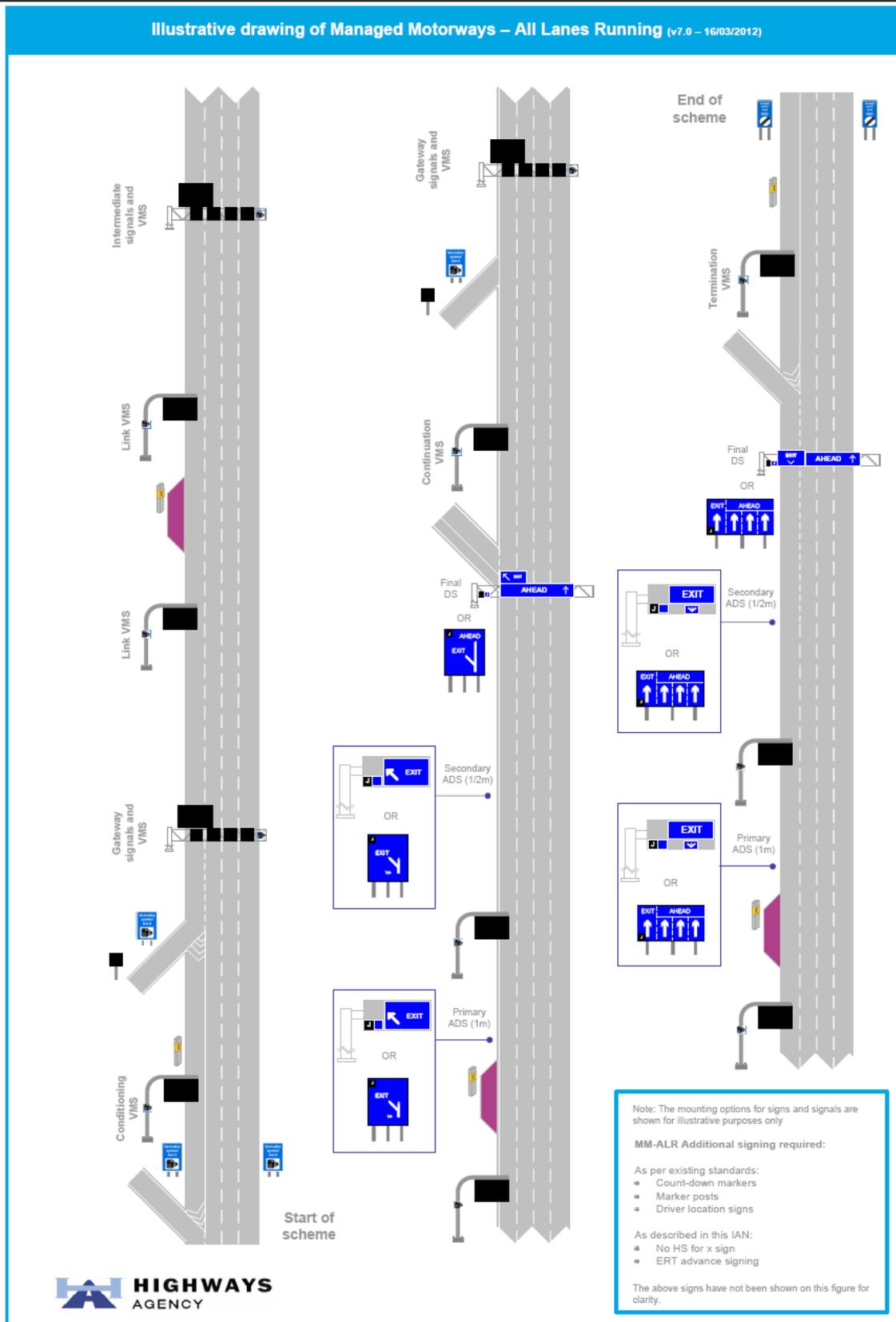


Figure 1-1: Illustrative drawing of Managed Motorways – All lanes running

1.3 Highways Agency Duty of Care

The Highways Agency (HA) as a highway authority owes a duty of care to road users. In the event that the HA breaches its duty of care a claimant will have a potential action in negligence if damage to that individual could reasonably have been foreseen.

In fulfilling its obligations, it is important that the HA addresses in its safety procedures, risk assessments etc, the foreseeability of an accident occurring in a particular location, or to a particular class of road user. If safety procedures are designed and managed in this way, it is much less likely that a claimant who has established that the HA owes him a duty of care will be able to establish that this duty has been breached.

1.3.1 Tolerable risk

The level of risk that would be deemed to be tolerable for a package of measures such as MM-ALR depends on a number of factors, which are discussed below.

1.3.2 Overall level of risk

The Road Traffic Act places a duty on highway authorities to consider the safety performance of their network, while the Highways Act places a duty to maintain the road system. For a well performing motorway network the HA must as a minimum maintain the current level of safety. The HA also need to consider different populations of road users and ensure that the management of risk for one group does not lead to risk for one or more other group exceeding the baseline. In addition, the HA seeks to reduce the absolute number of casualties on its network to support the strategic framework for road safety, so needs to look for risk reduction opportunities across the network.

1.3.3 Balancing risk

In general as long as the HA lower or maintain the global level of risk for road users they may allow the risk from some hazards to increase (i.e. the globally at least equivalent concept - GALE). This was accepted as a concept on the M42 ATM Pilot. So if an increase in the risk from one hazard can be balanced by a commensurate decrease in the risk of another hazard, then this has been deemed tolerable. However such a balancing process will always require some caution, so that the decrease in the second risk will need to be larger than the increase in the first – i.e. over time risk as a whole will decrease so as to ensure the appropriate balance is always achieved.

1.3.4 Not reducing risk as far as is possible

Risk reduction normally involves expenditure and effort and there may be different risk reduction options that require different levels of cost and the effort. It is common practice to review the cost benefit of the different options and select those that show the optimum cost benefit. That said this cannot be done in isolation as other factors need to be taken into account, such as the duty of care, GALE safety principle and the overall level of risk. In some cases a minimum degree of risk reduction might be considered necessary to meet the long term safety aims. Also duty of care might mean that a minimum degree of risk reduction for a particular hazard is deemed appropriate.

1.3.5 Good practice

Where good practice exists in risk reduction then there is a duty of care obligation to apply this good practice. Whilst approaches and initiatives introduced by Pilot or Trial schemes, e.g. the hard shoulder CCTV detection system used on the M42 Pilot, may

not be considered to be sustainable practice, they do set a potential benchmark against which any future scheme should be evaluated. Other elements of Managed Motorway have become good practice so a decision not to implement them would require significant review.

1.3.6 Allowing total risk to increase

While not common, allowing an increase in total risk has occurred in other transport sectors in the past; where non-safety benefits of the risk increase have significantly outweighed the safety disadvantages. Where such risk increases have occurred very substantial research has been undertaken to determine both the increase in risk and the benefits gained so as to be certain that the balance is appropriate. For example, no night time use of train horns on pedestrian footpath crossings increases risk to pedestrians, but it reduces the noise pollution and nuisance to neighbours².

1.3.7 System effects, versus local benefits

There may be occasions when risk mitigation has wider effects than just the scheme being considered. In these cases the safety benefits should only be evaluated for the scheme. The wider system benefits cannot be used to justify the tolerable risk criteria for the scheme. That said, the system benefits or disadvantage should be considered in making a risk mitigation decision. For example, implementing a unique layout for a road junction may have safety benefits locally but create disadvantages regionally.

1.3.8 Deciding on tolerable risk

The level of risk deemed tolerable for a scheme may therefore need to take into account a number of criteria:

- A maximum level of risk that is deemed tolerable for the section of road. This might consist of a percentage of the overall network or regional risk or an absolute criterion in terms of road users Killed and Seriously Injured (KSI) or road user fatalities, or some combination of these
- Levels of performance for risk mitigation systems that are deemed to be a minimum for the duty of care to be met
- Good practice that is available for mitigating the risk
- The cost benefit of different options for risk mitigation, as long as they deliver a risk level lower than the maximum tolerable risk and meet the minimum performance requirements
- The overall effects of the actions taken. For example, a national campaign to reduce stoppages on the hard shoulder would have benefits to the whole network, not just a dynamic hard shoulder scheme. While the network effects should not be taken into account in cost benefit for the scheme they may help show that the HA has adequately considered / discharged its duty of care.

1.4 Use of statistics

In compiling this generic MM-ALR report it proved useful when assessing the impact of level of safety achievable to use relevant statistical information. The outputs of statistical analyses presented in previous safety reports have been incorporated where relevant. A degree of caution should therefore be used when interpreting the figures presented within this report. When using these figures no additional statistical analysis has been

² The extensive research on this subject is available on the web site of the Rail Safety and Standards Board (RSSB).

undertaken nor has any verification of the calculations been sought. Where used, these figures are referenced back to the source document. Whilst the figures are useful in establishing the quantitative impact on safety it should be noted that the degree of confidence in each of the figures will vary due to differences in the quality of data used and also the period over which the data was collected. The figures quoted should therefore be considered indicative with regards to the generic safety improvement that is achievable and not taken as absolute.

The figures quoted should therefore be considered a guide as to what the likely safety improvement will be through the introduction of MM-ALR. In reality the actual safety improvement achieved by MM-ALR is dependent on the existing environment, and as such the safety improvement achieved may be more or less than the figures presented in this generic report.

1.5 Assumptions

The detailed design of a MM-ALR scheme is dependent on the characteristics of the stretch of motorway under consideration. Topography, number of junctions, distance between junctions, width of hard shoulder, clearance to structures, drainage construction are a few of the existing motorway characteristics that influence the design specification of any proposed MM scheme. Similarly the characteristics of the existing motorway will also affect the level of safety performance delivered by a scheme.

Each stretch of motorway needs to be considered separately when defining the details of an MM-ALR scheme including:

- An analysis of main carriageway and merge/diverging traffic flows – in order to determine the optimum traffic solution for the stretch of motorway over the design life of the scheme
- An analysis of the features of each location to determine the most appropriate operational speed

This report is based on the following key assumptions:

- The HA accepted the principle of Globally At Least Equivalent (GALE) as a way of measuring the safety performance of a given road improvement scheme for road users.
- The GALE principle has also been applied to specific links of the network. Applying the GALE principle to each link means that it is not acceptable to balance an increased risk for one link by reducing it in another
- The GALE principle has also been applied to specific road user groups, e.g. cars, HGVs, motorcyclists. Applying the GALE principle to each group means that it is not acceptable to balance an increased risk for one group, say motorcyclists, by reducing it in another, say the on-road resource team
- The HA accepts that risk to workers must be managed So Far As Is Reasonably Practicable (SFAIRP) – as required under the Health and Safety at Work, etc Act (1974). This includes, for example, Traffic Officers, road workers and

maintainers³ but not private vehicle recovery operators (who are licensed road users)

- The HA accepts that they may trade off the safety benefits of one MM element against the safety disadvantages of another MM element within a scheme (e.g. CM with Through Junction Running (TJR)) so as to achieve the overall operational benefit
- The safety report requirements will need to be reviewed and updated to state all the principles that will need to be applied in order that the safety of the schemes is achieved. A project will still be required to demonstrate that the overall effects of changes / mitigations and operating principles are acceptable: to make sure that the sum of many small cuts does not equal a major negative change to the safety that will be delivered.

1.6 The key challenges

The key challenges associated with MM-ALR are as follows:

- Adequate Guidance – ensuring that drivers are presented with enough information so that they comply with the information that they are being presented with
- Road Worker Safety – MM-ALR needs to ensure that road work safety meet an SFAIRP test and also is no worse than before
- Road User safety is maintained across all groups
- Operating and Maintenance Regimes
- Mitigations for top scoring hazards

1.7 Contents of this Report

This report is structured as follows:

Chapter 1: Introduction - details the background, objective and scope of this report

Chapter 2: Contributing Factors - explores the existing mandatory and Highways Agency processes and procedures that contribute to the delivery of safety on a scheme. These include Road Safety Audits (RSAs), the Construction (Design & Management) Regulations 2007 (CDM 2007), and the expectations of the Office of Government Commerce (OGC) regarding the delivery of best value from Government spending

Chapter 3: Achieving the safety objectives: Sets out the approach to demonstrating that the safety objective can be achieved.

Chapter 4: Has the Safety objective been agreed and is it likely to be achieved? Sets out the safety objective and safety baseline for MM-ALR, the methodology used to demonstrate that the safety objective can be achieved, and the demonstration that the safety objective is likely to be achieved;

³ The term As Low As Reasonably Practicable (ALARP) is applied particularly where risk can, in principle, be quantified. Because of this link to quantification, ALARP rather than SFAIRP is the term generally applied in a number of sectors – including Highways – when discussing risk management and risk philosophy.

Chapter 5: Has a safety management process been followed? – describes how an appropriate Safety Management System (SMS) has been selected and applied, and shows that the project has been resourced with competent people for the safety work, a robust safety approvals process is in place, there are plans in place to monitor project safety performance, and that the Safety Report will be handed over to the Highways Agency for operation and maintenance;

Chapter 6: Have hazards been well managed? – demonstrates that an appropriate risk assessment methodology, hazard log and set of hazards have been applied, all scheme hazards have been analysed, and how project safety requirements will be identified to meet the project design;

Chapter 7: Conclusions

Chapter 8: References

Appendices: Glossary of Terms and Abbreviations, GSN for MM-ALR Safety Report

2 Contributing factors

2.1 Existing Processes and Procedures

The purpose of this chapter is to present the processes and procedures that are currently in place that are intended to support the implementation of 'safe' schemes on the Highways Agency network. These are presented to demonstrate that the safety risk associated with a scheme is considered at a number of stages during the development of a scheme. Whether implicitly or explicitly they drive the need to develop appropriate Safety Objectives (and Baselines) for Managed Motorway schemes.

2.1.1 Road Safety Audits

According to DMRB HD19/03, Road Safety Audit is defined as:

“The evaluation of Highway Improvement Schemes during design and at the end of construction (preferably before the scheme is open to traffic) to identify potential road safety problems that may affect any users of the highway and to suggest measures to eliminate or mitigate those problems. The audit process includes the accident monitoring of Highway Improvement Schemes to identify any road safety problems that may occur after opening. This Stage 4 Audit will include the analysis and reporting of 12 and 36 months of completed personal injury accident data from when the scheme became operational.”

The Audit comprises four stages:

- Stage 1: Completion of preliminary design
- Stage 2: Completion of detailed design
- Stage 3: Completion of construction
- Stage 4: Monitoring

The implication of applying the Road Safety Audit process is that individually, each scheme will deliver a certain level of safety performance. This depends upon the type of scheme implemented, for example whether or not it is a safety or a congestion management scheme.

2.1.2 Construction (Design and Management) Regulations 2007

The Construction (Design & Management) Regulations 2007 (CDM 2007) came into force on 6 April 2007. The CDM Regulations aim to ensure that construction projects are safe to build, safe to use and safe to maintain.

In the context of MM schemes, CDM provides a framework by which worker safety (both during construction and subsequent maintenance) can be maintained. Central to CDM is the concept of managing risk So Far As Is Reasonably Practicable (SFAIRP).

2.1.3 OGC

The Office of Government Commerce (OGC) is an independent office of HM Treasury, established to help Government deliver best value from its spending. The OGC works with central Government departments and other public sector organisations to ensure the achievement of six key goals:

- Delivery of value for money from third party spend;
- Delivery of projects to time, quality and cost, realising benefits;

-
- Getting the best from the Government's £30bn estate;
 - Improving the sustainability of the Government estate and operations, including reducing carbon emissions, through stronger performance management and guidance;
 - Helping achieve delivery of further Government policy goals, including innovation, equality, and support for small and medium enterprises (SMEs); and
 - Driving forward the improvement of central Government capability in procurement, project and programme management, and estates management through the development of people skills, processes and tools.

Implicit in delivering best value is the efficient management of safety. By reducing the number of safety related incidents, the cost of those incidents is reduced.

2.1.4 Project Safety Risk Management

The Highways Agency implements a Safety Management approach called Project Safety Risk Management for all its Managed Motorways Schemes (IAN 139)

Highways Agency projects have traditionally used a prescriptive approach to demonstrating safety, relying on adherence to detailed standards. These standards are based on research, pilot activities and many years of experience, thus capturing the necessary risk mitigation properties. However, this approach is becoming less appropriate for the more complex and innovative systems now being installed and the need has been recognised for more formal safety management on highways projects.

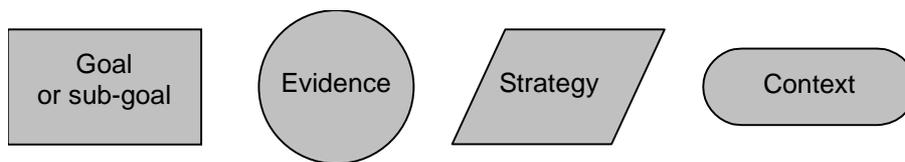
The approach, developed from the management of safety on the Active Traffic Management (ATM) Pilot on the M42 between Junction 3A and 7 provides a framework for managing road user and road worker risk so that an appropriate level of safety management is applied. This approach takes into account the size and complexity of the project to determine, amongst other factors, an appropriate Safety Baseline and Safety Objectives.

3 Achieving the safety objectives

The objective of this document is to evaluate whether MM-ALR, based on existing evidence, is likely to achieve the safety objectives that have been agreed by the Highways Agency.

3.1 Goal-Structured Notation (GSN)

Goal-Structured Notation (GSN) has been used to structure the safety arguments in a graphical manner. A GSN diagram shows how goals are broken down into sub-goals and eventually supported by evidence, whilst making clear the strategies adopted to meet the goals and the context in which goals are stated. These four entities are depicted by the following shapes.



The GSN diagram for MM-ALR is supplied as Appendix B of this document. Colour is used to denote progress with goals as shown in Figure 3-1.



Figure 3-1: Key to progress with GSN goals

Figure 3-2 shows an extract from the GSN diagram. It identifies three main strands to the safety argument, which are considered in Chapters 4, 5 and 6.

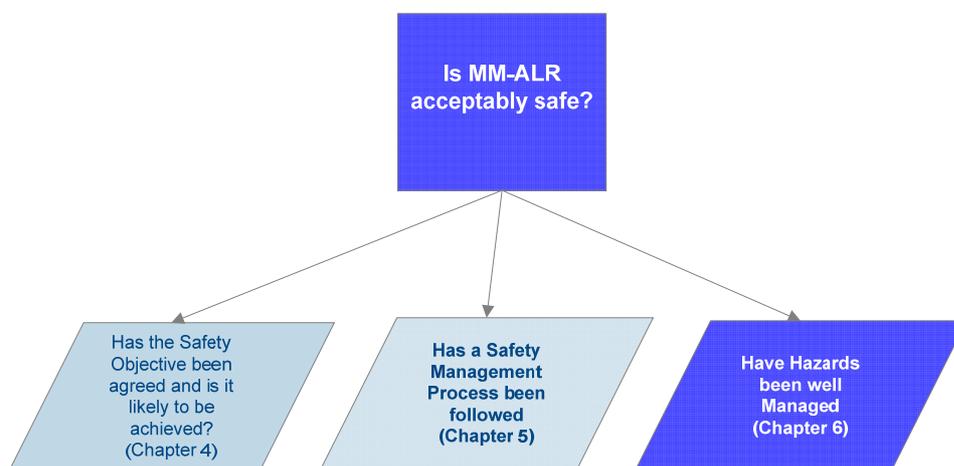


Figure 3-2: Three strategies are followed to demonstrate that MM-ALR is acceptably safe

3.2 Link with other Safety Documents

There are three documents that should be read in conjunction with this document:

- Demonstration of Meeting Safety Objective Report [5] provides the detail on that subject
- MM-ALR Provision of Adequate Guidance Review [8] provides information about whether or not MM-ALR will provide enough guidance to drivers so that the safety benefits of a controlled environment can be achieved.
- All-Purpose Trunk Roads (APTR)/Dual 3-lane Motorway (D3M) Analysis and Hazard Assessment Report [7] a document collecting evidence supporting the hazard assessment. In particular, this report provides evidence of the safety performance of multi-lane high speed roads on the APTR network which do not have a hard shoulder.

4 Has the Safety objective been agreed and is it likely to be achieved?

This chapter demonstrates that:

- The safety baseline for the project safety objectives has been agreed
- The safety objectives have been agreed for both road users and road workers
- Achievement of the safety objective can be demonstrated

The structure of the argument is illustrated in the GSN diagram in Figure 4-1 below.

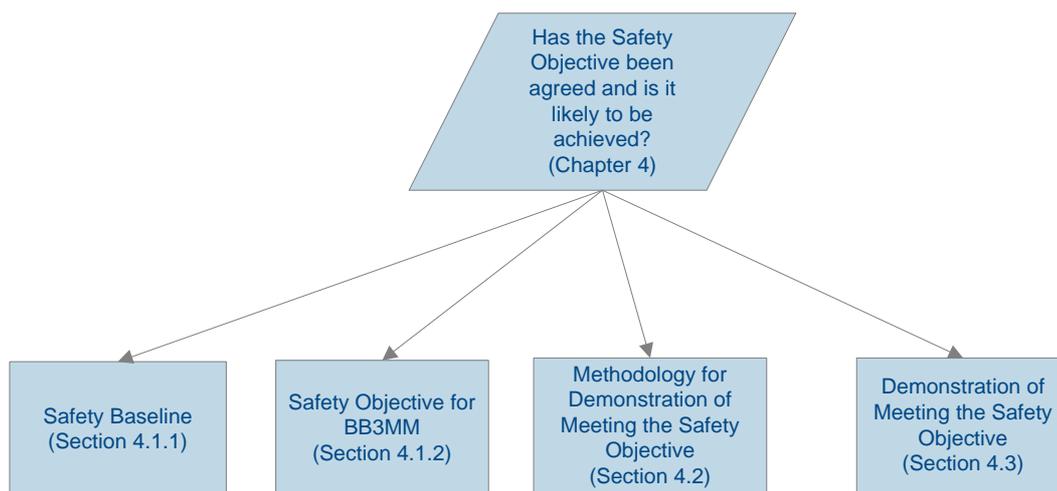


Figure 4-1: Extract of GSN diagram showing how it is demonstrated that a safety objective has been agreed and is likely to be achieved

4.1 Safety baseline and objectives for MM-ALR

A generic safety baseline and generic safety objectives have been agreed for MM-ALR schemes, as defined in IAN 161 [1]

4.1.1 Safety baseline

Validated STATS19 Personal Injury Accident (PIA) data covering the scheme extent, including entry and exit slips must be used to determine the road user safety baseline. The road user safety baseline used to demonstrate meeting the safety objective must be the number (averaged per annum) of all fatal and weighted injury (FWI) casualties and the rate of FWIs per billion vehicle miles per annum averaged for the three years prior to the installation of any element of MM-ALR.

FWI is defined as: (number of fatalities) + 0.1 x (number of serious casualties) + 0.01 x (number of slight casualties).

If more than 50% of the main line carriageway by length has motorway incident detection system and automatic signalling (MIDAS) installed, the road user safety baseline must be based on the recorded accident rate before installation of MIDAS or, if this information is not available or older than 5 years, the current three year average rate must be increased by 10% to account for MIDAS. It is generally accepted that MIDAS reduces accident rates by between 9% and 13%, therefore an addition of 10% must be used for this purpose.

For the purposes of this report, the safety baseline assumes prior to the implementation of any element of managed motorways.

4.1.2 Road user safety objective

A MM-ALR scheme will satisfy the road user safety objective if it is demonstrated for a period of three years after becoming fully operational that:

- the average number of fatal and weighted injuries (FWI) casualties per year is no more than the safety baseline, and
- the rate of FWIs per billion vehicle miles per annum is no more than the safety baseline,
- no population (e.g. car drivers, pedestrians, HGV drivers and motorcyclists) is adversely affected in terms of safety.

4.1.3 Road worker safety

There is no numerical objective or target for road worker accidents on managed motorways schemes and the risk must be managed in accordance with SFAIRP (So Far As Is Reasonably Practicable). This is a legal requirement. The Highways Agency's "Aiming for Zero" strategy is applied for further positive action to reduce the risk to road workers during maintenance and operation. One part of the strategy aims to eliminate all fatalities and serious injuries to road workers maintaining the Highways Agency's road network.

4.2 Methodology for Demonstrating Meeting of Safety Objective

This sub-section summarises the methodology for demonstrating the meeting of the safety objective. It initially considers meeting the safety objective for all users and then considers the impact on specific user groups.

4.2.1 Meeting of Safety Objective (for All Users)

The (generic) methodology is based on the methodology used successfully for the M42 MM and Birmingham Box Managed Motorways Phase 1&2 (BBMM1&2) Schemes. It is also documented in IAN 139 "Managed Motorways Project Safety Risk Work. Instructions" [6]. The foundation for the demonstration of meeting the safety objective is the risk assessment methodology which is documented in Appendix C.

The Demonstration involved a qualitative and quantitative risk comparison of MM-ALR with the safety baseline (a D3M without implementation of any element of managed motorways, i.e. without MIDAS).

The flowchart in Figure 4-2 summarises the process followed:

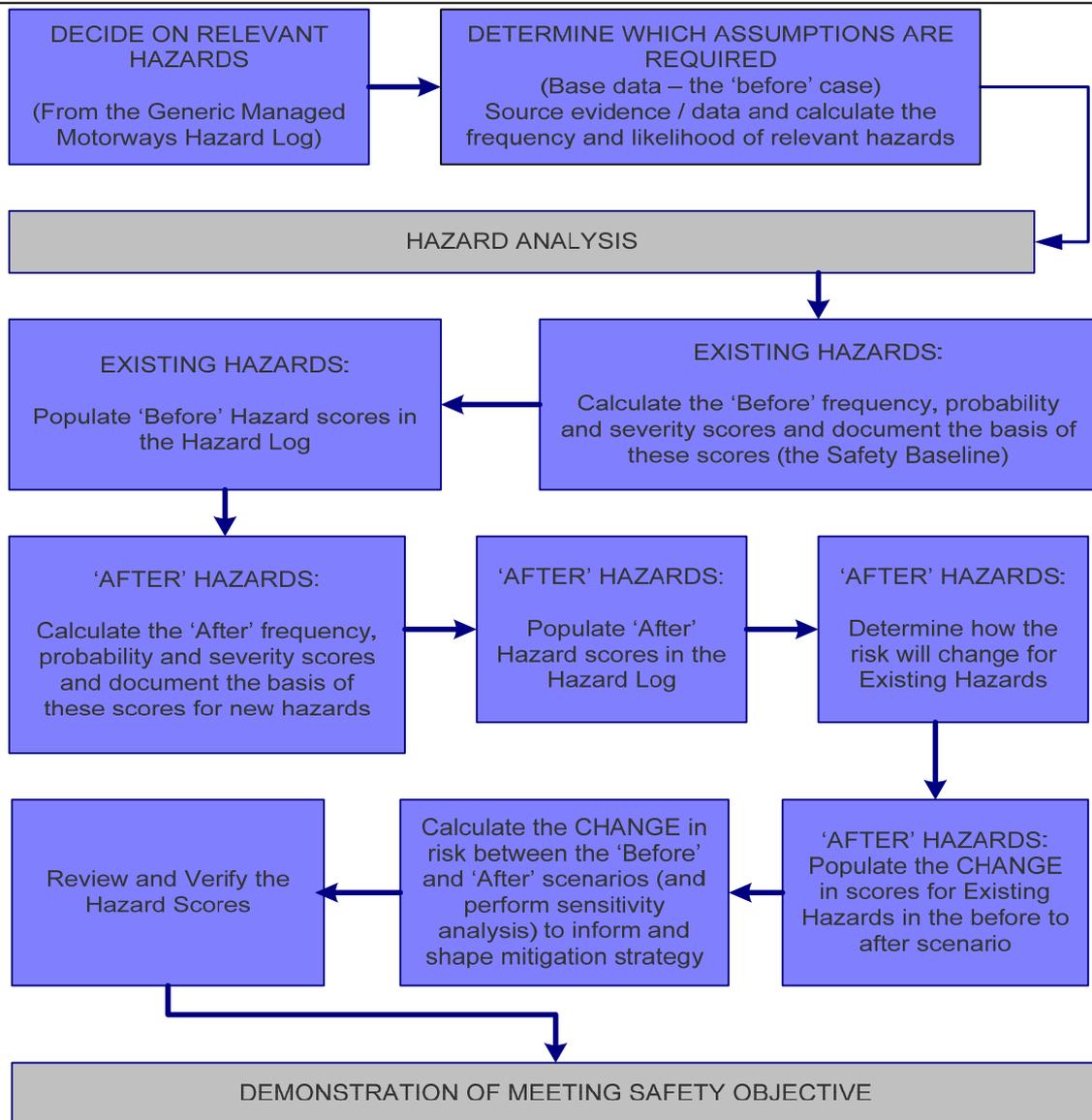


Figure 4-2 Process for demonstrating meeting of safety objective

4.2.2 Assessment of Safety Impact for Specific Road User Groups

In addition to considering the impact of the scheme on the safety of all road users (in line with the demonstration of meeting the safety objective), Chapter 5 of this document considers the safety impact of the scheme for the following specific user groups:

- Pedestrians
- Motorcyclists
- HGV Drivers
- **On Road Resources (ORR)**
- **Maintenance Workers**
- Emergency Services
- Recovery Organisations
- Disabled Drivers or Passengers

This approach is required as the Highways Agency does not seek to improve safety for one user group at the expense of another.

There is a separate safety objective for road workers (see Section 1.3), ORR and maintainers (**shown in bold**), so it is necessary to particularly focus on and understand how the implementation of MM-ALR will affect these two user groups.

In summary, the methodology involved the following steps:

- The MM-ALR hazard log was examined for all hazards relevant to the specific user group in question.
- The 'Before and After' scores (i.e. the difference between MM-ALR and the baseline) were reviewed as they could be different for a specific user group.

Finally the hazards with the largest contributing scores were examined to see whether the safety of that specific user group was improved, or not. This was done by:

- Checking whether the highest risk hazards that are relevant to the baseline have a different risk under MM-ALR
- Checking whether this is sufficient to counterbalance the risk of any new hazards introduced by MM-ALR

The conclusion for each user group is presented as a qualitative proposition. The hazard assessment is not suited to a quantitative approach.

4.2.3 Use of Quantitative Assessments

The demonstration of meeting the safety objective is based upon a qualitative risk comparison; a quantitative consideration of the risk change based upon the outputs of the hazard log review has also been included. Care must be taken not to assume that the numerical output represents a higher degree of precision than is possible given the limited accuracy and availability of input data. To avoid such misinterpretation, this document uses the numerical calculations as a tool for guiding the construction of a qualitative argument.

4.2.4 Impact of M42 MM Three Year Safety Review and Value Engineering

The hazard log has been updated to reflect the benefits of MM demonstrated on the M42 MM Scheme [2]. It is expected that the Value Engineering will reduce to some extent the amount of benefit achieved from MM-ALR, and this is reflected in the "change with MM-ALR" scores.

4.3 Demonstration of Meeting the Safety Objective

4.3.1 Achievement of Safety Objective for All Road users

The Demonstration of Meeting the Safety Objective Report [5] demonstrates that the design is likely to meet the safety objective due to:

- A reduction in risk for a significant number (15) of the highest scoring existing motorway hazards (20), due to a controlled environment being provided through a combination of regularly spaced mandatory speed signals, speed enforcement, and comprehensive CCTV coverage
- One highest scoring new MM hazard is introduced (E08/S08 and above) is introduced (Vehicle recovered from ERA)

-
- Three high-scoring existing hazards increase in risk
 - The impact of the new hazards is expected to be countered by the decrease in risk of existing highest scoring hazards
 - Anti-log calculations show that the total score for 'after' represents approximately a reduction of risk of 15% when compared with the safety baseline (no MIDAS).

This analysis suggests that MM-ALR is likely to meet its safety objective.

Further details are provided in the Demonstration of Meeting the Safety Objective Report [5].

4.3.2 Achievement of Safety Objective for Specific Road User Groups

With regard to meeting the safety objective for specific users the assessment demonstrates that MM-ALR reduces the risk of a number of existing hazards for these groups and introduces a number of new hazards. On balance it can be shown that for each of the road user groups considered, with the exception of road workers, the safety objective is likely to be achieved because the reduction in risk for the existing motorway hazards outweighs the increase in risk from the introduction of new hazards related to MM-ALR.

For road workers, improvements are required in the frequency and implementation of maintenance activities before it can be concluded that the safety objective is likely to be achieved or that the risk is managed SFAIRP. However there are indications that the hazards and risks identified can be either eliminated or mitigated so as to be as low as reasonably practicable resulting in the residual risks associated with the operations and maintenance of the MM-ALR layout being no more onerous than for a D3M layout.

Further details are provided in the Demonstration of Meeting the Safety Objective Report [5].

5 Has a Safety management process been followed?

This chapter demonstrates that:

- An appropriate Safety Management System (SMS) has been selected and applied
- The project has been resourced with competent people to carry out the safety work
- A robust safety approvals process is in place

The structure of the argument is illustrated in the GSN diagram in Figure 5-1 below.

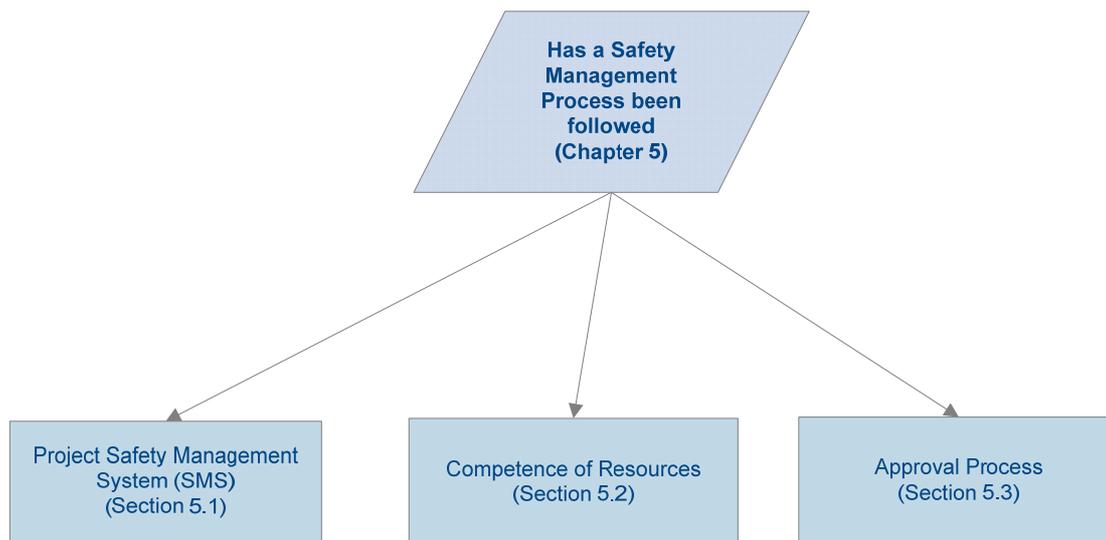


Figure 5-1: Extract of GSN diagram showing how it is demonstrated that an appropriate and robust safety management process has been followed

5.1 Project Safety Management System

5.1.1 Selection of Project Safety Management System

IAN139/11 [6] describes the process by which the SMS is selected for an MM project. It advises that the default position for all MM projects is that they will require a Type B SMS. For MM-ALR the assessment agrees with the advice provided by the Highways Agency that MM schemes require a Type B SMS. Table 5-1 provides a summary.

Feature	Results for project
1. Stakeholder interest	<p>Type C. A number of key stakeholders are involved</p> <p>Key stakeholders include:</p> <ul style="list-style-type: none"> – Highways Agency Network Delivery and Development (NDD) and Traffic Management Division (TMD), – Traffic Officer Service – Maintenance operatives – Emergency services
2. Operational experience	<p>Type B. Experience of (Controlled All Lanes Running) CALR has been achieved on short sections of existing motorway – usually where there is some form of constraint, i.e. hard shoulder discontinuity on M25 Controlled Motorways links. Multi-lane running without a hard shoulder exists on some A-roads (for example sections of the A3, A23 and A45) and some sections of motorway (for example M6 J7-8E). The Controlled Motorways element of the design has also been used on the M25 (which is adjacent to the proposed scheme), M42 MM scheme and BBMM1&2 schemes.</p>
3. Technology	<p>Type B. The technology is used on several sections of motorway, notably M25 J10 to J16, M42 MM and BBMM1&2 schemes.</p>
4. Standards and legislation	<p>Type B. Design requirements for MM-ALR are available through IAN 161</p>
5. Impact on Organisation	<p>Type B/C. The role of control centres will need to be expanded to cover the operation of this section (although this is not considered to be as significant for MM-ALR as it would be for HSR – no hard shoulder opening checks). At a local level changes are expected to be required and training/briefings will be required for relevant staff to inform them of the change.</p> <p>The impact on the Highways Agency as a whole is not considered to be Type C as much of the impact on procedures has already occurred as a result of the M42 MM and BBMM1&2 schemes.</p> <p>Therefore, potentially high impact on a local level, but medium impact on the HA as a whole.</p>
6. Project Scale	<p>Type B. Moderate lengths of the Highways Agency Motorway network are likely to be affected.</p>

Table 5-1: Reasoning for classification decisions for MM-ALR

5.2 Competence of Resources

The work presented in this document has been carried out by the same team that carried out the hazard assessment work on the following Highways Agency projects:

- M42 Managed Motorways (MM)
- Birmingham Box Managed Motorways Phase 1&2 (BBMM1&2) Schemes

This team has competency consistent with the guidance contained in the Remit for Organisation and Governance - National Safety Control Review Group and Project Safety Control Review Group.

5.3 Approval Process

The work presented in this document has been subject to an appropriate internal approvals process, as well as review by appropriate Highways Agency specialists.

The hazard assessment for MM-ALR has been verified at hazard log risk scoring workshops. Further details are provided in the Demonstration of Meeting the Safety Objective Report [5].

6 Have hazards been well managed?

This chapter demonstrates that:

- An appropriate risk assessment methodology, hazard log and set of hazards have been applied;
- All scheme hazards have been analysed;
- The project safety requirements will be identified before construction starts.

The structure of the argument is illustrated in the GSN diagram in Figure 6-1 below.

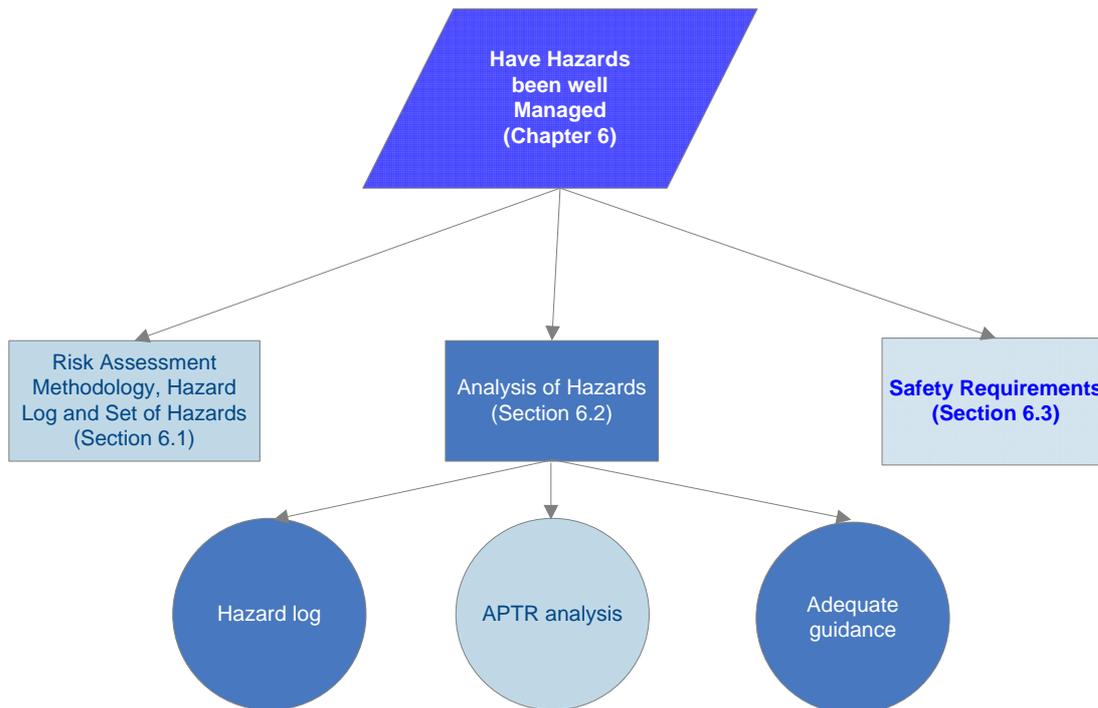


Figure 6-1: Extract of GSN diagram showing how it is demonstrated that hazards have been well managed

6.1 Risk Assessment Methodology, Hazard Log and Set of Hazards

6.1.1 Generic methodology

The risk assessment methodology applied is based on the methodology used for the M42 MM and BB MM 1&2 Schemes and is described in IAN 139/11 [6].

From that generic MM hazard log, a list of specific hazards and their scores has been developed for MM-ALR and documented in Demonstration of Meeting the Safety Objective Report [5]. Hazards were categorised as ‘Event’ or ‘State’ hazards, each hazard consisting of three parameters as detailed in Figure 6-2. The individual scores for the three parameters are then added together to give an overall Risk Score for that hazard (e.g. E09 or S08). It is not possible to do direct risk comparisons of event and state hazards.

For existing hazards, i.e. those hazards that exist both before and after the implementation of the scheme, changes in risk as a result of the scheme implementation are simply added to or taken away from the numeric part of the risk

score. For example, if the before risk for a hazard is scored as E08 and the reduction in risk is 0.2, its after score is E07.8.



Figure 6-1: Calculation of Event and State hazard risk scores

See Appendix C for more details.

6.1.2 Use of M42 MM Scheme Monitoring Results

To provide an evidential basis for scoring the changes in risk that may result from the scheme reference was made to the monitoring results obtained from the M42 MM Scheme [2] (the number of accidents has decreased from an average of 5.08 a month to 2.25 a month; the Accident Severity Ratio has improved by 56% and the Casualty Severity Ratio has improved by 64% indicating that the remaining accidents are resulting in less severe casualties). This was justified on the basis that the proposed scheme shared a number of significant characteristics with the M42 MM Scheme most notable the presence of a controlled environment.

6.2 Analysis of hazards – evidence gathering and assessment

In order to collect evidence to support the hazard analysis a number of studies have been undertaken. Two of these studies have direct relevance to this report. These are:

- All-Purpose Trunk Roads (APTR)/Dual 3-lane Motorway (D3M) Analysis and Hazard Assessment [7]– referred to as the “APTR” report
- Provision of Adequate Guidance Review [8] – referred to the “Adequate guidance” report.

The “APTR” report collected evidence from existing roads in order to better understand the likely safety implications of the road layout component of MM-ALR.

The adequate guidance report considers amongst other issues whether or not the technology elements of MM-ALR are adequate for maintaining a good level of compliance by drivers.

6.2.1 All-Purpose Trunk Roads (APTR)/Dual 3-lane Motorway (D3M) Analysis and Hazard Assessment

The “APTR” report summarised the results of a number of strands of work intended to provide an understanding of the safety challenges involved and to gain a level of assurance of how MM-ALR design would be expected to perform in terms of safety. Three distinct elements of work were undertaken:

- Analysis of accident and casualty data collected from the Dual 3-lane Motorways (which have hard shoulders) and multi-lane All-Purpose Truck Roads (which do not). The purpose of this analysis is to establish the safety implications of converting the hard shoulder to a running lane without any further mitigation. That is, what is the underlying safety risk associated with the MM-ALR road layout.
- Detailed analysis of some of the more significant safety hazards has been undertaken using the accident and casualty data described above. The purpose of this is to ensure that the safety implications of these are as fully understood as possible.
- A Hazard Assessment was undertaken with respect to MM-ALR. This formed the basis of the hazard assessment presented in the demonstration of meeting safety objective report [5]

Analysis of accident and casualty data⁴ collected from all the Dual 3-lane Motorways and multi-lane All-Purpose Truck Roads (APTR) in England indicated that 3-lane APTRs have a rate⁵ of Killed and Seriously Injured (KSI) accidents that is approximately 9% higher than that encountered on the D3M network. With regard to KSI casualties, the rate is approximately 5% higher. These rates take into account the impact of MIDAS queue protection and are therefore measured against a baseline of a D3M without MIDAS.

The implication of the above result is to constrain the possible safety impact of MM-ALR to less than 9% greater than the baseline. This is because the MM-ALR layout shares many of the characteristics of 3-lane APTRs (i.e. no hard shoulder and lay-bys / refuge areas at a maximum of 2.5km intervals).

Detailed analysis of some of the more significant safety hazards concluded that in comparison with D3M links, multi-lane APTR links are characterised by:

- A four to five fold increase in the frequency of vehicle parked in main carriageway accidents.
- An increase in the frequency of accidents involving vehicles leaving the carriageway
- No increase in the frequency of fatigue related accidents
- An increase in frequency of Pedestrian accident

⁴ Personal Injury Accident (2005-2009 validated Stats19) data from the entire Highways Agency D3M, 2-lane and 3-lane APTR road network was used in the analysis. The data was restricted to those occurring on links between junctions as 2-lane and 3-lane APTRs have at grade junctions while the D3Ms do not.

⁵ per Million Vehicle Mile

- No increase in the frequency of Debris related accidents
- An increase in the frequency of accidents involving a motorcycle.

The analysis concluded it is likely that the frequency of vehicle parked in main carriageway and vehicles leaving the carriageway accidents are related to the loss of the Hard Shoulder. However, it is likely that most of the increase in the frequency of pedestrian accidents is due to different levels of access to the road. The reason for the increase in frequency of Motorcycle accidents is less clear and may be due to a number of factors including differences in geometrical standards between the two types of road.

In addition to the above, a more general analysis of data, detailed analysis was also undertaken on three sections of roads which are known to have three lanes without a hard shoulder or substantial hard strip.

The three specified sections are:-

- A3 – Stoke Interchange to Stratford Bridge
- A23 – M23 Junction 11 to Handcross
- A46 – Junction with A249/B4115 to Junction with A45

The analysis of the accident and casualty data collected from the three selected APTR links suggests that 3-lane APTR links are capable of performing at a level of safety comparable with D3M links with similar geometry.

The “APTR report” provided a basis for understanding key hazards could be impacted by the layout of MM-ALR and this has been carried through to the hazard assessment. It particular detailed assessment has been undertaken of the safety risk associated with vehicle parked in main carriageway accidents (i.e. accidents involving vehicles that breakdown in the carriageway)

6.2.2 Provision of adequate guidance review

The “Adequate guidance” report considered the following question:

Is an adequate level of information (guidance) provided to the road user so that he understands how he is expected to behave within the new MM-ALR environment?

It considered a number of sources of information and concluded that:

- Evidence from existing MM-HSR schemes (M42 MM and BBMM1&2) shows a high level of compliance.
- Existing MM-HSR schemes provide more reliable journeys encouraging compliance.
- Evidence from existing MM-HSR schemes (M42 MM and BBMM1&2) shows MM creates a controlled environment.

The report also noted that:

- The level of speed compliance on the M42 MM and Birmingham Box Managed Motorways Phase 1 (BBMM1) schemes has significantly supported the safe and successful operation of the schemes.
- Controlling the speed and behaviour of traffic has enabled the realisation of traffic benefits. In order to achieve a similar level of compliance on an MM-ALR scheme a comprehensive compliance strategy and education campaign will need to be in place.
- MM-ALR scheme will provide additional capacity and help to alleviate any congestion on the section. The additional capacity should result in a higher probability of free driving conditions and therefore there is likely to be less inclination for a driver to change lanes or speed to gain an advantage over other traffic. In addition, if the majority of road users travel at the speed limits then it limits the ability of a minority of road users to speed.
- The introduction of more reliable journeys is a key consideration for the driving public as surveys have indicated that ‘not knowing’ the time a journey is going to take is a major frustration. Therefore making Journey Times reliable day in, day out – even if the average journey time increases by a small percentage – is a key benefit that the existing MM-HSR schemes (i.e. M42 MM Pilot) has delivered to the road user.
- MM-ALR will introduce a reduced level of infrastructure when compared to an IAN 111/09 scheme. Through their whole design the existing MM (IAN 111/09) schemes have encouraged compliance. Through the introduction of additional capacity on an MM- ALR designed scheme there will be a higher probability of free driving conditions than previous and drivers will be encouraged to comply.
- The concept of a controlled environment was to some extent related to the amount of infrastructure and technology introduced through the existing MM-HSR (IAN 111/09) [1] schemes. This will be reduced with an MM-ALR scheme with no fixed hard shoulder cameras and fewer opportunities to provide information. However there will still be comprehensive CCTV coverage and information will be located at spacing which minimises the amount of time that a driver cannot see the next signal/variable message sign.
- MM-ALR will increase the spacing of signalling, and a significant amount of it will come from the verge (the MS4s) rather than overhead for all lanes. Signalling will be regularly spaced and the design of the MM-ALR schemes will result in good forward visibility before the next signal. The location of signs and signals will need to meet a number of design requirements to appropriate provision of information.

In conclusion the “Adequate guidance” report suggests that the environment of MM-ALR (Mandatory signals, VMS and MIDAS) is likely to lead to a level of driver compliance (i.e. responding as appropriate to signs and signals). However, evidence is still being collected (in particular from a driving simulator trial) and until this evidence is collected, the full benefits as highlighted in the M42 MM Three Year Safety Review [2] cannot be relied upon in their entirety. This has been taken account in the hazard assessment.

6.2.3 High Risk Hazards

This section provides information about how the highest risk hazards (those that have a score of S08/E08 and above) are impacted by MM-ALR. Further details can be found in the demonstration of meeting the safety objective report [5]

The highest scoring hazards drive the hazard analysis summarised in Chapter 4 and represent approximately 89% of the total baseline risk.

Table 6-1 presents the change in safety risk for hazards with the greatest risk score:

- 'Green' means a reduction in risk
- 'Red' means an increase in risk
- NEW means that a new hazard has been introduced by MM-ALR

Hazard	Description	Type	Before Safety Risk	After Safety Risk	%age change in Safety Risk	Comments
H10	Driver Fatigued - unable to perceive hazards effectively	Event	E09	E08.98	-2.718	Some benefit during peak of the controlled environment. Considerable benefit from the controlled environment during the peak
H37	Individual vehicle is driven too fast	State	S09	S08.75	-42.72	The number of lane closures per day per motorway mile is 0.22. However, the breakdown rate is 1.56. Assuming that all the breakdowns happen in carriageway. This would imply that the risk of this hazard is 7 times its original rate. However, it is assumed that 50% of vehicle breakdowns will be able to make it to an ERA, dropping the risk to 3.5 times higher. Add in some benefit from setting signals the now rate is assumed to be at least 3 times the
H136	Vehicle Stops in Running Lane - Off Peak (Event)	Event	E08.01	E08.50	216.2	

Hazard	Description	Type	Before Safety Risk	After Safety Risk	%age change in Safety Risk	Comments
						original rate or an increase of more than 200%
H67	Pedestrian in running lane - live traffic	Event	E08.5	E08.4	-20.56	Benefit from the controlled environment. Considerable benefit from the controlled environment during the peak
H91	Tail gating	State	S08.5	S08.20	-49.38	
H129	Vehicle stops in running lane – Peak	Event	E07.68	E08.17	214.06	See H136 above
H76	Rapid change of general vehicle speed	Event	E08.5	E08.15	-54.36	Considerable benefit from the controlled environment during the peak
H52	Maintenance workers setting up and taking down work site	State	S08	S08.1	25.892	Although there is benefit from the controlled environment (setting of signals during set-up and taking-down). The number of times TM is used is likely to increase.
H109	Vehicle drifts off carriageway (i.e. leaving the carriageway as a result of Road Environment)	Event	E08	E08	0	Although traffic is travelling closer to the edge of the carriageway, most of this traffic will be during peak and will be subject to a controlled environment,
H119	Vehicle recovered from ERA	Event	E00	E08	NEW	New hazard
H89	Sudden weaving at exit point	Event	E08	E07.92	-15.42	Some benefit from Controlled Environment
H54	Motorcycles filter through traffic	Event	E08	E07.91	-18.51	Some benefit from Controlled Environment
H13	Driver loses control of vehicle	Event	E08	E07.9	-20.56	Some benefit from Controlled Environment

Hazard	Description	Type	Before Safety Risk	After Safety Risk	%age change in Safety Risk	Comments
H120	Vehicle rejoins running lane	Event	E08	E07.9	-20.56	Trivia stops are reduced and most remaining stops will be in ERAs.
H121	Vehicle reversing along exit slip	Event	E08	E07.9	-20.56	Some benefit from Controlled Environment
H103	Unsafe lane changing Driver ignores closed lane(s) signals that are protecting an incident	Event	E08	E07.82	-32.81	Some benefit from Controlled Environment
H11	Vehicle enters main carriageway unsafely	Event	E08	E07.8	-36.9	More prominent signals can be used to reduce this risk Some benefit from Controlled Environment
H112	TO/ISUO in running lane	Event	E08	E07.79	-37.41	Considerable benefit from the controlled environment and the use of rolling road-blocks
H95	Vehicle stopped on Hard Shoulder (D3M) or verge (MM-ALR)	State	S08	S00	-100	Effectively Eliminated. Trivial stops are reduced and most remaining stops will be in ERAs.

Table 6-1: Change in safety risk for hazards with the greatest risk score

Presented below is a discussion of the very highest scoring hazards (i.e. those with a score of greater than E08/E09).

The two highest scoring hazards, H10 “Driver falls asleep” (E09) and H37 ‘Individual vehicle is driven too fast’ (S09) are applicable to the existing motorway and also post implementation. The M42 MM Monitoring report [2] suggests that there could be a slight reduction in risk and this has been taken into account within the analysis.

However, H37 “Individual vehicle is driven too fast” is expected to reduce significantly in risk post implementation because a controlled environment is provided through a combination of regularly spaced mandatory signal gantries, perceived speed enforcement, and the perceived monitoring by PTZ CCTV cameras.

H136 “Vehicle Stops in Running Lane - Off Peak” and H129 “Vehicle Stops in Running Lane - Off Peak” are likely to see a substantial increase in safety risk. Although the provision of ERAs will off-set a substantial amount of the safety risk. It is anticipated that vehicles will still stop in the running lane. However, these vehicles will be much better

protected through the use of enhanced signals. Notwithstanding this, an increase in risk is anticipated reflecting a substantial increase in frequency.

A change in risk is expected for H67 “Pedestrians in running lane - live traffic”. Although there will be an increase in vehicles stopping in live traffic with the absence of the hard shoulder this will be mitigated by much better and quicker protection of all incidents in live lanes.

The risk from H76 “Rapid change of general vehicle speed” and H91 “Tail gating” are expected to reduce significantly mainly due to the increased capacity provided by HSR at peak times and the controlled environment provided by regularly spaced signal gantries with MIDAS congestion algorithm.

The frequency of H52 “Maintenance workers setting up and taking down work site” is expected to increase under MM-ALR due to the presence of additional equipment and the removal of the hard shoulder.

The frequency for H109 “Vehicle drifts off carriageway” is anticipated to remain the same. It could be anticipated to reduce significantly in line with the M42 MM Three Year Safety Review results [2]. However, with the absence of a hard shoulder it is considered appropriate to anticipate that MM-ALR will have a neutral effect.

One new high scoring hazard is introduced (H119 “Vehicle recovered from ERA”)

6.2.4 Lower risk hazards

The scoring and analysis of lower risk hazards is covered in the demonstration of meeting the safety objective report [5]

6.3 Safety Requirements

The hazard assessment has generated/confirmed a number of safety requirements. These are presented in Table 6-2.

Reference	Responsible	Safety Requirement
'Strategic' Safety Requirements		
Situational awareness / creation and maintenance of a 'Controlled environment'		
SR-01	HA/Design	Signal sequencing rules must facilitate the required signalling outcomes in response to manual or automatic primary signal settings, and be appropriate for the signal / message sign spacing and operating speed.
SR-02	Design	For the prevailing traffic conditions, motorists shall be given clear instruction on which lane(s) to use. These instructions must facilitate vehicle movements (from lane to lane) in a controlled and safe manner.

Reference	Responsible	Safety Requirement
SR-03	Design	Variable mandatory speed control must be provided.
SR-04	Design	An automatic queue protection system (e.g. MIDAS) to alert both operators and road users of changes in traffic conditions must be provided.
SR-05	Design/Operator	An enforcement strategy must be implemented to ensure creation and maintenance of a 'controlled' environment.
SR-06	Other	A monitoring strategy must be in place to enable the creation and maintenance of the required network and safety performance data
SR-07	Other	Stakeholder engagement must be designed to facilitate and support effective education and encouragement of road users
'Tactical' Safety Requirements		
Maintenance:		
SR-10	Design	All equipment must be designed to eliminate or minimise the need for maintenance and reduce the exposure for road workers SFAIRP (So Far As Reasonably Practicable).
SR-11	Design	Roadside equipment requiring maintenance should, where practicable, be clustered and an appropriate access strategy put in place minimising the need for temporary traffic management in live lanes.
SR-12	Maintainer	Maintenance contractors must be trained and competent in the appropriate maintenance procedures.
SR-13	Maintainer	Winter treatment must include all designated refuge areas.
SR-14	HA / Designer	Faults that impact on the safe and efficient operation of the system shall be defined and response / repair times incorporated into relevant contracts in accordance with their impact.

Reference	Responsible	Safety Requirement
SR-15	Maintainer	Sightlines must be effectively maintained to signs and signals
Scheme Operation		
SR-20	Operator	Procedures and guidance must be appropriate and effective for safe operation
SR-21	Operator	<p>Traffic Officers must be trained and competent to work in accordance with the latest National Procedures and the Operational Procedures and Guidance provided within the MM Manual</p> <p>Operators must be trained in the MM-ALR scheme procedures. They must also be competent in carrying out the procedures and guidance.</p>
SR-22	Operator	Operators must have instantaneous access to the current Procedures and Guidance at all relevant workstations.
SR-23	Operator	The interfaces with Emergency Services must be effective and must allow them to carry out their functions
SR-24	Operator	Procedures shall use a consistent lane referencing system across a scheme.
SR-25	Operator/Maintainer	A system must be established to operationally manage the access and actions of maintenance personnel.
Technology		
SR-30	Design	Software/hardware must be in accordance with Highways Agency standards
SR-31	Design	Software development procedures and testing must be in accordance with Highways Agency standards.
SR-32	Design	All site and system data must be maintained under strict version control.
SR-33	Maintainer	After maintenance activity has been carried out on the technology system and / or equipment, tests shall be carried out to re-commission them to the 'as-built' / as-commissioned.

Reference	Responsible	Safety Requirement
SR-34	Design	Comprehensive Closed Circuit Television (CCTV) camera coverage must be provided of the carriageway (including refuge areas). Comprehensive is defined as the ability of operators to see up to 95% of the total scheme area and be able to interpret the images correctly. It is noted that it is sometimes impractical to provide 100% CCTV coverage eg: signs or bridges may obscure part of the view. 95% coverage and the absence of any blind spots at refuge areas, ERTs and locations where a broken down vehicle would not be able to leave the carriageway (e.g. a viaduct) is therefore acceptable.
Infrastructure		
SR-40	Design	Fixed signage must be provided directing motorists to ERTs.
SR-41	Design	Marker posts must direct users to ERTs such that their exposure to risk is minimised
SR-42	Design	Safety barrier must only be installed where necessary, i.e. gaps should not be necessarily closed.

Table 6-2: Safety Requirements

7 Conclusion

This document is the Generic Safety Report for MM-ALR. The objective of the document is to demonstrate that the appropriate level of safety management has been undertaken to assess the expected safety outcome for the implementation of MM-ALR.

The information presented in this report demonstrates that:

- **A safety objective has been set for the scheme and is likely to be achieved**
 - A safety objective has been set for MM-ALR for road users and road workers.
 - The safety baseline for the scheme has been set as “a dual 3-lane motorway before implementation with MIDAS queue protection”.
 - A robust methodology has been used to demonstrate whether the safety objective can be achieved. The methodology is based on the methodology used for the M42 MM and BBMM1&2 Schemes (the foundation for the demonstration of meeting the safety objective is the risk assessment methodology which is documented in IAN139/11 [6]).
 - The demonstration of meeting safety objective based on the use of a scheme specific hazard log.
 - For individual populations, with the exception of road workers the relevant safety objectives are likely to be achieved. However, for road workers further work is required on reducing the frequency and risk associated with maintenance before it can be demonstrated that their risk has been managed So Far As Is Reasonably Practicable. However, there are indications that the hazard and risk identified can be either eliminated or mitigated so as to be low as reasonably practicable resulting in the residual risks associated with the operations and maintenance of the MM-ALR layout being no more onerous than for a D3M layout.
- **An appropriate Safety Management Process has been selected for the project and has been applied**
 - An appropriate SMS has been selected and applied in accordance with Highways Agency PSRM Work Instructions, IAN139/111 [6] MM-ALR has been classified as ‘Type B’.
 - The project has been resourced with competent people to carry out the safety work.
 - A robust safety approvals process is in place to approve safety documents, in particular for key safety documents.
- **Hazards are well managed**
 - An appropriate risk assessment methodology consistent with the M42 MM and BB MM 1&2 Schemes and IAN139/11 [6], has been used.
 - The MM generic hazard log has been used as the starting point to develop a list of hazards applicable to MM-ALR.

-
- All identified scheme hazards have been assessed and the risk level they present has been determined.
 - Project safety requirements have been confirmed.

It can be concluded from the information summarised in this Safety Report that the objective to “demonstrate that the appropriate level of safety management has been undertaken to assess the expected safety outcome for the implementation of MM-ALR” has been met. However, there are indications that the hazard and risk identified can be either eliminated or mitigated so as to be low as reasonably practicable resulting in the residual risks associated with the operations and maintenance of the MM-ALR layout being no more onerous than for a D3M layout.

8 References

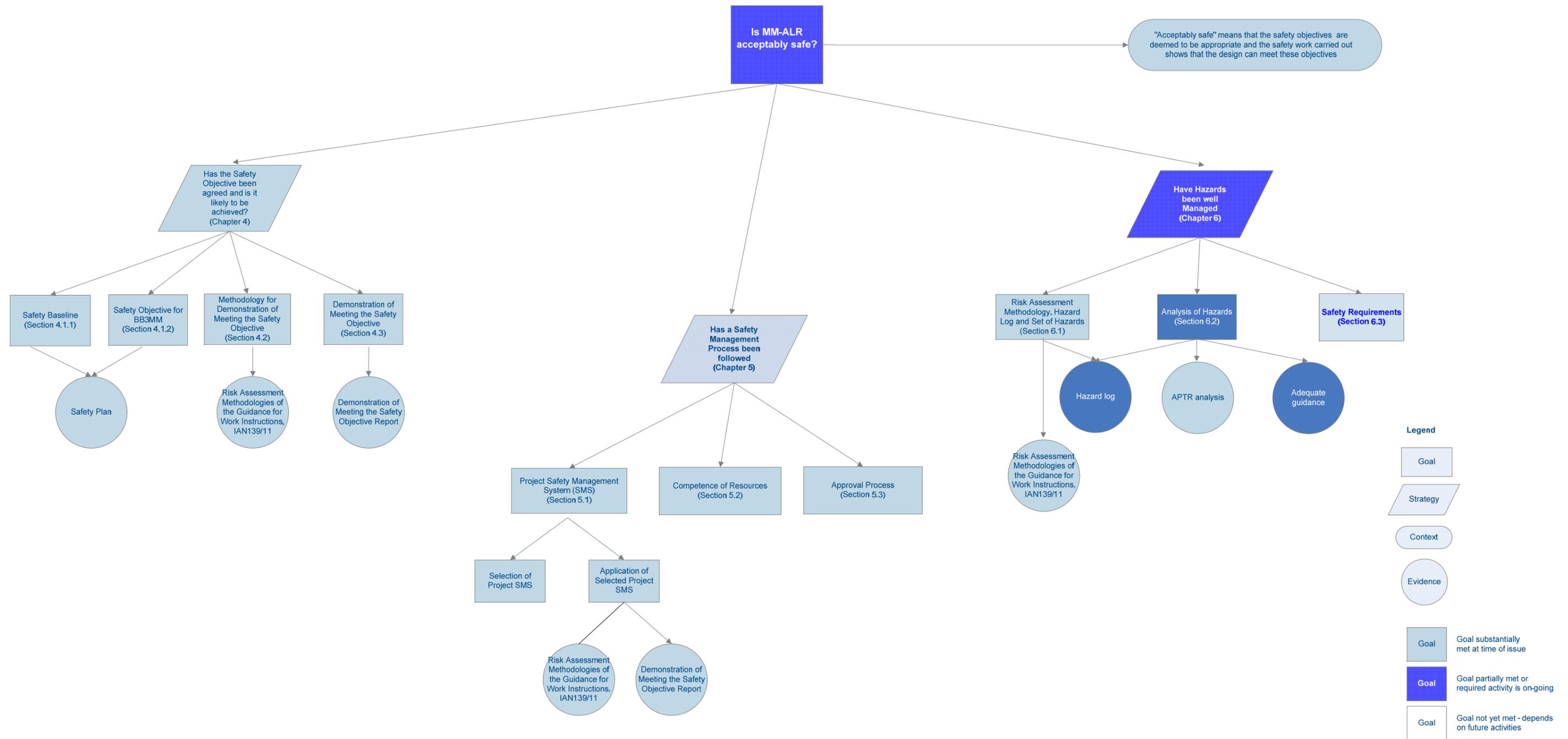
[1]	Interim Advice Note 161/12, Managed Motorway – All lanes running
[2]	M42 MM Monitoring and Evaluation, Three Year Safety Review, HCG, January 2011
[3]	Interim Advice Note 111/09, Managed Motorway Implementation Guidance - Hard Shoulder Running
[4]	Interim Advice Note 112/08, Managed Motorways Implementation Guidance - Through Junction Hard Shoulder Running
[5]	MM-ALR Demonstration of Meeting the Safety Objective Report, 1039092/DMS/017
[6]	Interim Advice Note 139/11 Managed Motorways Project Safety Risk Work Instructions.
[7]	All-Purpose Trunk Roads (APTR)/Dual 3-lane Motorway (D3M) Analysis and Hazard Assessment, 1039092/ATA/035
[8]	MM-ALR Provision of Adequate Guidance Review, 1039092/AGR/042

Appendix A: glossary of terms and abbreviations

Acronym	Description
AM	Access Management
APTR	All Purpose Trunk Road
ATM	Active Traffic Management
BB3MM	Birmingham Box Phase 3 Managed Motorways
BBMM1&2	Birmingham Box Managed Motorways Phases 1 and 2
CCTV	Closed Circuit Television
CDM	Construction (Design & Management)
CM	Controlled Motorway
D3M	Dual 3-lane Motorway
DHS	Dynamic Hard Shoulder
DMRB	Design Manual for Roads and Bridges
ERA	Emergency Refuge Area
ERT	Emergency Roadside Telephone
FWI	Fatal and Weighted Injury
GALE	Globally At Least Equivalent
GSN	Goal Structured Notation
HA	Highways Agency
HGV	Heavy Goods Vehicle
HSR	Hard Shoulder Running
KSI	Killed, Seriously Injured
LGV	Large Goods Vehicle
LBS	Lane Below Signal
MAC	Managing Agent Contractor
MHS	Maintenance Hard Standings
MIDAS	Motorway Incident Detection and Automatic Signalling
MM	Managed Motorways
MM-ALR	Managed Motorways – All Lanes Running
MM-HSR	Managed Motorway – Hard Shoulder Running
MS4	Motorway Signal Mark 4
MSA	Motorway Service Area
NDD	Highways Agency, Network Delivery and Development
NetServ	Highways Agency, Network Services Directorate
NSCRG	National Safety Control Review Group
OGC	Office of Government Commerce
ORR	On Road Resource
PCF	Product Control Framework
PIA	Personal Injury Accident
POPE	Post Opening Project Evaluation

Acronym	Description
PSA	Public Service Agreement
PSCRG	Project Safety Control Review Group
PSRM	Project Safety Risk Management
PTZ	Pan-Tilt-Zoom
RCC	Regional Control Centre
RSA	Road Safety Audit
SFAIRP	So Far As Is Reasonably Practicable
SGAR	Stage Gate Assessment Review
SME	Small Medium Enterprise
SMS	Safety Management System
SRO	Senior Responsible Owner
TechMAC	Technology Managing Agent Contractor
TJR	Through Junction Running
TOS	Traffic Officer Service
TP	Triple Package
TMD	Highways Agency, Traffic Management Directorate
VMS	Variable Message Sign
VMSL	Variable Mandatory Speed Limit

Appendix B: GSN diagram for the MM-ALR safety report



Legend

- Goal (light blue rectangle)
- Strategy (light blue parallelogram)
- Context (light blue rounded rectangle)
- Evidence (light blue circle)

Goal status legend:

- Goal (light blue rectangle): Goal substantially met at time of issue
- Goal (dark blue rectangle): Goal partially met or required activity is on-going
- Goal (white rectangle): Goal not yet met - depends on future activities

Appendix C: Risk Assessment Methodology

The risk assessment methodology is based on deriving safety risk scores for each hazard by adding together individual parameters.

Hazards are categorised as either an 'Event' or a 'State'.

Event hazard risk scores are evaluated by adding together a score for each of the following three factors:

- The rate at which the hazard is expected to occur
- The probability that the hazard causes an incident
- The severity of the incident

State hazard risk scores are evaluated by adding together a score for each of the following three factors:

- The likelihood that the hazardous state is present
- The rate at which incidents occur if the hazardous state is present
- The severity of the incident, which is the same as for event hazards

Therefore, Risk scores for both Event and State hazards consist of three parameters as shown in figure AC.1 below. The individual scores for the three parameters are then added together to give an overall Risk Score for that hazard. However, the risk 'score' is based on a logarithmic scale, which is explained in more detail below.

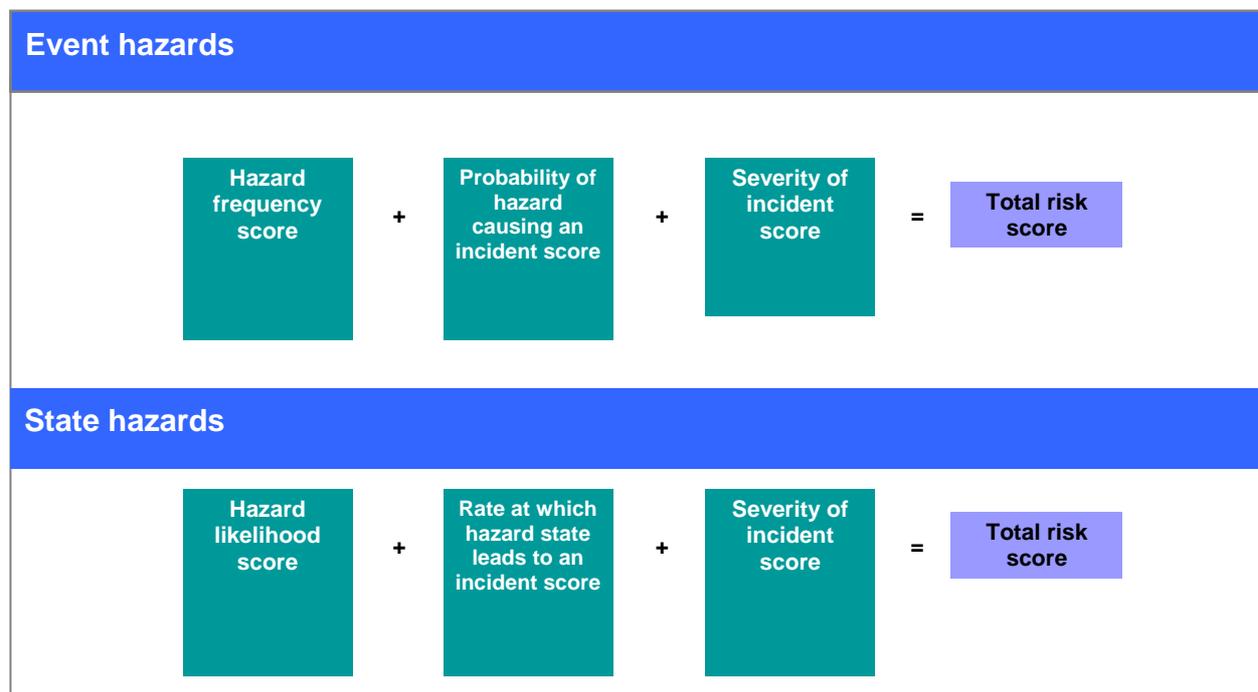


Figure AC.1: Risk Score Components

C.1 Index Values used for Event Frequency and State Likelihood

The values that are actually entered into the hazard log database for these parameters are known as 'Index Values'. These can be explained by looking at the Frequency and Likelihood parameters.

Event Frequency

The index values used for an Event Frequency are shown in Table AC.2.

Frequency Classification	Nominal Value: Occurrences/year/mile	Index Value
Very frequent	1000	6.0
	316	5.5
Frequent	100	5.0
	31.6	4.5
Probable	10	4.0
	3.16	3.5
Occasional	1	3.0
	0.316	2.5
Remote	0.01	2.0
	0.00316	1.5
Improbable	0.001	1.0
	0.000316	0.5
Incredible	0.0001	0.0

Table AC.2: Frequency classifications and Index Values

So if an Event Hazard is expected to occur 100 times a year on a mile of motorway (of the scheme), the value that is entered in the database is 5.0. However, if it occurs 10 times a year an Index Value of 4.0 is entered.

This 'logarithmic' scale of scoring is used to cover the necessary range of values and then present them in a manageable form. An increase of 1 in a score therefore represents a factor of 10 increase in the risk.

Therefore if an Event Hazard has the following Index Values for each of its parameters;

- Frequency Index Value = 5.0,
- Probability Index Value = 1.0
- Severity Index Value = 1.0

Its overall Score is E7.0

State Likelihood

The index values used for State Hazard likelihoods are shown in Table AC.3.

Likelihood Classification	Interpretation	Index Value
Very frequent	At least 1 occurrence present at any one time per Motorway mile.	6.0
	Present 115 days per year per Motorway mile	5.5
Frequent	Present 36.5 days per year per Motorway mile	5.0
	Present 11.5 days per year per Motorway mile	4.5
Probable	Present 3.65 days per year per Motorway mile	4.0
	Present 1.15 days per year per Motorway mile	3.5
Occasional	Present 9 hours per year per Motorway mile	3.0
	Present 3 hours per year per Motorway mile	2.5
Remote	Present 50 minutes per year per Motorway mile	2.0
	Present 15 minutes per year per Motorway mile	1.5
Improbable	Present 5 minutes per year per Motorway mile	1.0
	Present 90 seconds per year per Motorway mile	0.5
Incredible	Present 30 seconds per year per Motorway mile	0.0

Table AC.3: Example of Likelihood Classification of State Hazards and Index values

So if an Event Hazard is expected to be present 9 hours per year on a mile of motorway (of the scheme), the value that is entered in the database is 3.0. However, if it occurs 11.5 days per year, an Index Value of 5.0 is entered.

If a State Hazard has the following Index Values for each of its parameters;

- Likelihood Index Value = 4.0
- Rate Index Value = 1.0
- Severity Index Value = 2.0

Its overall Score is S7.0

The Index Values used for the other parameter are defined in the following subsections.

C.2 Index Values used for Event Probability and State Rate

The values used for Event Probability and State rate are presented in Table AC.4.

Probability that an Event/State causes collisions			
Classification	Events	Value	States
	If this hazard occurs then:		This hazard, if present, will:
Certain	A collision is certain	4	Definitely causes a collision
Probable	A collision is probable	3	Frequently causes a collision
Occasional	A collision will occasionally happen	2	Occasionally causes a collision
Remote	There is a remote chance of a collision	1	Infrequently causes a collision
Improbable	A collision is improbable	0	Rarely causes a collision

Table AC.4: Event/State Collision Probability rates

C.3 Index Values used for severity

The values used for severity for both Event and State hazards are presented in the Table AC.5

Severity Classification	Interpretation	Index Value	Person outside of vehicle	Stationary Vehicle	Motorcycle	Car	Large Vehicle (LHV, HGV, Bus)
Severe	The proportion of collisions that are fatal is expected to be higher than average by at least a factor of 10	2.0	Involved	Involved	Involved	Speed differential approx 60 mph	Speed differential approx 50 mph
Higher than average	The proportion of fatal collisions is expected to be higher than average by a factor between 3 and 10	1.5	No involvement	No involvement	No involvement	Speed differential approx 50 mph	Speed differential approx 40 mph
Average	The distribution of collisions (i.e. ratio of damage-only to fatal) is expected to be similar to the highway average	1.0	No involvement	No involvement	No involvement	Speed differential approx 40 mph	Speed differential approx 30 mph
Lower than average	The proportion of fatal collisions is expected to be lower than average by a factor between 3 and 10	0.5	No involvement	No involvement	No involvement	Speed differential approx 30 mph	Speed differential approx 20 mph
Minor	The proportion of collisions that are fatal is expected to be lower than average by at least a factor of 10	0.0	No involvement	No involvement	No involvement	Speed differential < 20 mph	Speed differential < 10 mph

Table AC.5: Event/State severity scores