Guidance on the preparation and use of company risk assessment profiles for transport operators

As required by The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS)
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1 Overview

1.1 Purpose

This document has been produced to give guidance to transport operators on how to prepare and maintain risk assessments covering their operations. The principles described represent a good practice approach to risk assessment and is designed to help ensure:

a) A consistent and robust approach is taken to risk assessments
b) Transport operators select appropriate risk assessment techniques
c) Best use is made of current industry risk information e.g. the Safety Risk Model (SRM) and supporting templates; both developed and supported by RSSB
d) Risk is reduced to a level that is as low as reasonably practicable (ALARP) via a practical and effective ALARP demonstration

1.2 Scope

This guidance document considers:

a) The purposes of risk assessment (Section 2)
b) The legislative requirements for risk assessment (Section 3)
c) What safety risk assessment is (Section 4.1)
d) Possible risk assessment methods, including consideration of the definition of ‘suitable and sufficient’ (Sections 4.2 and 6)
e) Criteria for assessing the results of risk assessments and ensuring that risk is reduced to ALARP (Section 5.3)
f) The type of risk assessment information records that should be kept (Section 5.4)

This guidance document replaces GE/GN8561 ‘Guidance on the Preparation of Risk Assessments within Railway Safety Cases’. GE/GN8561 was written to be consistent with the Railway (Safety Case) Regulations 2000 which were superseded by the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS).

Although the legislative framework has changed the fundamental principles and methods applied throughout the industry for undertaking risk assessment have not. The process described in this document continues to represent a good practice approach to undertaking company risk assessments.
The development of risk assessment methods and techniques is an ongoing process. In carrying out their risk assessment it is possible that a transport operator will:

a) Develop or refine the methodologies outlined in this guidance document for their particular operation

b) Make improvements to the SRM templates, or

c) Identify new hazardous events and precursors not considered within the current version of the SRM.

RSSB welcomes any questions, comments and examples of good practice that can be considered for inclusion in future versions of this guidance document, the SRM and its templates. All feedback should be e-mailed to: risk@rssb.co.uk. RSSB is able to provide direct support to its members in the application of the processes described in this document, and through this process actively facilitates such enhancements.

1.2.1 Definitions

Definitions of terms have been provided in the text. Additional references have also been added to Section 7 Glossary and references. Where an online definition of a term is available, a hyperlink has been added to the glossary. Hyperlinks are also included in the references and further reading section to facilitate access to documentation.

Hyperlinks were functional at the time of publication; they will be periodically tested and the guidance updated accordingly.

1.2.2 Exceptions/limitations

This guidance refers only to the assessment of safety risk, i.e. the identification and quantification of the risk associated with events that can lead to injury or death to people from the operation or maintenance of the railway. Methodologies specifically associated with occupational health issues, economic (production loss) and environmental risk assessment are not addressed.

1.2.3 Acceptance and Approval

This document was developed by the RSSB, in partnership with the Safety Risk Model Practitioners Working Group (SRM-PWG), who reviewed the contents in June 2009.

1.3 Keeping the contents up to date

This is issue 1 of this guidance document, published in July 2009. As time goes by changes to the contents of this guidance document will be made to keep it up to date and in line with current requirements. The current version will always be available at www.safetyriskmodel.co.uk. Changes to the document will be explained within a chapter dedicated to updates in future issues.
2 Purpose of a transport operator’s risk assessment

The main purposes of a transport operator’s risk assessment are to:

a) Meet the requirements of health & safety legislation as described in Section 3

b) Help ensure that company managers and staff identify and understand all aspects of the risk associated with their operation (the potential hazardous events, causes, control measures and consequences that can influence their operation)

c) Provide confidence that a system can be operated safely given the equipment, facilities, safety management system and operating strategy in place

d) Identify, understand and control the interfaces with other companies and related operations that can affect the safe operation of a system

e) Assist in the identification of new control measures that could be used to reduce risk

f) Help direct the development of company safety plans and associated safety objectives

g) Assess the change in risk which could result from a change in the operating strategy or following alterations/renewal of a system

h) Enable resources to be directed effectively to achieve the maximum risk reduction

i) Help determine the requirements and areas requiring safety audit and other monitoring measures

j) Enable a company to demonstrate that the level of risk associated with its operation is controlled to a level that is ALARP

k) Provide a basis for continuous safety review and improvement

l) Provide an input into the development of wider industry controls and standards

Most risk assessments, particularly for hazardous events of low frequency with potentially high consequences, require a level of risk quantification or ranking. This has the potential to become overly detailed and sophisticated and it should be emphasised that the qualitative aspects of the risk assessment and the dissemination of this information throughout a company provide the most significant potential benefit from the risk assessment, in terms of:

a) Improved awareness of such events,

b) The ways in which failures can be prevented, controlled or managed, and

c) The consideration of additional control measures.

All risk assessments contain uncertainties and therefore their results can only be used as a guide to the level of risk within the bounds of the uncertainty. The results of such assessments should therefore only be used as an input into decision making and should not be the sole basis for making a decision.
3 Legislative requirements for risk assessment

The key requirements for risk assessment are detailed within the following legislation –

The Health and Safety At Work Act 1974

The requirement to undertake risk assessment originates from the Health and Safety at Work, etc Act 1974 which places general duties on employers to provide employees and non-employees, including members of the public, with a safe and healthy workplace, working environment, safe systems of work, safe plant and equipment, and adequate information, instruction, training and supervision ‘so far as is reasonably practicable’.

The Management of Health and Safety at Work Regulations 1999 (MHSWR)

MHSWR state that ‘Every employer shall make a suitable and sufficient assessment of:

a) The risks to the health and safety of his employees to which they are exposed whilst they are at work, and

b) The risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking.’

‘Suitable and sufficient’ is not defined in the regulations but practical examples are given in the guidance to the regulations.

The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS)

ROGs places a specific duty on transport operators to carry out a ‘suitable and sufficient’ assessment of the safety risks involved in running their operation. The purpose of this assessment is to identify the measures needed to make sure the operation runs safely. ROGS gives transport operators some additional duties -

a) Measures identified as necessary by risk assessment must be put in place.

b) Records must be kept of:

i) The assessment process, including methods used of any calculation and any assumptions made.

ii) The significant findings of the risk assessment including the measures in place and any further measures the transport operator intends to take to ensure safe operation of the transport system in relation to his operation.

iii) The arrangements for planning, organising, controlling, monitoring and reviewing these measures.

c) The assessment must involve working with any related operators to tackle risks that arise from the ‘interfaces’ between operators.
Note
In addition to the requirements covering existing operations, ROGS also places a duty on transport operators to undertake an assessment of risk prior to any new vehicles or infrastructure being placed in service. This is not the focus of this document although some guidance on the selection of risk assessment in this area is provided in Section 6.

4 What is a risk assessment?

4.1 Definition
Risk is defined as being the rate of the occurrence of a hazardous event causing harm (the frequency) and the degree of severity of the harm (the consequence).

A risk assessment is a systematic and structured process for:

a) Identifying the hazardous events which have the potential to cause injury or death to passengers, workers and members of the public who are directly or indirectly exposed to the operation and maintenance of the railway.

b) Identifying the precursors i.e. the component, sub-system or system failures, physical effects, human error failures or operational conditions, which can result in the occurrence of each hazardous event.

c) Identifying the control measures that are in place to control or limit the occurrence of each precursor that cannot be eliminated.

d) Estimating the frequency at which each precursor and hazardous event can occur.

e) Estimating the consequences in terms of injuries and fatalities that could occur for the different outcomes that may follow the occurrence of a hazardous event. This would include identifying the control measures that are in place to control or limit:

i) The occurrence of each escalation factor that cannot be eliminated, and

ii) The consequences of the hazardous event.

f) Estimating the overall risk associated with each hazardous event.

g) Estimating the individual risk associated with exposed group(s) (as defined in Appendix E).

h) Identifying any additional control measures required to ensure that risk is ALARP.

i) Providing clear and comprehensive documentary evidence of the methodologies, assumptions, data, judgements and interpretations used in the development of the risk assessment and the analysis of its results.
4.2 Types of risk assessment

4.2.1 Overview

Risk assessment is used to support professional judgements about safety. Risk assessments can be of a qualitative or quantitative nature.

‘Qualitative’ refers to descriptive analysis and judgements about the factors relevant to risk. ‘Quantitative’ refers to numerical estimates and analysis of risk. In practice most analyses are based on elements of both. The two categories of analysis have the following common characteristics -

a) The effort and rigour of analysis are proportionate to the complexity and importance of the decision

b) The skills and competence used are relevant to support each judgement in the process

c) A person or group is identified as responsible for the assessment, taking account of all relevant judgement and analysis, and structured processes are used where appropriate

d) The evidence on which the assessment was based, and the reasoning used to interpret that evidence, are recorded. The records will again reflect the complexity and scale of the decision, (ranging for example from meeting minutes to a full formal analysis and report)

e) A degree of independent review or challenge may be necessary.

4.2.2 Qualitative analysis

Qualitative risk analysis commonly takes two forms in the railway industry; expert judgement, and qualitative risk ranking.

a) Expert Judgement

In many cases in the railway industry, decisions about safety are made by gathering together the relevant experts to discuss an issue and agree a sensible safety argument and resolution. Various structured techniques might be applied to support such discussions, for example; surveys, questionnaires, consultations, incident data trends etc. The record of such discussions, describing the problem or hazard, and the agreed resolution for it, represents a type of qualitative analysis.

b) Qualitative Risk Ranking

Risk ranking is a method of scoring hazardous events according to the frequency and the severity of their potential consequences. It is often used in combination with a risk ranking matrix, which is a simple method of representing the important hazardous events in terms of their risk graphically.
The aim is to order the hazards on the basis of how likely it is that each will lead to harm. Risk ranking matrices can be qualitative, or semi-quantitative. Qualitative risk ranking matrices use subjective categories for assigning frequency and consequence rankings and estimating risk (e.g. ‘high’, ‘medium’ or ‘low’ risk). Qualitative risk ranking matrices should only be used for low risk hazards that are well understood and their use is not specifically recommended for any of the activities described in this guidance note.

Matrices are used to rank hazards in order of their estimated risk, not to gain any understanding of absolute risk.

4.2.3 Quantitative analysis

The estimation of risk is sometimes undertaken numerically using a quantified risk assessment (QRA). This will comprise analysis supported by available data and the use of expert judgement. QRA is useful because it provides an objective basis for decisions and provides some bounds to the risk assessment. It also helps the analyst to understand the potential accident sequences that must be prevented and this helps with the identification of preventative measures. However, it is worth noting that there are some pitfalls that any decision taker using the outputs of such an assessment to inform a decision needs to be aware of. In particular:

a) Stating numerical risk estimates can sometimes lead to a false perception that the figures are precise. They are normally only indicative estimates.

b) Risk can vary greatly depending on the particular situation or location. The assumptions underpinning a risk assessment need to reflect the particular circumstances in which the risk is considered. Anyone using such analyses to inform a judgement should be aware of the weaknesses, sensitivities, and assumptions of the model so that they can be factored into the judgement that the QRA influences.

In Appendices A-C three types of quantitative or semi-quantitative analysis are described:

a) The SRM Templates

RSSB have developed the template risk assessment tool to allow Transport Operators to draw upon the SRM structure and data, and their own data, to develop a quantified risk profile more quickly and easily than would otherwise be possible. It is important for those using the templates to understand the degree of applicability the approach has to their particular operations (more information regarding this can be found in Section 6) and where the approach might need to be supplemented.
The templates have been designed so that they are relevant for all of the following groups:

- Passenger train operators.
- Freight train operators.
- Infrastructure managers and contractors

Collectively known as transport operators

A more detailed description on how to apply the templates to support risk assessment is provided in Appendix A

**Note:** The SRM calculates risk in units of average number of fatalities and weighted injuries (FWIs) that could occur per year on the railway (within the boundaries set out in 5.1.1). It can be calculated as the product of how often an event is likely to occur per year (the event frequency) and the FWIs that would be expected should an event occur i.e.:

\[ \text{Frequency of Hazardous Event} \times \text{The consequences given the event occurs} = \text{Collective Risk} \]

To demonstrate what this looks like in practice, some example results of a risk assessment for a series of hazardous events are shown in the table below.

<table>
<thead>
<tr>
<th>Hazardous event description</th>
<th>Frequency (Events per year)</th>
<th>Consequences (No. of FWIs per event)</th>
<th>Collective Risk (Expected FWIs per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collision between two trains</td>
<td>1.8</td>
<td>3.32</td>
<td>5.97</td>
</tr>
<tr>
<td>2. Collision of train with object on line - no derailment</td>
<td>49.7</td>
<td>0.006</td>
<td>0.3</td>
</tr>
<tr>
<td>3. Collision between two trains in station</td>
<td>6.0</td>
<td>0.025</td>
<td>0.15</td>
</tr>
<tr>
<td>4. Collision with buffer stops</td>
<td>40.9</td>
<td>0.029</td>
<td>1.2</td>
</tr>
<tr>
<td>5. Train collision with road vehicle on level crossings</td>
<td>21.5</td>
<td>0.28</td>
<td>6.02</td>
</tr>
<tr>
<td>6. Train derailment</td>
<td>14.3</td>
<td>0.30</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Total collective risk from these 6 hazardous events = 17.9

Note: The numbers quoted in the table above are examples only

b) Semi-Quantitative Risk Ranking Matrices

A suggested approach to the use of risk ranking matrices is described in Appendix B. This approach could be used by operators to estimate the risk from their hazardous events, in situations or circumstances where the SRM templates cannot be used, for example where the activities are distinctly different from a typical transport operator.

c) Fault tree and Event Tree Analysis

For high risk hazards and locations, and for situations where there is little operational data or understanding of a safety issue, there may be a requirement to undertake more detailed and targeted quantified risk assessment using techniques such as fault and event tree analysis. This work is likely to be time-consuming and requires risk modelling expertise. Further guidance on this can be found in Appendix C.
5  **Key elements of risk assessment**

Regardless of what risk assessment analysis you use (qualitative, quantitative or a mixture of both) the following key elements should always be included in the process.

5.1  **Risk assessment input data**

Data relating to the operation being analysed is a key input into the risk assessment process. In order to improve the accuracy of the risk assessment and to ensure local factors are accounted for, wherever possible data relating directly to the transport operator's own operation should be used.

The primary source of data for the railway industry is the Safety Management Information System (SMIS) maintained on behalf of the railway industry by RSSB.

If there is only limited data available in SMIS (often the case for transport operators with small unique operations), consideration could also be given to widening the data gathering to include some or all of the following sources of data.

- RSSB Quarterly/Annual safety performance reports
- Monthly SPAD reports RSSB & ORR
- RSSB special topic reports
- CIRAS Data
- RAIB Investigation Reports
- Local incident failure databases
- Risk Assessments undertaken for the development of RGS
- Personal experience from staff
- Risk Profile Bulletin
- ORR Annual Reports
- Transport Operators own data
- External sources, e.g. non UK operations or from outside of the railway industry

Note: Sources of data should always be referenced in the risk assessment
5.1.1 Safety Risk Model (SRM)

The SRM is a comprehensive mathematical representation of 120 hazardous events affecting passengers, workers and members of the public (MOPs) that could lead directly to injury or fatality on the railway within the following boundaries:

<table>
<thead>
<tr>
<th>In SRM Scope</th>
<th>Not in SRM Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>People</strong></td>
<td></td>
</tr>
<tr>
<td>• Passengers on trains</td>
<td>• The risk to staff due to long term occupational health issues.</td>
</tr>
<tr>
<td>• Passengers at stations within areas to which they have legitimate access.</td>
<td>• Risks associated with terrorist activity.</td>
</tr>
<tr>
<td>• Railway workers on trains</td>
<td></td>
</tr>
<tr>
<td>• Railway workers in public areas at stations</td>
<td><strong>Yards, sidings and depots</strong></td>
</tr>
<tr>
<td>• Railway workers working on or near the line</td>
<td>• Events occurring within yards, sidings and depots. However those events relating to the movement of trains entering and leaving yards, sidings and depots, and events relating to the condition of trains joining the system from the depots are included.</td>
</tr>
<tr>
<td>• Railway workers in Signal Boxes, Signalling Centres and Electrical Control Offices</td>
<td></td>
</tr>
<tr>
<td>• Railway workers involved in road traffic accidents while on duty.</td>
<td><strong>In stations</strong></td>
</tr>
<tr>
<td>• MOPs (not passengers) outside, but affected by the mainline railway or legitimately crossing the mainline railway (i.e. on a level crossing).</td>
<td>• Non-public areas at stations, i.e. the work side of a ticket office. However members of the workforce assaulted by a MOP who is in the public side of the ticket office are included.</td>
</tr>
<tr>
<td>• MOPs who enter the mainline railway with no legitimate purpose (e.g. tresspassers, including passengers who enter areas for which they have no legitimate access).</td>
<td>• Retail outlets within stations.</td>
</tr>
<tr>
<td>• Events associated with vandalism and MOPs falling or tresspassing on the mainline railway.</td>
<td>• Station toilets.</td>
</tr>
<tr>
<td>• Suicides and MOP assaults are quantified but not included in the overall results discussion.</td>
<td>• Everything roadside of a station e.g. car parks, access roads, forecourts, taxi ranks etc.</td>
</tr>
<tr>
<td><strong>On trains</strong></td>
<td>• Offices.</td>
</tr>
<tr>
<td>• All on train events.</td>
<td></td>
</tr>
<tr>
<td>• Events on the mainline railway which affect trains, including Level Crossings.</td>
<td></td>
</tr>
<tr>
<td>• All train, movement and non-movement accidents related to the movement of OTP that occur within possessions</td>
<td></td>
</tr>
<tr>
<td><strong>In stations</strong></td>
<td></td>
</tr>
<tr>
<td>All areas associated with the movement of passengers and staff inside the physical boundaries of stations</td>
<td></td>
</tr>
</tbody>
</table>

The SRM has been designed to take full account both of high-frequency, low-consequence events, and low-frequency, high-consequence events. It was developed using modelling techniques informed by a combination of incident data and expert judgement. The use of expert judgement reduces the problems that can arise with calculating risk estimates purely on the basis of data, which may be insufficiently representative of the underlying level of risk. Most of the data used to populate the SRM comes from SMIS.
The SRM has been developed in the form of a cause and consequence analysis utilising where appropriate fault trees and event trees to represent the hazardous events. Its power lies in its ability to inform decisions on safety priorities and assess the impact of possible risk controls.

The causes and consequences of each event are modelled in detail, considering the railway as a whole, rather than concentrating on a particular route or operator.

5.1.2 Risk Profile Bulletin (RPB)

The RPB is the output from the SRM. It provides:

a) A description of the SRM, its modelling approach and assumptions

b) National railway risk profiles that show which events are expected to cause the most harm

c) The major causes of hazardous events set out together with their risk contributions

d) A comprehensive list of definitions used in risk analysis including definitions of all hazardous events (HE).

5.1.3 Taking Safe Decisions

Risk assessment and their results should be used within a robust decision making process. The agreed industry approach to decision making is described in RSSB publication ‘Taking Safe Decisions’, which is referenced, where appropriate in the remainder of this document.
5.2 Risk assessment process

This section gives an overview of the key stages of the risk assessment process, an overview of which is summarised in the following chart:-

5.2.1 Involvement of staff and others

There should be involvement from a full range of company staff with the competencies required to consider the whole operation in detail within the risk assessment process, particularly in relation to the hazardous event and precursor identification and ALARP assessment stages. In particular companies may wish to engage with their H&S reps in this respect. In addition transport operators may also wish to involve representatives from other organisations who may be affected by or interface with their operation.
5.2.2 Identification of hazardous events
Identify all foreseeable hazardous events applicable to your operation. A good place to start would be those listed in the RPB, supplemented with the other sources of data listed in Section 5.1.

Consideration should be given to identifying the most exposed groups i.e. those with the highest individual risk. This information will subsequently help to prioritise efforts for the identification of ALARP control measures.

5.2.3 Assessment of precursors
For each hazardous event you should identify:

a) The precursors (cause) (consider all failure modes, human factors, environmental and local factors, etc)

b) The existing control measures preventing the precursor and who applies them

c) The frequency of the precursors and the resulting hazardous event (use actual data, RPB information or expert opinion).

Record any assumptions and/or judgements made and the sources of local data used.

5.2.4 Consequences assessment
For each hazardous event identify:

a) The most exposed group (railway employee, passenger, public)

b) Any relevant escalation factors e.g. things that could happen after the initial accident that could make the outcome worse such as a slow response, spread of fire, over-crowding

c) The most likely outcome and its probability of occurrence (use actual data or expert opinion)

d) The realistic worst case outcome and its probability of occurrence (use actual data or expert opinion)

e) The control measures that effect the probability of the outcomes and the resulting accident consequences.

Record any assumptions and/or judgements made and the sources of local data used.

5.2.5 Risk derivation
To derive the risk:

a) For each hazardous event, use the frequency of the event and the average consequences per event to calculate the collective risk. These can then all be summed to give an overall risk estimate, or ranked if a semi-quantitative risk ranking scheme has been used.

b) For each exposed group; (if a numerical assessment has been done) add up the risk (with fatality outcomes only) from all applicable hazardous events and calculate the individual risk (see Appendix E)
Effort should then be prioritised to identify controls relating to the risk arising from the highest risk hazardous events.

5.3 Checking results

5.3.1 ALARP assessment

For each significant hazardous event:

a) Identify additional control measures which would reduce risk further, this may involve a systematic evaluation in a workshop setting in order to justify that a thorough and robust approach has been taken.

b) Consider the cost associated with applying the additional control measures and the potential benefits to be gained (use expert judgement where no other data is available).

For each additional control measure, identify:

a) Those that are not reasonably practicable (costs high and potential risk reduction low)

b) Those that have marginal benefit and perform a cost benefit analysis (CBA) to confirm whether they are reasonably practicable, if appropriate

c) Those that are reasonably practicable (costs comparable to or less than potential risk reduction).

Introduce any new controls found to be reasonably practicable.

See Appendix D for more details on the use of good practice, expert judgement and cost benefit analysis, more detailed information concerning the wider process of ALARP decision making is provided in the RSSB publication ‘Taking Safe Decisions’.

5.3.2 Sensitivity analysis

In carrying out any risk assessment and subsequent ALARP assessment it is often necessary to make assumptions and, due to lack of data, use judgement when quantifying precursor frequencies and probabilities and hazardous event consequences. The results of the overall risk and ALARP assessment may be very dependent on the way in which the assumptions and judgement are made and therefore it is necessary to be aware of the relative importance of these assumptions and judgements within the overall results. A guide to the influence of these assumptions and judgements can be made using sensitivity analysis.

Having completed the risk assessment, review the results to make sure that they make sense, namely:

a) Do the results look believable in terms of overall collective risk, the hazardous events ranked by risk and the individual risk estimates?

b) Are they what you expected?

c) How do they compare with the national averages?

d) Are the major risk contributors what you expected? If not, is there a rational explanation for the difference?
Whether the results make sense or not; it is important that the specific assumptions and judgements made and recorded within the risk assessment process are examined to determine if there are any for which there is a high level of uncertainty (e.g. a factor of 2 or greater). If there are, the sensitivity of the results to changes in the assumptions should be checked, one way of doing this would be to ask the question, ‘if there were a factor of 2 to 5 difference (higher or lower) in the numbers affected by the assumption or judgement would it make a material difference to the conclusions of the risk and/or ALARP assessments?’ If it would make a material difference, consideration should be given to:

a) A more detailed examination of the assumptions and judgements to see if more accurate assessments can be made, and if this is not possible

b) Confirm that the existing or additional control measures are sufficiently robust to cater for the potential level of uncertainty.

5.4 Documenting the risk assessment results

To enable a better understanding of the basis of the risk assessment and to make the assessment more meaningful, it is essential that the origin and derivation of the data behind each frequency and consequence estimate and all the assumptions made for the purposes of the risk assessment are justified and recorded within the risk assessment documentation. The records should include:

a) The risk assessment methodology used

b) The sources of data/information used (including staff / experts involved in any workshops) and any key assumptions

c) Any judgements made during workshop sessions. For cases where modified national data have been used an explanation of why it is believed the data is applicable should be given. Where possible, factors specific to the operation being considered which might increase or decrease the data with respect to the national average should be referred to, e.g. average passenger loadings, type of rolling stock and train speeds

d) The results of the risk assessment for the most significant hazardous events (e.g. top 10) and identify where the arrangements for implementing the existing controls are in the SMS

e) Summarise the results of the ALARP assessment

f) Identify any areas where there is a high level of uncertainty

This information would assist:

a) In demonstrating compliance with legal requirements

b) A reviewer in understanding the background to the risk assessment

c) In demonstrating that the risk assessment is robust

d) Anybody needing to change or update the risk assessment to understand where the assumptions, data and results have come from.
5.5 Using the results

5.5.1 Significant findings - overall risk profile

The risk assessment report should provide a table listing all the hazardous events and their associated risk contributions ranked by risk contribution.

For each of the hazardous events that provide a significant risk contribution, for example the top 10 hazardous events or all the hazardous events contributing more than 5% of the overall risk, there should be a discussion of:

a) The exposed groups
b) The event frequency
c) The event consequences
d) The existing control measures in place to control the frequency and consequences relating to the event
e) Any potential additional control measures considered as a part of the risk assessment process and whether these additional controls need to be implemented to reduce collective risk to a level that is ALARP
f) Any other issues considered relevant.

The discussion should include references to any potentially high risk locations (e.g., tunnels, long bridges and below ground stations) on the routes used by the transport operator. These should have been identified as a part of the hazardous event identification process. Even if the risk at these locations is not quantified in detail within the risk assessment, the specific controls and interface procedures in place to minimise the risk should be described. This will help to demonstrate that:

a) The transport operator is aware of such locations
b) There are controls in place to minimise the occurrence of incidents and deal with incidents, and
c) The interfaces issues, with other transport operators, have been adequately addressed.

5.5.2 Significant findings – multiple fatality risk

Particular consideration should be given to the infrequent multiple fatality events with potentially high consequences.

The risk assessment report should provide a list of all the hazardous events that have the potential to lead to multiple fatalities ranked by their risk contribution. A discussion of the issues relating to the highest risk contributors and the measures in place to control the risk should be included to provide confidence that such events have been recognised and the necessary controls are in place. Particular attention should be given to single failures that could lead directly to a multiple fatality event.

5.5.3 Significant findings - precursor risk profile

The document should provide a list of the precursors or groups of similar precursors with the highest risk contributions ranked by their risk contribution (perhaps the top 20). Discussion on the significance of the results should be included within the report.
5.5.4 Significant findings - individual risk

The report should:

a) Present results for each exposed group considered within the risk assessment

b) Discuss the results in terms of the major contributors.

Where individual risk levels are high the report should describe:

c) Efforts taken to identify possible controls to reduce risk to those individuals, and

d) ALARP assessment of those controls.

5.6 On-going risk assessment process

5.6.1 Using the results in a SMS

The SMS should include a description of the transport operator's policy and process for systematically identifying and assessing risk on an on-going basis. This should include the application of risk assessment strategies and methodologies used for review and update of the risk assessment as well as details on workplace risk assessments, task risk assessments, interface risk assessments and risk assessments for temporary activities or arrangements.

The SMS might include details of how the transport operator makes use of historical data, human factor considerations and assumptions made within risk assessments. The description provided could demonstrate how the transport operator uses the output of risk assessments to determine appropriate preventative and protective control measures and the incorporation of these measures into the SMS. Confirming the validity of risk assessment output against benchmarks should also be recognised within the overall process. The use of risk assessment to inform management decision making within the company, particularly in relation to prioritising improvements, project design, business plans, formulating objectives and implementing control measures should be referenced.

Principles governing the frequency of risk assessment reviews should be described as well as an explanation of how the overall approach to risk assessment is co-ordinated and integrated across all activities.

The SMS would be expected to describe the process for providing assurance about the competence of those involved in undertaking risk assessments at all levels within the organisation as well as describe how personnel are made aware of their responsibilities pertaining to risk assessment. The SMS might summarise the key components of the process for procuring technical expertise in risk assessment techniques where expertise or resource is not available from within the transport operator’s organisation.
The SMS would additionally be expected to describe how the findings of risk assessments are communicated to all affected personnel as well as to other appropriate train and station operators, the Infrastructure Manager, RSSB, contractors and suppliers. The involvement of these other interfacing organisations in the on-going risk assessment process should also be recognised together with the input of local safety representatives and ground level personnel.

6 Selection of risk assessment methods

As previously stated in Section 2, MHSWR and ROGS make reference to the need for a risk assessment to be ‘suitable and sufficient’ in regard to the nature of the operation and the type and extent of the hazardous events and risk that exist.

The definition of what constitutes ‘suitable and sufficient’ has, historically, been very difficult to establish owing to the wide range and scales of operation such risk assessments have been applied to. For the purposes of this guidance it is considered worthwhile considering some criteria for judging what constitutes ‘suitable and sufficient’.

RSSB considers that the various aspects of transport operators operations covered by the risk assessment techniques described in this guidance document fall into 4 main categories. These categories are listed in the matrix below together with the suggested type of risk assessment technique that if adopted should ensure a suitable and sufficient risk assessment.

The term ‘covered by’ means that the operations of the Transport Operator are considered to be typical of operations across the network and therefore for which the assumptions underpinning the SRM are considered reasonable. This is not a cut and dried judgment – an operator might have some typical and some non-typical aspects of its operations and services.

<table>
<thead>
<tr>
<th>Option</th>
<th>Use SRM templates</th>
<th>Semi-quantitative risk ranking</th>
<th>Additional/specific Quantitative analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Option 2</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Option 3</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Option 4</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

① Consideration should be given to supplementing the initial risk assessment with a bespoke QRA where potentially high risk areas of the risk profile are identified but there is little local data available.
## Option 1

For these types of operations the recommended minimum risk assessment requirements should be:

a) Detailed hazardous event identification analysis using the SRM templates as the initial basis for the risk assessment, modified to take account of the specific factors applicable to the operation which may involve new or different hazardous events, causes or consequences and individual potentially high risk locations.

b) Quantified risk assessment using the SRM templates as the basis of the analysis but modified to account for the characteristics and data of the operation being considered.

A proposed methodology for this scenario is described in Appendix A.

## Option 2

This could typically relate to newly implemented operations or a new franchise. For these types of operations the recommended minimum risk assessments requirements should be:

a) Detailed hazardous event identification analysis using the SRM templates as the initial basis for the risk assessment, modified to take account of the specific factors applicable to the operation which may involve new or different hazardous events, causes or consequences and individual potentially high risk locations.

b) Quantified risk assessment using the SRM templates as the basis of the analysis but modified to account for the characteristics and data of the operation being considered.

c) Identification of potentially high risk areas of the risk profile where little data is available, and consideration given to supplementing the initial risk assessment with a semi-quantitative risk ranking approach, or bespoke QRA.

A proposed methodology for this scenario is described in:

a) Appendix A for the use of the SRM templates,

b) Appendix B for an outline of semi-quantitative risk ranking

c) Appendix C for the background to the use of fault tree and event tree analysis.
Option 3

This could typically involve operations not explicitly modelled in the SRM, such as those operating with Automatic Train Protection (ATP). For this option the recommended minimum risk assessments requirements should be:

a) Detailed hazardous event identification analysis using the SRM templates as the initial basis for the risk assessment, modified to take account of the specific factors applicable to the operation which may involve new or different hazardous events, causes or consequences and individual potentially high risk locations.

b) Identification of high risk areas of the risk profile that are not well aligned to the scope and assumptions of the SRM, for which consideration should be given to supplementing the initial risk assessment with a semi-quantitative risk ranking approach, or bespoke QRA.

A proposed methodology for this scenario is described in:

a) Appendix A for the use of the SRM templates,

b) Appendix B for an outline of semi-quantitative risk ranking

c) Appendix C for the background to the use of fault tree and event tree analysis.

Option 4

This could typically relate to the introduction of novel technology to the railway. For this scenario the recommended minimum risk assessments requirements should be:

a) Detailed hazard identification analysis, the SRM template hazardous event and precursor list provides a useful checklist for this process.

b) Detailed quantified risk assessment using a semi-quantitative risk ranking approach, and/or a more detailed analysis methodology such as a fault and event tree analysis.

A proposed methodology for this scenario is described in:

a) Appendix B for an outline of semi-quantitative risk ranking

b) Appendix C for the background to the use of fault tree and event tree analysis.

This aspect of risk assessment will tend to align with existing industry safety assurance activities, and the approaches described in this document only offer supporting guidance.
8 Glossary and references

8.1 Glossary

Where appropriate and available, web references have been given where additional information on a particular term can be accessed.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARP/SFAIRP</td>
<td>As low as is Reasonably Practicable – The Health and Safety at Work etc Act 1974 places duties on employers in the UK to ensure safety ‘so far as is reasonably practicable’ (SFAIRP). When these duties are considered in relation to risk management, the duty is sometimes described as a requirement to reduce risk to a level that is ‘as low as is reasonably practicable’ (ALARP). These terms therefore express the same concept in different contexts and for all practical purposes should be considered synonymous. <a href="http://www.rssb.co.uk/pdf/safety/taking_safe_decisions/Taking%20safe%20decisions%20-%20Part1.pdf">www.rssb.co.uk/pdf/safety/taking_safe_decisions/Taking%20safe%20decisions%20-%20Part1.pdf</a></td>
</tr>
<tr>
<td>ALARP demonstration</td>
<td>A process for demonstrating that the collective risk from a transport operator’s operation has been reduced to a level that is as low as reasonably practicable.</td>
</tr>
<tr>
<td>CBA</td>
<td>Cost Benefit Analysis – A method of weighing the expected cost of one or more options against the expected benefits in order to find the best option <a href="http://www.rssb.co.uk/pdf/safety/taking_safe_decisions/Taking%20safe%20decisions%20-%20Part1.pdf">www.rssb.co.uk/pdf/safety/taking_safe_decisions/Taking%20safe%20decisions%20-%20Part1.pdf</a></td>
</tr>
<tr>
<td>CIRAS</td>
<td>Confidential Incident Reporting and Analysis System</td>
</tr>
<tr>
<td>Collective Risk</td>
<td>Collective risk can be quantified as the average number of fatalities, or FWIs, per year that would be expected to occur to a defined group. When undertaking an assessment of whether or not a measure is necessary to reduce risk to a level that is ALARP, the change in risk associated with the measure is a collective risk estimate.</td>
</tr>
<tr>
<td>Consequences</td>
<td>The number of fatalities, major injuries, minor injuries and shock trauma resulting from the occurrence of a particular hazardous event outcome.</td>
</tr>
<tr>
<td>Control measures</td>
<td>The measures (hardware systems and equipment or procedural) that are put in place to prevent or minimise the frequency at which precursors occur or to mitigate the consequences following the occurrence of a hazardous event.</td>
</tr>
<tr>
<td>Escalation factors</td>
<td>A system failure, sub-system failure, component failure, human error, physical effect or operational condition which could individually or in combination with other precursors (consequences) result in significantly different outcomes following a hazardous event. For instance, following a train derailment there could be a bridge collapse onto a train, a fire or a toxic goods release.</td>
</tr>
<tr>
<td>Fatality</td>
<td>Death within one year of the causal incident.</td>
</tr>
<tr>
<td>FOC</td>
<td>Freight Operating Company</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Frequency</td>
<td>The frequency of an event is the number of times an event occurs over a specified period of time e.g. number of events/year.</td>
</tr>
<tr>
<td>FWI</td>
<td>Fatalities and Weighted Injuries</td>
</tr>
<tr>
<td></td>
<td>1 FWI = 1 fatality; or 10 major injuries; or 200 RIDDOR reportable minor injuries; or 1000 Non RIDDOR reportable minor injuries; or 200 Class 1 shock/trauma; or 1000 Class 2 shock/trauma</td>
</tr>
<tr>
<td>HASAWA</td>
<td>Health and Safety at Work etc Act 1974</td>
</tr>
<tr>
<td>HAZID</td>
<td>Hazard Identification</td>
</tr>
<tr>
<td>Hazardous event</td>
<td>A hazardous event is an event that has the potential to lead directly to death or injury e.g. derailment, collision or fire.</td>
</tr>
<tr>
<td>HMRI</td>
<td>Her Majesty’s Railway Inspectorate</td>
</tr>
<tr>
<td>HSC</td>
<td>Health and Safety Commission</td>
</tr>
<tr>
<td>HSE</td>
<td>Health and Safety Executive</td>
</tr>
<tr>
<td>Individual risk</td>
<td>The probability of fatality per year to which an individual is exposed from the operation of the railway.</td>
</tr>
<tr>
<td>Infrastructure Manager</td>
<td>The person responsible for developing and maintaining the railway infrastructure or, in relation to a station, the person who is responsible for managing and operating that station,</td>
</tr>
<tr>
<td>Major injuries</td>
<td>Injuries to passengers, staff or members of the public as defined in the Reporting of Injuries, Diseases, and Dangerous Occurrences Regulations 1995 (RIDDOR 1995). This includes injuries such as fractures, amputations, loss of sight or an injury resulting in admittance to hospital for a period of more than 24 hours.</td>
</tr>
<tr>
<td>MHSWR</td>
<td><em>The Management of Health and Safety at Work Regulations 1999</em></td>
</tr>
<tr>
<td>Minor injuries - Reportable</td>
<td>Injuries to passengers, staff or members of the public which are not major injuries, but are reportable under RIDDOR.</td>
</tr>
<tr>
<td>Minor injuries - Non-Reportable</td>
<td>Injuries to passengers, staff or members of the public which are not major injuries and are not reportable under RIDDOR.</td>
</tr>
<tr>
<td>ORR</td>
<td>Office of the Rail Regulator</td>
</tr>
<tr>
<td>OTM</td>
<td>On-Track Machine</td>
</tr>
<tr>
<td>Outcomes</td>
<td>The range of scenarios that could arise following the occurrence of a hazardous event.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Precursor (cause)</td>
<td>A system failure, sub-system failure, component failure, human error or operational condition which could individually or in combination with other precursors result in the occurrence of a hazardous event e.g. broken rail, signal passed at danger (SPAD) or dragging brakes are precursors to the hazardous events derailment, collision and fire respectively.</td>
</tr>
<tr>
<td>Probability</td>
<td>The likelihood of an event occurring over a specified period of time or on demand (when an individual component or system is called upon to operate).</td>
</tr>
<tr>
<td>QRA</td>
<td>Quantified Risk Assessment</td>
</tr>
<tr>
<td>Residual risk</td>
<td>Residual risk relates to the level of risk remaining when the current risk control measures &amp; their degree of effectiveness are taken into account.</td>
</tr>
<tr>
<td>RGS</td>
<td>Railway Group Standard</td>
</tr>
<tr>
<td>RIDDOR</td>
<td>Reporting of Injuries, Diseases, and Dangerous Occurrences Regulations 1995</td>
</tr>
<tr>
<td>Risk contribution</td>
<td>This is a term used in the SRM analysis software and relates to the reduction in the total collective risk estimate for a hazardous event if the frequency or probability of a precursor (cause), escalation factor or group of precursors was reduced to zero.</td>
</tr>
<tr>
<td>RMMM</td>
<td>Rail Mounted Maintenance Machine</td>
</tr>
<tr>
<td>ROGS</td>
<td>Railways and Other Guided Transport Systems (Safety) Regulations 2006</td>
</tr>
<tr>
<td>RPB</td>
<td>Risk Profile Bulletin</td>
</tr>
<tr>
<td>RRV</td>
<td>Road Rail Vehicle</td>
</tr>
<tr>
<td>R2P2</td>
<td>Reducing Risks, Protecting People</td>
</tr>
<tr>
<td>SFAIRP</td>
<td>See ALARP/SFAIRP</td>
</tr>
<tr>
<td>SMIS</td>
<td>Safety Management Information System</td>
</tr>
<tr>
<td>SMS</td>
<td>Safety Management System</td>
</tr>
<tr>
<td>SPAD</td>
<td>Signal Passed at Danger</td>
</tr>
</tbody>
</table>
| SRM                  | Safety Risk Model  
http://www.rssb.co.uk/safety/spr/srmodel.asp                                                                                                                                           |
| SRM-PWG              | Safety Risk Model-Practitioners Working Group                                                                                                                                                        |
| TOC                  | Train Operating Company                                                                                                                                                                              |
| Train                | Any self powered vehicle, or vehicles hauled by a self powered vehicle, with flanged wheels on guiding rails.                                                                                       |
| Transport Operator   | Any infrastructure manager or railway undertaking.                                                                                                                                                   |
| VPF                  | Value of Preventing a Fatality                                                                                                                                                                    |
### 8.2 References

<table>
<thead>
<tr>
<th>Reference</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSI BS 5760-7: Guide to Fault Tree Analysis</td>
<td><a href="http://www.rssb.co.uk/national_programmes/sms_duty_cooperation.asp">http://www.rssb.co.uk/national_programmes/sms_duty_cooperation.asp</a></td>
</tr>
<tr>
<td>A guide to ROGS requirements for duty of cooperation between transport operators</td>
<td><a href="http://www.rssb.co.uk/national_programmes/sms_duty_cooperation.asp">http://www.rssb.co.uk/national_programmes/sms_duty_cooperation.asp</a></td>
</tr>
<tr>
<td>ORR guidance on undertaking CBA to support safety related investment decisions</td>
<td><a href="http://www.rail-reg.gov.uk/server/show/nav.1118">http://www.rail-reg.gov.uk/server/show/nav.1118</a></td>
</tr>
<tr>
<td>Risk Profile Bulletin</td>
<td><a href="http://rssb.co.uk">http://rssb.co.uk</a></td>
</tr>
<tr>
<td>RSSSB Guidance on the use of Cost-Benefit Analysis in making decisions affecting safety</td>
<td><a href="http://www.rssb.co.uk/safety/safety_strategies/vpf.asp">http://www.rssb.co.uk/safety/safety_strategies/vpf.asp</a></td>
</tr>
<tr>
<td>Safety Risk Model</td>
<td><a href="http://www.rssb.co.uk/safety/spr/srmodel.asp">http://www.rssb.co.uk/safety/spr/srmodel.asp</a></td>
</tr>
</tbody>
</table>
Appendix A - Risk assessment based on the use of information from the SRM (supported by local data)

9.1 Introduction

If a transport operator’s operation is similar to the type of operations considered within the SRM i.e. railway operations and maintenance on the mainline railway, then the information from the SRM can be used as the initial basis for the company risk assessment, modified to take account of the specific factors applicable to the operation being considered. It is not acceptable to apply the information from the RPB without the specific factors applicable to the operation being considered.

To support transport operators in applying this process RSSB produces the SRM Templates and a supporting user guide on how to use them. Copies of these can be obtained from RSSB and www.safetyriskmodel.co.uk.

The RPB, and SRM templates, contain a detailed list of the hazardous events associated with train and station operations within the boundaries of Network Rail managed infrastructure.

When undertaking a company risk assessment it is important that, in addition to the information contained within the SRM, use is made of any previous risk assessment studies that have been undertaken that can inform the process and any available local data (see section 5.1).

9.2 Stage 1 - Hazardous event identification

9.2.1 Purpose

The purpose of this stage of the assessment is to establish a comprehensive list of the hazardous events, taking full account of the factors specific to the transport operator’s operations.

9.2.2 Preparation

a) Obtain the pre-prepared SRM templates from RSSB
b) Complete the normalisation data section with your own company data
c) Identify typical operations or journeys through the system which will be considered within the workshop e.g.:
   i) Passenger arriving at station, moving through the station, boarding train, train journey, alighting the train and exiting the station
   ii) Train driver (passenger or freight) boarding train, train journey, alighting from the train and other duties if appropriate
   iii) Train crew (passenger, freight and OTM) – typical duties
   iv) Platform staff – typical duties
   v) Trackside worker
   vi) Member of the public using a level crossing
   vii) Member of the public living adjacent to the railway.
9.2.3 Tasks

Hold a workshop to introduce to the participants the risk assessment process and identification of the hazardous events that will form the core of the risk assessment.

The competency of the participants and the way the workshop is conducted are key to the success of the process.

The workshop should aim to involve individuals covering the broad range of skills and experience within the transport operator’s operation.

The workshop could include:

a) Introduction to the risk assessment and workshop processes.

b) A review of the most exposed groups to be considered for the assessment of individual risk and confirmation that the operations or journey stages identified in the preparation stage are representative of the transport operator’s activities. Add or remove exposed groups and typical activities/journeys as appropriate.

c) For each operation or journey stage consideration of the hazardous events that have the potential to lead directly to death or injury to the exposed group. This should include:

   i) Reference to the list of the related hazardous events from the SRM templates.

   ii) Identification of any additional related hazardous events relevant to the transport operator but not identified in the SRM Templates.

   

d) For each type of operation or journey the workshop team should be asked to consider if additional hazardous events could occur as a result of:

   i) Normal operations

   ii) Perturbed running e.g. train failure

   iii) Degraded or abnormal operations

   iv) Day or night

   v) Extreme weather

   vi) Disabled people or other vulnerable groups

   vii) Crowding on stations or in trains

   viii) Criminal activity

   ix) Other conditions specific to the transport operator’s operations.

---

1 Due to the maturity of the SRM It is unlikely that any additional hazardous events will be identified.
e) As a part of the hazardous event identification process the geography of the transport operator’s operation should be considered to determine if there are any potentially high risk locations (tunnels, long bridges, below ground stations, etc) for which additional controls may be required. Even if the risk at these locations is not quantified, the risk assessment should demonstrate that the transport operator is aware of such locations, that there are controls in place to minimise the occurrence of incidents and that any interfaces issues are adequately addressed.

9.3 Stage 2 - Precursor assessment

9.3.1 Purpose
The purpose of this stage of the assessment is to identify all the precursors that could individually, or in combination with other precursors, cause each hazardous event to occur.

9.3.2 Preparation
a) From the output from stage 1, use the SRM template to prepare a rationalised list of all hazardous events applicable to the transport operator’s operation
b) The SRM templates contain a pre-prepared list of cause precursors for each hazardous event in the SRM, use this as a basis for precursor assessment during this stage
c) Additionally identify any relevant, available company specific related data applicable to the cause precursors for each hazardous event.

9.3.3 Tasks
Hold a workshop to systematically work through each hazardous event to confirm that all relevant precursors, even if the precursors are not under the direct control of the transport operator. It should be noted that, when considering the individual risk to any exposed group it is the total risk exposure that should be considered not just risk resulting from the hazardous event precursors controlled directly or indirectly by the transport operator.

When considering precursors, the workshop participants should consider:

a) The type of traction, rolling stock or OTM being used
b) The characteristics of the geography of the transport operator’s operation in terms of specific features, areas particularly prone to vandalism and other such issues
c) Any additional human factors issues relating to the transport operator’s operation. Using the SRM templates list the identified precursors under one of the predefined or new precursor category:

For the precursors which are under the direct (D) or joint (I) control of the transport operator, consideration should be given (and recorded) as to the percentage of the overall frequency that is likely to be applicable to each of the transport operators precursors. This assessment will give a measure of the overall frequency of each hazardous event that is under the direct or indirect control of the transport operator.

More information on managing shared risk between transport operators can be found in RSSB document A guide to ROGS requirements for duty of cooperation between transport operators.

Note - Control measures considered are ones which control the frequency at which the precursor occurs. Consideration should include a summary of the key control measures required by RGSs as well as any additional control measures applied by the transport operator. Information for this section can also be supplemented outside the workshop.

**Using data to quantify frequency**

The SRM templates provide a structured process to help determine the number of hazardous events/year using -

- The normalised national data
- Transport operator’s actual data
- Transport operator specific factors and/or judgements, including the perceived effectiveness of the existing control measures.
Note - Where transport operator’s own actual data is available for a particular precursor, care should be taken interpreting the data.

- If there are 3 or more recorded events recorded for a precursor over the data period analysed, it can be considered that the actual data is representative of the transport operator’s operation and the actual data can be used.

- If there are less than 3 recorded events for a precursor, then the data can only give limited confidence that it is representative of the transport operator’s operation. In this case consideration should be given to supporting the data with the transport operator’s specific factors and/or judgements which make the failure frequency higher or lower than the national average.

### 9.4 Stage 3 - Consequence assessment

#### 9.4.1 Purpose

When assigning consequence rankings to hazardous events the rankings are based normally on the average consequences for the event. For some hazardous events, however, different outcomes can lead to significantly different consequences.

For example, a train derailment would typically only lead to minor injuries, due perhaps to passengers falling over inside the train, whereas in extreme cases, derailments can lead to multiple fatalities. It is recommended that in such cases, to get a better understanding of the risk profile, particularly in relation to potential multi-fatality outcomes, two separate rankings should be considered for the hazardous event as follows:

a) The most likely outcome – FWI to passengers, staff and MOPs

b) If applicable, a realistic worst case outcome, in terms of FWI, single or multiple fatalities to passengers, staff and MOPs

<table>
<thead>
<tr>
<th>Actual Frequency</th>
<th>Consequences</th>
<th>Frequency Ranking</th>
<th>Consequences</th>
<th>Risk Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.95 events/year</td>
<td>Typical outcome e.g. minor injury</td>
<td>6 + 1 = 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.05 events/year</td>
<td>Realistic high consequence outcome e.g. multiple fatality (2 - 5 fatalities)</td>
<td>3 + 5 = 8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To recognise the fact that the individual risk criteria applies to specific exposed groups of individuals it is necessary to also consider the fatality related consequences for the exposed groups for both outcomes defined above.
9.4.2 Preparation

Using the output from Workshop 1 entered into the SRM templates

For each hazardous event review the consequences in the SRM

Confirm which groups of individuals will be considered as part of the assessment of individual risk

Collate any local or national data relating to consequences for each hazardous event

9.4.3 Tasks

Hold a workshop to systematically work through each hazardous event to identify the likely consequences resulting from the occurrence of each hazardous event.

The SRM templates provide a structured process to undertake the consequence assessment.

To calculate overall risk:

Notes - The use of two different outcomes should only be considered where there is a clearly recognisable worst case outcome that differs significantly in terms of the frequency and consequences when compared to the most likely outcome.

The sum of the probabilities assigned to the two outcomes should always equal 1

Consider the consequences in terms of FWI applicable to each outcome in relation to the national average figure quoted from the SRM templates. The transport operator’s specific factors should be considered in the context of the consequences being higher or lower than the national average.

If the hazardous event is not considered within the SRM, use your own specific data or judgement within the workshop to estimate the consequences in FWIs for each outcome.

Overall risk for the outcome is calculated within the SRM templates and is summed to give the overall risk for the hazardous event.

Record all rationale, data sources, assumptions and judgements.
**Individual risk for exposed groups:**

To determine individual risk levels, a transport operator should consider the individual risk associated with the groups of individuals most exposed to their operation. As individual risk relates only to the probability of fatality per year, it is necessary to consider the fatality related consequences for each exposed group separately.

Use transport operators own specific data or judgement within the workshop to estimate the consequences in terms of the exposed group only for each outcome.

If in such cases it is considered that a fatality will not always occur for the given outcome, the appropriate fraction of a fatality should be considered for the consequence ranking.

Complete the process for other identified exposed groups where necessary.

**9.5 Stage 4 - ALARP assessment**

There are two stages to the ALARP Process-

- Precursor Assessment; and
- Consequence Assessment

Appendix D details the process for demonstrating that risk is reduced ALARP. More detailed information concerning the wider process of ALARP decision making is provided in RSSB publication ‘Taking Safe Decisions’.

**9.5.1 ALARP precursor assessment**

Having identified the existing control measures and attempted to quantify the frequency for each precursor over which the transport operator has direct or indirect control, the next step is to consider whether all reasonably practical measures are being taken to control the frequency, this can be done by considering:

- Whether it is reasonably practicable to implement each additional identified control
- The proposed strategy for dealing with each potential additional control identified

When completed, record all rationale, assumptions and judgements.

**9.5.2 ALARP consequences assessment**

Having identified the existing control measures and attempted to quantify the consequences for each outcome, the next step is to consider whether all reasonably practical measures are being taken to control/mitigate the consequences resulting from each outcome, this can be done by considering:

- Whether it is reasonably practicable to implement all potential additional controls which could be employed to further minimise the consequences associated with each outcome
- The proposed strategy for dealing with each potential additional control identified

When completed, record all rationale, assumptions and judgements.
9.6 Stage 5 - Analysis of results

Once the workshop and the risk estimates for each hazardous event have been completed it will be possible to:

a) Rank each hazardous event by overall risk and identify the most significant risk contributors in relation to the transport operator’s operation.

b) Calculate the individual fatality risk for the passengers and drivers to see if any types of individual have high levels of individual risk.

c) Assess which additional control measures are:
   - Considered to be reasonably practicable,
   - Required to be assessed using cost-benefit analysis and
   - Are clearly not reasonably practicable.

d) Calculate the risk contribution from individual precursors or groups of specific precursor types (individual precursor frequency (events/year) x average consequences (FWs) per event for the hazardous event.

9.6.1 Tasks

It is recommended that once the risk and ALARP assessments have been completed that a workshop is re-convened to carryout a final common sense check on the results to make sure they all make sense and no unsupported assumptions have been made, this would include -

a) Do the results look believable in terms of overall risk, the hazardous events ranked by risk and the individual risk estimates?

b) Are they what you expected?

c) How do they compare with the national averages in the RPB?

d) Are the major risk contributors what you expected? If not, is there a rational explanation for the difference.

e) Are there any specific assumptions made within the risk assessment process, for which there is a high level of uncertainty, which have a potentially significant affect on the overall risk, or the individual risk estimates.

Following such reviews it may be necessary to re-visit parts of the risk assessment to re-assess and refine certain inputs to the process. Any re-visit and subsequent changes would need to be structured and appropriately recorded, in a similar way to the initial risk assessment.
Appendix B – Risk assessment based on the use of semi-quantitative risk ranking

10.1 Introduction

Experienced Safety Practitioners will be familiar with Risk Ranking Methods. Understanding the advantages and limitations of risk ranking methods is essential in selecting this method as an appropriate approach. In terms of overall Company Risk Assessments we advocate the use of the SRM Risk Templates wherever possible as this provides a more comprehensive approach allowing clearer comparison between groups of people and hazardous events.

Risk ranking may be appropriate where the SRM Risk Templates cannot be applied and the nature of the operation is not novel or result in multi-fatality consequences. For new, more complex or operations with potential for multi-fatilities a more bespoke quantified risk assessment may be appropriate (see Appendix C).

Risk ranking may be appropriate for an initial assessment and carried out as part of a HAZID workshop to gain an initial view of the identified hazardous events in order to prioritise those that require further evaluation.

There are limitations associated with using risk ranking, in particular derivation of the total risk to which individuals or groups of people is exposed is difficult. Therefore the approach should be used with great caution when using it to support judgements about the acceptability of risk.

10.2 Risk ranking approaches

A risk matrix of some kind is central to risk ranking; the two scales on the matrix being used to record the estimated frequency and consequences of the hazardous event. The number of steps on each scale can be varied to suit the application, typically between three and seven with the five-by-five matrix often being used.

The labelling of the scales determines whether a qualitative or semi-quantitative approach is used. Where possible a semi-quantitative approach should be used as this provides for a greater level of accuracy and consistency in the risk estimates. A qualitative approach would be appropriate in situations where there is no data or the risk ranking is being undertaken as an initial evaluation to identify hazardous events requiring assessment in greater detail.
The size of the matrix and the factor difference in frequency and consequence rankings can be altered to give the best ranges to suit a particular application. The following two tables provide examples of frequency and consequence scales. A qualitative approach would ignore the middle columns and concentrate on the description and ranking only.

This information can then be combined into a single matrix as shown below. This is effectively a 6 x 7 matrix showing the consequences down the left hand side and the frequency scale across the top. The top number in each cell shows the risk expressed as FWI/yr for the corresponding frequency and consequence. You will note that each cell with the same risk has the same combined ranking score shown in bold. This can be derived by adding the frequency and consequence ranking.

<table>
<thead>
<tr>
<th>Frequency Description</th>
<th>Approximate value events/year</th>
<th>1 in 100 yrs</th>
<th>1 in 20 yrs</th>
<th>1 in 4 yrs</th>
<th>1 in 9 mths</th>
<th>1 in 2 mths</th>
<th>1 in 12 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-point estimate frequency</td>
<td>0.01</td>
<td>0.05</td>
<td>0.25</td>
<td>1.25</td>
<td>6.25</td>
<td>31.25</td>
<td>156.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consequence Description</th>
<th>Approx FWI/Event</th>
<th>Ranking</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple fatalities (&gt; 25 eq. fatalities)</td>
<td>125</td>
<td>0.25</td>
<td>0.5</td>
<td>1.25</td>
<td>6.25</td>
<td>31.25</td>
<td>156.25</td>
<td>781.25</td>
</tr>
<tr>
<td>Multiple fatalities (6 to 25 eq. fatalities)</td>
<td>25</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Multiple fatalities (2 to 5 eq. fatalities)</td>
<td>5</td>
<td>0.05</td>
<td>0.05</td>
<td>0.25</td>
<td>1.25</td>
<td>6.25</td>
<td>31.25</td>
<td>156.25</td>
</tr>
<tr>
<td>Multiple major/ single fatality</td>
<td>1</td>
<td>0.001</td>
<td>0.05</td>
<td>0.25</td>
<td>1.25</td>
<td>6.25</td>
<td>31.25</td>
<td></td>
</tr>
<tr>
<td>Major injury</td>
<td>0.2</td>
<td>0.002</td>
<td>0.01</td>
<td>0.05</td>
<td>0.25</td>
<td>1.25</td>
<td>6.25</td>
<td></td>
</tr>
<tr>
<td>More serious injury/ multiple minor injuries</td>
<td>0.04</td>
<td>0.0004</td>
<td>0.002</td>
<td>0.01</td>
<td>0.05</td>
<td>0.25</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td>Reportable minor injury /Class 1 Shock/trauma</td>
<td>0.008</td>
<td>0.00008</td>
<td>0.0004</td>
<td>0.002</td>
<td>0.01</td>
<td>0.05</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Non reportable minor injury/ Class 2 shock trauma</td>
<td>0.0016</td>
<td>0.000016</td>
<td>0.00008</td>
<td>0.0004</td>
<td>0.002</td>
<td>0.01</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C – Background and use of fault tree and event tree analysis in risk assessment

11.1 Introduction

There may be cases where a risk assessment has to be produced for a completely new type of operation or franchise for which there is little or no operational experience to use as input into the risk assessment. Alternatively new systems or ways of working, or new technical systems, might be introduced. These circumstances would include, but not be limited to, changes requiring safety verification under ROGS.

In such cases it is recommended that initially a structured semi-quantitative risk ranking methodology, as described in Appendix B, is used to establish a basic understanding of the hazardous events, precursors and risk profile. In such cases the selection of frequency and consequence rankings would be based almost entirely on judgement.

If as a result of this process one or more accident sequences are identified for which there is considerable uncertainty about the failure frequency relating to systems or sub-systems, or the types of outcomes that could occur particularly relating to fatalities, it is recommended that more detailed fault tree and event tree analysis techniques are used to examine the risk issues and quantification in more detail.

The text below gives a broad overview of the fault tree and event tree analysis techniques. It is not however the intention of this guidance note to give a detailed guidance on how to undertake fault and event tree analyses. There are many commercially available courses that could be used to obtain a working knowledge of the techniques. Alternatively, external consultants with specific expertise in risk assessment could be used. Further useful guidance can also be found in the Yellow Book.

Specific advice on the use of fault tree and event tree analysis techniques can be obtained from RSSB.

11.2 Fault Tree analysis

Fault tree analysis (FTA) is a technique which analyses the possible causes of a specified undesirable end or ‘Top’ event. Logic symbols, known as ‘gates’, are used to work back systematically to the originating failure or basic events. This technique is particularly useful for systems having substantial redundancy, since the combination of failures which will lead to the top event can be determined and quantified.

The most commonly used gates in fault tree analysis are ‘AND’ and ‘OR’ gates. An ‘AND’ gate is used when all inputs should fail for the output to occur. For an ‘OR’ gate any failure will cause the output failure.

By assigning a probability (or frequency) to each basic event and using the mathematical rules of Boolean algebra the basic event probabilities can be combined at each gate to give the top event probability or in the case of this study the top (initiating) event frequency.
Guidance on the use of fault trees can be found in standards such as BSI BS 5760-7: *Guide to Fault Tree Analysis*, or the US military's *Fault Tree Handbook*.

### 11.3 Event tree analysis

<table>
<thead>
<tr>
<th>Train derailment</th>
<th>Does it obstruct the adjacent line</th>
<th>Is there a secondary collision with a train on the adjacent line</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the context of a risk analysis the event tree analysis technique can be used to identify and, if necessary, quantify (in terms of the frequency of occurrence) all the possible outcomes which could result from a particular initiating event. This includes the consideration of the success and failure of the components, systems and operator actions which are intended to prevent the initiating event developing into undesirable consequences. In addition, the influence of physical effects or other factors which could affect the outcome of the initiating event can be considered.

An event tree takes the form of a diagrammatic representation of the events which could occur following an initiating event. An event tree expands out as an increasing number of physical effects, components, systems or operator actions are considered.

Once an event tree is fully expanded, the consequences of each possible outcome can be assessed. Probabilities can then be assigned to each branch of the tree and combined with the frequency of the initiating event to give the overall frequency of occurrence and the risk for each possible outcome.
12 Appendix D – Method for demonstrating risk is ALARP

12.1 Introduction

Once the risk has been assessed, the next step in the risk management process is the identification and implementation of controls to reduce the risk to a level that is ALARP. In order to demonstrate ALARP it is necessary to identify, assess and implement all reasonably practicable controls.

The purpose of this appendix is to give guidance on how the reasonable practicability of a proposed control or controls can be determined. Where a number of controls are proposed, they should be assessed individually and in combinations in order to determine the lowest residual risk that can be achieved within the bounds of reasonable practicability.

Further guidance and a more detail on the agreed approach to ALARP decision making can be found in RSSB publication ‘Taking Safe Decisions’.

12.2 Reasonably practicable

“‘Reasonably practicable’ is a narrower term than ‘physically possible’ … a computation must be made by the owner in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other, and that, if it be shown that there is a gross disproportion between them – the risk being insignificant in relation to the sacrifice – the defendants discharge the onus on them.”

There are two factors which can inform a judgement about reasonable practicability:

a) Deciding by good practice
b) Deciding on “first principles” including:
   • Competence-based judgement; and
   • Cost benefit analysis (CBA).

12.2.1 Using good practice

In most situations, deciding whether the risks are ALARP involves a comparison between the control measures a transport operator has in place or is proposing and the measures we would normally expect to see in such circumstances i.e. relevant good practice. "Good practice" is defined by the HSE as standards for controlling risk that HSE has judged and recognised as satisfying the law, when applied to a particular relevant case, in an appropriate manner, examples include:

a) The practice is established in more than one other national railway, which is similar in scale and operation to the British system.
b) The practice is established and widely implemented in another industrial sector.
c) The practice is enforced by legislation in more than one other country.
d) The practice is already established elsewhere on the UK railway.

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2 The Court of Appeal (in its judgment in Edwards v. National Coal Board, [1949] 1 All ER 743)
If all of the following also apply:

a) It has demonstrably improved safety in its current application.

b) It can be implemented without significant modification or difference in cost.

c) It is relevant to the circumstances, for example similar operating conditions.

Good practice is generally most relevant to new builds and upgrades rather than existing operations.

12.2.2 Using ‘first principles’

Competence-based judgement,

Where the situation is complex, it may be difficult to reach a decision on the basis of good practice alone. There may also be some situations (for example, a new technology) where there is no relevant good practice. In such cases, good practice should be followed as far as it can be, and then consideration given to whether there is any more that can be done to reduce the risk. If there is more, the presumption is that the transport operator will implement these further measures but this needs to be confirmed by going back to first principles to compare the risk with the sacrifice involved in further reducing it.

Often such “first principles” comparisons can be done qualitatively, i.e. by applying common sense and/or exercising professional judgment, or experience. For example if the costs are clearly very high and the reduction in risk is only marginal, then it is likely that the situation is already ALARP and further improvements are not required. In other circumstances the improvements may be relatively simple or cheap to implement and the risk reduction significant: here the existing situation is unlikely to be ALARP and the improvement is required. In many of these cases a decision can be reached without further analysis.

CBA

There are instances (e.g. new technology with potentially serious consequences) where the situation is less clear-cut. In such cases, a more detailed comparison has to be undertaken. Risk and sacrifice are not usually measured in the same units, so it’s a bit like comparing apples and pears. In these instances, a more formal CBA may provide additional insight to help make a judgment.

CBA is a methodology for comparing the benefits achieved by introducing a new control or combination of controls with the costs of implementation. The level of detail can vary significantly depending on the complexity of the issue, the scale of costs involved and the level of uncertainty in the analysis.

It is recommended that the advice of a professional experienced in quantitative CBA (in-house or external) is sought before undertaking detailed quantitative CBAs.
The elements of a CBA are summarised as follows:

Each item (a) to (f) is described in turn below.

a) Quantification of costs:

The cost side of the analysis needs to include all costs that are necessary and sufficient to the introduction of the control, less any direct cost savings. They should be evaluated in real terms for the years in which they are to be incurred. The outcome of this stage of the CBA is a cost profile of the control over its full lifetime.

Costs and/or cost savings should include:

i) Capital investment  
ii) Installation and commissioning  
iii) Training  
iv) Performance costs  
v) Management and administration  
vi) Operation and maintenance  

Costs and cost savings should not include those which are speculative, for example:

i) Improved reputation and the response of the market to the new control and its safety or commercial effects  
ii) Reduced insurance premiums.  
iii) Civil damages and legal costs

Some of the costs identified above are described in more detail in Section 11.3.
b) Evaluation of safety benefits:

The benefit side of the analysis includes all safety benefits arising directly from the implementation of the control, less any safety risk imported by its implementation. Imported safety risks typically include those imposed on the workforce during installation.

The safety benefit should be calculated in FWIs. At the time of publication, the equivalent fatality ratio is:

\[
1 \text{ FWI} = \begin{cases} 
1 \text{ fatality}; & \text{or} \\
10 \text{ major injuries}; & \text{or} \\
200 \text{ RIDDOR reportable minor injuries}; & \text{or} \\
1000 \text{ Non RIDDOR reportable minor injuries}; & \text{or} \\
200 \text{ Class 1 shock/trauma}; & \text{or} \\
1000 \text{ Class 2 shock/trauma}.
\end{cases}
\]

Given that the current risk has already been assessed, an estimate of the risk remaining after the implementation of the control(s) enables the safety benefit to be calculated as the difference between the two. The evaluation should generate a profile of safety benefits over the whole life of the control, taking into account any initial period in which the benefit may be lower.

c) Translation of safety benefit into financial terms:

The safety benefits in FWIs should be multiplied by the appropriate VPF to obtain a financial value for the benefits. The VPF is calculated annually by RSSB on behalf of the railway industry and can be found in RSSB document Guidance on the use of Cost-Benefit Analysis in making decisions affecting safety.

d) Discounting of costs and benefits:

All relevant future costs and benefits resulting from a decision must be calculated in present value terms to enable their comparison. A discount rate is used to do this. ORR guidance document Discount Rates for Rail Safety Scheme Appraisals - NERA proposes certain discount rates for various types of costs and benefits:

‘The law imposes health and safety obligations on duty holders because of the benefits this provides to society. We therefore consider that costs and benefits should be discounted using public sector discount rates. Future costs and cost savings should be discounted at 3.5% per year for the first 30 years and 3.0% per year for the next 35 years. The value of future health and safety benefits has a constant utility value over time and is therefore increased in real terms each year by real GDP per capita growth. Current real GDP per capita growth is around 2% a year which, coupled with a discount rate of 3.5%, gives an effective discount rate for health and safety benefits of 1.5% a year for the first 30 years and 1% a year for the next 35 years’.

This guidance is subject to change and should be reviewed before being applied to determine the discount rates applicable at that time.

e) Comparison of costs and benefits:

Once the costs and safety benefits are in comparable present value units, a simple comparison can be carried out, either as a ratio of benefits to costs, or as benefits minus costs.
Both the costs and the benefits will be subject to uncertainties, and even in fully quantitative analyses there will typically be a number of subjective judgments. The nature and scale of both uncertainties and assumptions should be recorded. A sensitivity analysis to test the robustness of the CBA conclusion should be carried out. This may vary from a simple estimate to a complex evaluation, and professional advice should be sought where necessary.

Where, making suitable allowances for the uncertainties and assumptions, e.g. the costs are less than the safety benefits, the control is considered reasonably practicable. Where the uncertainties are large, this should be made clear to the decision makers, who should take this into account.

Numerical cost-benefit analysis should always be seen as an input to the final decision, not the decision itself.

12.3 Quantification of costs included

Details of each of the types of cost outlined in section 11.2.2(a) that should be considered within a CBA are as follows. It should be noted that these descriptions are not exhaustive, nor should it be assumed that all these costs are relevant to all analyses. Both costs and cost savings are potentially relevant.

12.3.1 Capital investment

This is the total cost to the company of procuring the proposed control, including as appropriate design and development costs, and purchase costs where a tangible item is required.

12.3.2 Installation and commissioning, including out of service costs

This is the total cost of implementing the control into the railway system. It will include material costs, labour costs, certification costs, and costs of taking equipment, infrastructure or people out of normal service.

In all cases where out of service costs will be incurred, account should be taken of opportunities to include the installation in existing maintenance windows, or undertake the work alongside other improvements to minimise the costs. Equally account should be taken of the potential opportunity to undertake other work during an out of service period, and costs reduced appropriately. This is in accordance with recommendations in Reducing Risks, Protecting People.

Where there is the option to implement the control retrospectively, or apply it only to new builds, two separate cost estimates should be made.

12.3.3 Training

All training costs associated with the new measure, both initially and on an ongoing basis should be included. Where training will be incorporated in existing programmes, only the incremental cost of adding a new element to it should be counted. Consideration should be given to the training of all those affected, including installers, maintainers, operators and managers.

If a measure reduces overall training costs, this difference should be added to the cost savings and offset against expenditure.
12.3.4 Management and administration

All additional management and administrative costs associated with the procurement, implementation and operation of the new control should be included. This includes project management of the initial implementation. Whilst this will in many cases be difficult to quantify, estimates should be made.

If a control reduces management or administration costs, for example by simplifying a procedure, then the difference should be added to the cost savings and offset against expenditure.

12.3.5 Operation and maintenance

If the control changes maintenance methods or schedules, or makes any change to operations, then the incremental costs or savings compared to existing practice should be included.

A loss of utility is also considered a cost, for example if the passenger capacity would be reduced below that currently utilised, then there would be a guaranteed loss that should be included. However if spare capacity is lost, or it is anticipated that the measure may deter passengers then any financial losses are speculative so are excluded.

The cost of additional delays should be accounted for where these are certain to follow implementation of the measure.

Offset against these costs should be any cost savings, or commercial benefits where these are guaranteed to follow the implementation of the measure and can be quantified. Any speculative savings or commercial benefits, for example gaining new passengers, should not be included.

12.3.6 Decommissioning

This includes any costs relating to the removal and disposal of the equipment or infrastructure required by the measure at the end of its life. Care must be taken not to double count, as the costs of removal may also be included with the costs of installing new equipment in its place.

If there is any residual value which can be reclaimed through resale or recycling, this should be deducted from the costs.

12.3.7 Performance costs

Performance costs and benefits are potentially relevant to an ALARP judgement. This is qualified by a judgement of whether or not costs/benefits strongly relate to the measure being considered. For example there is a strong argument that lost revenue occurring as a result of a network upgrade would be relevant. However ongoing increased or lost revenue is less closely coupled to the measure as it depends on other things, such as passenger demand.
12.3.8 Avoided costs of accidents

There are three components of the costs arising from an accident:

a) Material damage includes all costs of repair and replacement to property damaged in the accident.

b) Business Interruption includes temporary loss of revenue or profit, or increased costs of working due to the disruption of the accident, including expenses such as British Transport Police activity.

The costs included should only be those directly incurred by such accidents. Costs incurred to implement inquiry recommendations or to make other consequential equipment or operational changes should be excluded as should any legal costs or civil damages.

12.4 Costs not included

There are a number of costs which it is not appropriate to include within a CBA being constructed to support an ALARP decision, which related to the strict legal duty. RSSB document Taking Safe Decisions stresses that these factors might still be relevant to the overall business case and might also influence political decision making and legislation.

12.4.1 Improved reputation and response of the market to the new measure and its safety or commercial effects

It might be anticipated that the installation of a significant new safety measure could attract more passengers, or make them prepared to pay higher fares. However, these consequences are not certain so cannot be included within the cost assessment. Conversely, the impact of an accident or safety incident on a business’ reputation should not be included. These issues are obviously relevant to the wider business case but they are not considered to relate directly to the objective assessment of risk and are therefore not relevant to ALARP judgements.

12.4.2 Reduced insurance premiums

The link between insurance premiums and improvements in the safety measures on the system is considered tenuous, therefore there is no certain cost saving which can be included in the assessment.

12.4.3 Civil damages and legal costs

The industry consensus view is that it is not sensible to factor the avoided legal costs associated with the prevention of an accident into a cost benefits analysis undertaken to support a judgement about whether or not a measure is necessary in order to ensure safety SFAIRP. The transport operator’s view is that these avoided costs are one of a number of knock on financial impacts of accidents, and their avoidance, that should instead be factored into the overall business case.
13 Appendix E - Calculation of individual risk

13.1 Individual risk criteria

Individual risk relates to the probability of fatality per year that an individual is exposed to from the transport operator’s operation. It is likely to be impractical to undertake a quantitative assessment of individual risk for all the identified exposed groups. Instead duty holders should prioritise their attention to those groups of individuals that are known to be exposed to the highest risk. Examples of the minimum level of individual risk assessment that might be expected are:

a) For a train operating company - passengers and train drivers.

b) For an infrastructure controller - passengers, train drivers, trackside workers and members of the public using different types of level crossings.

c) For a station operator – platform staff.

In the examples given, the identified groups are likely to be the most exposed groups within the particular type of operation.

When defining different types of individual, consideration should be given to the number of exposed on the system. If it is assumed that:

a) There are approximately 1,228 million passenger journeys per year on the national network, and these are undertaken by regular travellers; at 450 journeys per regular traveller there would be about 2,729,000 regular travellers, and

b) there are approximately 15,000 train drivers.

A selection of passenger and train driver fatality rates and their equivalent individual risk figures are shown on the following figures. It should be noted that this only includes the fatality component of the risk, any risk due to other injury types is ignored.
It is important to note that when individual risk estimates are made, the total risk to the individual is accounted for. For example, for a passenger the individual risk calculation should include the fatality risk associated with:

a) Entering and moving through the station
b) Boarding the train
c) The train journey
d) Alighting from the train
e) Moving through and leaving the station

In each case all the accident causes, both internal and external to the train, should be included even if the causes are not under the direct control of the duty holder eg track faults, signalling system faults and obstructions on the line.

Having estimated the overall fatality risk to the most exposed groups, for example passengers and train drivers, their individual risk can be calculated as follows:

**Passengers**
For a typical train operating company it is the regular travellers (commuters) who are normally considered to be the most exposed passenger group. It is assumed typically that a regular traveller on average makes 450 journeys/year (2 journeys/day, 5 days/week for 45 weeks/year).

**Train driver**

It should be noted that:

a) The individual risk criteria relate to the total individual risk (sum of the individual risk for all hazardous events) and not the individual risk estimated for each hazardous event.

b) There is a legal requirement to carry out an ALARP assessment for all hazardous events identified within the risk assessment regardless of the assessed individual risk.

c) However, if an individual is exposed to relatively high levels of individual risk it is sensible to prioritise efforts for the identification and evaluation of ALARP measures to reduce risk exposure to that type of individual.