Assessing crowd safety risks: a research into the application of the risk assessment principles to improve crowd safety management and planning in major public venues

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ASSESSING CROWD SAFETY RISKS –
A RESEARCH INTO THE APPLICATION OF THE RISK ASSESSMENT
PRINCIPLES TO IMPROVE CROWD SAFETY MANAGEMENT AND
PLANNING IN MAJOR PUBLIC VENUES

by

SIU YAM ZACHARY AU

A Doctoral Thesis
Submitted in partial fulfilment of the requirements for the award of
the Degree of Doctor of Philosophy of
Loughborough University

October 2001

Supervisor: Dr. Andrew Shepherd
Department of Human Sciences

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I wish to express my gratitude and appreciation, first and foremost, to my supervisor Dr. Andrew Shepherd for his guidance, help, support and friendship. I would also like to thank my previous employer, RM Consultants Ltd, and my colleagues in RMC. Without their support I would not have been able to complete this work.

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In the course of this work, I had received help and assistance from many individuals and organisations: especially Brian Blake of Westminster City Council, Prof. Sue Cox of the Centre for Hazard and Risk Management at Loughborough University, Trevor Dowens of Tyne and Wear Metro, Prof. Trevor Kletz, Robert King and his colleagues in the Metropolitan Police Service, David Olley and Mark Westwood of Heathrow Airport Limited, John Stephenson of the MetroCentre, Geoff Wilson of the Football Licensing Authority, Alton Towers, Camelot Theme Park, Leeds United Football Club, and London Underground Limited. My thanks to them and many others for their time and for sharing with me their valuable knowledge and experience.

I would also like to express my special thanks to Prof. Stuart Kirk. Without his help and support at the beginning stage of my career I would not be in the position to undertake this work in the first place.

Thank you also to all the students who took part in the experiments and Joanne Bibby for proofreading this thesis for me.

Finally, I dedicate this thesis to my parents and my family.
THESIS SYNOPSIS

This thesis considers the subject of crowd safety and investigates how the application of risk assessment can provide support for decision making in crowd safety management and planning. The focus is on major public venues and events where large crowds are a normal part of the operation.

Conventional methods of assessment tend to be ad hoc, reactive and rely on individual experiences. The risk assessment approach, which is comprehensive, systematic and pro-active, can help to overcome these shortfalls. Risk assessments have already been successfully applied in many workplaces, ranging from high hazard industrial plants to the office environment. However, this thesis argues that for it to be of benefit, the risk assessment must be appropriate to the nature of the operation and the nature and the extent of the hazards involved. The existing risk assessments are inappropriate to crowd safety in this respect and a more suitable methodology is required. Therefore, the specific aims of the thesis are:

(i) To show that risk assessment can be applied to crowd safety and that it can improve on the conventional crowd safety assessments.
(ii) To investigate, through the development of a risk assessment methodology for crowd safety, how risk assessment can be best applied to support crowd safety management and planning.
(iii) To demonstrate that the methodology, which takes into consideration the nature of crowd safety risks, can lead to further improvements in crowd safety assessment.

The thesis describes the research work carried out to achieve these aims and presents the outcomes. The first part of the research is devoted to identifying the differences in terms of the hazards between the various work environments and crowd safety. It also looks at the assessment of crowd safety hazards and their risks. As there is little published research knowledge on the subject, two case studies and a survey of public venue assessors were conducted to collect the necessary information and data. A task analysis was also performed to examine the tasks involved in assessing crowd safety risks and identify the factors that enable the assessors to successfully complete their
tasks. It has found that crowd safety hazards are very different to those encountered in other contexts where existing risk assessments are applied. In addition to the kind of hazards one would normally encounter in a work situation, the presence of large crowds also presents a set of hazards that are unique to major public venues. Findings of the venue survey suggest that existing risk assessments are inadequate, particularly in dealing with this type of crowd and behaviour related hazards, and venue assessors are experiencing difficulties in identifying such hazards and assessing their risks. As a summary of the research findings so far, a set of criteria was drawn up to highlight what is needed in a risk assessment suitable for crowd safety.

In order to identify the methods and tools that could provide the potential solutions to the problems of assessing crowd and behaviour related hazards, a review of other risk assessments was conducted. It has highlighted a number of techniques and tools that could be applied to assess crowd safety risks. Based on the criteria mentioned above and the findings of this review, a prototype crowd safety risk assessment methodology was developed. A series of trials were conducted to evaluate the validity and usability of the prototype. Revisions were made accordingly to produce the final draft.

Experiments and a questionnaire survey were then carried out on the final draft to test and verify the methodology. In general, they show that the methodology has led to an improvement in most aspects of crowd safety risk assessment. In the experiments that compared the methodology against methods representing the existing risk assessments and the conventional way of assessing crowd safety, subjects using the methodology tend to perform better in most areas. More hazards were identified. In the evaluation of risks, better consistency was achieved between individuals using the methodology. However, their judgements appeared to be less consistent over time. The use of a larger rating scheme with more choices available in the methodology could have an impact on consistency in risk evaluation. Another key factor could be that the subjects who took part in the experiments were all novice assessors. Possible learning effect may have occurred in between experiments, which could have resulted in a change of mind over time. If this is the case, this result could be an indication that the methodology is more sensitive to changes in risks or risk perception. It will be interesting to find out if experienced assessors can achieve better consistency. In the questionnaire survey where only a small number of experienced assessors were
involved, the results were also favourable to the methodology. All assessors regarded the hazard identification and risk evaluation methods in the final draft as useful or very useful. Compared to their own risk assessment methods that they were using at the time, the vast majority of them found that the proposed methods were either better or much better.

By and large, the experiments and questionnaire survey have served to verify, at least in part, the arguments that risk assessment is better than the conventional assessment method and that there are more benefits to be gained when the risk assessment is more appropriate to the nature and the extent of the crowd safety hazards that could arise in major public venues. Nevertheless, it is important to recognise that the research work presented in this thesis is merely the first step towards a crowd safety risk assessment methodology. There are outstanding issues yet to be resolved, not least the issue of the apparent lack of consistency over time in risk evaluation. This thesis has identified the research and development work that is required to resolve these issues and to further the benefits that risk assessment could bring to crowd safety.
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CHAPTER 1
INTRODUCTION

1.1 Overview

This thesis explores crowd safety planning and decision making and examines the use of risk assessment as a means of supporting this process. Deciding how to ensure crowd safety in public venues has long been a matter of personal judgement often based on personal views and experience of the individual planners and decision makers alone (e.g. venue owners and their operation managers). Their approach is often ill structured, piecemeal and ad hoc, and the decisions can be unduly influenced by, for example, past experience, problems that have recently arisen and the "hot issues" of the time.

Past disasters and recent studies (e.g. Au et al, 1993; Harvey, 1993) have shown that this traditional approach to crowd safety planning is inadequate. Two of the most recent and high profile disasters serve to highlight the problems; namely the failure to recognise the hazards and a lack of appreciation of the risks. In the Hillsborough Stadium Disaster in 1989, the police apparently had their mind-set on crowd disorder and football hooliganism and (Lord Justice Taylor, 1990) had failed to identify overcrowding as a potential problem. Even when the spectators in the overcrowded stands began to escape onto the pitch, it was initially seen by the police officers in-charge as a pitch invasion. The King’s Cross Disaster two years before that was caused by an escalator fire. The enquiry by Fennell (1988) has revealed that escalator fires had occurred in other underground stations before. This was a hazard that was known to London Underground (LUL) but the management had failed to appreciate the risks and did not take any actions that could have prevented the disaster.

Disasters like these show that there is a need for a more comprehensive and more proactive approach to crowd safety planning and decision making. Decisions ought to be made on a more rational basis rather than on an ad hoc basis reacting to whatever problems or issues that come to mind. This thesis argues that by providing a more rational basis for decision making, a systematic risk assessment can help to improve the situation. Risk assessment has been successfully used in many applications but has
never been applied to crowd safety. There are significant differences in the nature of risks between public venues and the other contexts where risk assessment is used; this will be illustrated later on in the thesis. Hence, it is important to establish a risk assessment that is suitable for these risks. Therefore, this thesis sets out to investigate how risk assessment can be best applied to provide support and to improve crowd safety planning and decision-making.

1.2 Crowd Safety in Public Venues

A public venue is a place where members of the public are admitted and where crowds of people could gather. It may open regularly, occasionally or on a one-off basis only and it may open to any members of the public or to invited guests only (i.e. fee paying or non-fee paying). A public venue could be in a privately owned property or on public land. It could be indoor or outdoor, purpose-built or adopted, fixed or transient. There are many types of public venues. They range from relatively small places such as clubs, public houses and village halls to major venues such as airports, train stations, shopping malls, exhibition halls, stadiums, leisure parks, fairgrounds, etc. Places that are used to host public events such as pop concerts, festivals and street parties can also be regarded as public venues.

Crowd safety can be taken to mean the safety of the visiting crowds to a public venue in general. Safety problems exist in public venues just as they exist in other places. But common sense suggests that the higher the number of people gathering in one place, the bigger the problem is likely to be. A loose cable across the floor, for example, presents a tripping hazard regardless of whether this takes place at home, in the workplace or in a public venue environment. But in a public venue, more people are likely to walk past it and therefore more people could trip over it. Therefore, general safety hazards such as a loose cable across the floor often present a bigger problem in a public venue than in other places. The busier the venue is, the bigger the problem is likely to be. In addition, the gathering of large crowds in public venues could, in itself, present safety problems that are not normally encountered in other places. Excessive crowding, for example, is one such problem that could arise purely from the presence of a large high-density crowd. On a smaller scale, it could affect the safety of individuals; e.g. individuals get
pushed or crushed against a gate. On a larger scale, the crowd as a whole could be affected; e.g. crushing, people get trampled under foot and/or a pile-up of people. Moreover, members of the public are less subject to the disciplines that would be expected of a trained workforce.

1.3 Crowd Safety Problems

A catalogue of past disasters and inadequacies shows that crowd safety is an important issue that needs to be addressed. Failure to ensure crowd safety can result in significant problems that threaten the safety and well-being of visitors to public venues and events.

There has been no shortage of major crowd safety related incidents in public venues that resulted in large numbers of injuries and fatalities. The King's Cross Underground Fire (Fennell, 1988) and the Hillsborough Stadium Disaster (Lord Justice Taylor, 1989 and 1990) are two high profile examples of such incidents that took place recently in the UK. Similar tragedies also occurred in other parts of the world. A list of crowd related disasters over the years was drawn up by Dickie (1993) and is given in Table 1.1 below. It shows that they could happen in a variety of venue types and at different stages of operation:

<table>
<thead>
<tr>
<th>Year</th>
<th>Place</th>
<th>Venue</th>
<th>Deaths</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1863</td>
<td>Santiago, Chile</td>
<td>Church</td>
<td>2000</td>
<td>Emergency egress</td>
</tr>
<tr>
<td>1881</td>
<td>Vienna, Austria</td>
<td>Theatre</td>
<td>570</td>
<td>Emergency egress</td>
</tr>
<tr>
<td>1883</td>
<td>Sunderland, UK</td>
<td>Theatre</td>
<td>182</td>
<td>Egress</td>
</tr>
<tr>
<td>1902</td>
<td>Ibrox, UK</td>
<td>Theatre</td>
<td>26</td>
<td>Structural failure</td>
</tr>
<tr>
<td>1903</td>
<td>Chicago, USA</td>
<td>Theatre</td>
<td>602</td>
<td>Emergency egress</td>
</tr>
<tr>
<td>1943</td>
<td>London, UK</td>
<td>Tube station</td>
<td>173</td>
<td>Ingress</td>
</tr>
<tr>
<td>1946</td>
<td>Bolton, UK</td>
<td>Stadium</td>
<td>33</td>
<td>During event</td>
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<tr>
<td>1961</td>
<td>Rio de Janeiro, Brazil</td>
<td>Circus</td>
<td>250</td>
<td>Emergency egress</td>
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<tr>
<td>1964</td>
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<td>318</td>
<td>Riot</td>
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<tr>
<td>1967</td>
<td>Kayseri, Turkey</td>
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<td>1968</td>
<td>Buenos Aires, Argentina</td>
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<td>1971</td>
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<td>Egress</td>
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<th>Deaths</th>
<th>Comment</th>
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<td>1974</td>
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<td>1982</td>
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<td>96</td>
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<tr>
<td>1990</td>
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<td>1992</td>
<td>Bastia, Corsica</td>
<td>Stadium</td>
<td>10</td>
<td>Structural failure</td>
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The list in Table 1.1 is not exhaustive, but it serves to illustrate the scale of the problem should a disaster occur. There have been other crowd disasters since 1992. For example, in the following year, overcrowding at a New Year’s Eve celebrations in Lan Kwai Fong, Hong Kong resulted in crushing and people being trampled under foot and, consequently, caused many fatalities (Mr Justice Bokhary, 1993).

In addition to these high profile disasters, there are likely to have been many more incidents and near misses that were unreported or did not receive as much media coverage. Moore (1992) has given two earlier examples of near disasters in UK’s football grounds: the collapse of a huge retaining wall at the Sheffield Wednesday’s ground in 1914 that injured 75 people, and an overcrowding at the Wembley Stadium in 1923 during which many people fainted. Over 1,000 people were treated for shock and minor injuries. Such incidents and near misses have the potential to develop into something much more serious and tragic.

The power of television has brought home to many people the horror of recent disasters. The Hillsborough Disaster is particularly hard hitting in this respect. Vivid pictures of the disaster were transmitted live and later on in the evening and the following days to many, showing people being crushed to death. In his inquiry report, Lord Justice Taylor (1989) pointed out that his was the ninth official inquiry of this kind and many of his recommendations had already been made before in previous inquiries. Yet, sadly, Hillsborough still happened. It would have been avoidable if lessons from past disasters had been learnt properly.
The Hillsborough Disaster has highlighted to the public the dangers of overcrowding. Its inquiry and the prosecutions that followed have also brought to the attention of many venue owners and their managers the importance of ensuring crowd safety. So, has enough been done to ensure crowd safety since then?

Although the football industry (especially the grounds of the higher divisions’ clubs) has since applied many of the Taylor recommendations and made efforts to improve crowd safety on the ground, crowd safety provisions in many venues are still inadequate some years after Hillsborough. This view is reinforced by the findings of two studies commissioned by the Consumers’ Association. The first study was carried out between 1990 and 1991 (Consumers’ Association, 1992; Harvey, 1993), the second study was conducted in 1994 (Consumers’ Association, 1995). In both cases, crowd safety inspections were carried out by safety experts to a number of indoor and outdoor public venues throughout the UK. In the second study, the safety expert also discussed pre-planning with management to judge the level of consultation had taken place before the event. A total of 19 venues were covered in the studies, they include concerts, matches, motor racing, shows and firework displays. Although on the whole the studies found a good standard of safety at many of the venues, a catalogue of problems were revealed. They include:

- Inadequate means of escape, blocked emergency routes and locked escape doors.
- Poor maintenance of some constructions.
- Building design pre-dating modern standards.
- Too much reliance on good stewarding or policing to prevent crowd safety problems.
- Inadequate separation of vehicles and pedestrians.
- Dangerous crowd bottle-necks and obstructions.
- Serious deficiencies in electrical safety, fire safety provisions and marquee layout.

The findings of the Consumers’ Association studies were particularly critical of one-off events held at sites not normally used for that purpose. In some venues, the inspections
revealed what the study reports describe as “serious shortcomings” and “instances where safety lacks could have cost lives”.

1.4 Improving Crowd Safety

Crowd safety problems are different in many ways to those found in other industries and workplaces. Thus, the conventional methods of problem identification and assessment via testing, performance review and/or failure data are not always suitable.

The fundamental difficulty is that there are no reliable ways to test and validate any crowd safety plans and provisions before implementation. Conventionally, the development of products or services is aided by testing and a continuous process of analysis, revision and re-analysis. For example, in medical research, a new drug can be tested through laboratory analyses, animal experiments and, eventually, trials involving human subjects. In the motor industry, crash tests can be used to test the safety features of their vehicles under different collision scenarios and identify areas for improvement. In engineering, new designs can be evaluated through testing the key components and by conducting trials on the entire system under actual or simulated conditions. In all these cases, once the products or services are launched, their performance can be monitored and information on failures, accidents and mishaps can be collected. This data can then be fed back for improving the products and for future research and development. But none of these approaches can be applied to assessing crowd safety (particularly for one-off events) because of two main reasons.

Firstly, there are little or no means of properly testing crowd safety. Field trials are often expensive to run, disruptive to venue operations if actual visitors are involved and, more importantly, could expose the participants to dangers and unacceptable risks. Occasionally, when the enforcing authorities require public venues to carry out field trials to ensure that safety provisions are adequate, the trials are usually carried out in the quieter hours of the venue operations (e.g. late night) and sometimes use volunteers. Whilst they may be useful exercises for staff training and rehearsal purposes, this arrangement is insufficient as the sole means of testing. This is because the visitor types (and their behaviour) could be different and the numbers involved could be much higher.
in real-life situations. Also, such trials are usually carried out for the purpose of testing evacuation arrangements; the other aspects of crowd safety, such as overcrowding, remain untested. Computer simulations are available for crowd modelling. In theory, they can also be used as a testing tool. However, they too are restricted to emergency evacuations only and they have been criticised for failing to take sufficient account of human behaviour (e.g. Sime, 1991). There have been some attempts to simulate crowd movement in non-emergency situations, but the early models were very primitive and have yet to be properly validated. There appears to be some improvements to the more recent efforts, but details about them are still unavailable at the time of writing this thesis.

Secondly, the scope for learning from past mistakes and failures is limited. Serious crowd safety accidents are relatively rare in comparison to, say, road accidents or accidents in the workplace. But the consequences are often far more severe. For minor incidents, mishaps and near misses, there has been little effort by public venues to record, collect and collate such information. This is partly due to the reluctance of public venue owners to publish their information. Recorded failure data concerning crowd safety is, therefore, limited. The lack of failure data and information poses a number of problems to both the practitioners (e.g. public venue owners) and the researchers. Firstly, there are insufficient data for venues to analyse the performance of their crowd safety plans and identify areas for improvements. Secondly, because of their potentially severe consequences, crowd safety accidents should not be allowed to occur in the first place. This means that venue owners would have to address any crowd safety problems without proper data and the opportunity to learn from serious past mistakes.

These reasons also help to explain why the traditional approach that relies so heavily on the experience of individuals has not been very successful for crowd safety planning. If crowd safety plans and provisions cannot be properly tested and validated in the same way as in the other contexts, then it becomes even more important that planners and assessors must get it right the first time when deciding how to ensure crowd safety in their venues.
1.5 The Application of Risk Assessment to Crowd Safety

Crowd safety, though very different from most other contexts, is not unique. The high hazard industries (e.g. the Nuclear and the Chemical industries) also have a similar problem in that they too experience infrequent but severe accidents and, hence, they too cannot solely rely on learning from such accidents. Compared to crowd safety, however, the high hazard industries have devoted much more effort in research and development to find a suitable tool to assist and support the decision-making process. The tool they have adopted is risk assessment (HSE, 1992a). It is a systematic and structured way to identify hazards and evaluate their risks. It is also a proactive approach that enables planners and decision makers to examine the overall situation (rather than narrowly focusing on specific issues alone), to determine what problems could arise and to put them into perspective so that efforts and resources to those problems that require more attention. Risk assessment is a well-established method and is currently applied to many other contexts. Experience has shown that it is an invaluable aid to decision making and provides a credible solution to the problem of insufficient planning.

There is also a practical reason for using risk assessment; i.e. the legal requirements set out in the Management of Health and Safety at Work Regulations 1992 (i.e. MHSWR). The Regulations were revised in 1999 but the requirements on risk assessment remain the same. Under the regulations, all employers, including venue owners, are required to carry out risk assessments. This gives rise to the need for a suitable risk assessment for crowd safety.

Risk assessment can be regarded as the process to identify and assess hazards and risks. The literature review in Section 2.2 will look at what is meant by risks and the risk assessment principles in more detail. But in brief, risks arise from hazards, and a hazard can be referred to as something that has the potential to cause harm, such as an item, a substance, an activity, a process or an adverse event. The term “risk” implies something that is uncertain and undesirable. Therefore, risk might, for example, be expressed as the likelihood (i.e. an uncertainty) of people suffering from a certain health problem, serious injury or even death as a result of, say, poor work practice, over-exposure in a
hazardous environment or an accident (i.e. an undesirable outcome). Risk assessment is a process that enables people to seek answers to the following:

- What are the hazards (e.g. hazardous substances, activities, processes and events)?
- How likely is it that people will be harmed?
- What harm could occur and how many people might be affected?

The idea of a risk assessment is that by answering these questions, public venue owners will have a better understanding of the problems. They will then be in a better position to make more informed and more rational decisions.

1.6 Research Objectives

Given the problems and concerns associated with assessing crowd safety, the objectives of the research work presented in this thesis are:

(i) To show that risk assessment can be applied to crowd safety to remedy the pitfalls of the conventional methods highlighted above and, therefore, to improve crowd safety assessment.

(ii) To investigate and explore, through the development of a crowd safety risk assessment methodology, how risk assessment can be best applied to assess crowd safety risks and provide support for decision making in crowd safety management and planning.

(iii) To demonstrate that such a methodology, which takes into account the specific nature of crowd safety risks, can lead to further improvements in crowd safety assessment.

In order to achieve the above objectives, there are specific risk assessment issues that need to be addressed. They are highlighted in Section 1.7 below.
1.7 The Research Questions

Essentially risk assessment is about two things. Firstly, to establish what could go wrong or what problems may arise so that precautionary measures can be incorporated into the safety plan. Secondly, to decide how significant these problems are (i.e. their risks) to ensure that important problems are addressed and resources are efficiently deployed. It has to be noted that the high hazard industries are also different to crowd safety in terms of the availability of failure data. In the high hazard industries, failure data and similar information is available to enable safety engineers to risk assess a particular plant, a part of the plant or a process of operation. But as previously discussed in Section 1.4, there is no such data in crowd safety. Also, in the high hazard industries, the behaviour of the systems, the substances they handle and the operations involved are all more predictable, better understood and can be clearly defined. Furthermore, risk assessments in the high hazard industries are often carried out by specialist safety engineers. These differences could have significant impacts on the kind of risk assessments that can be employed. What is suitable to safety engineers in the high hazard industries may be unsuitable for public venue managers. Hence, the specific research questions that need to be looked at are as follows:

- How best to assist public venue owners to identify potential safety problems, bearing in mind the wide ranging outcomes due to human behaviour? To address this, it is necessary to look at what hazards could arise in public venues and how they differ from problems elsewhere.
- How to evaluate the risks given that there are no relevant failure data to support the evaluation process?
- Overall, how to ensure that the risk assessment method for crowd safety is suitable and can be used by practitioners as efficiently as possible?

1.7.1 Hazards and Hazard Identification

Different contexts involve different operations and different task activities are conducted under different operating conditions. These differences, in turn, cause different hazards. So the hazards in, say, the nuclear industry are not the same in manufacturing industries.
The hazards in road travel are not the same as those in rail or air travel. Equally, the kinds of hazards found in a factory will be different from those in an office, or in a laboratory or a building site or in a mine. By the same token, crowd safety and public venue operations are also likely to present a set of hazards that are different from those in other industries and workplaces. Therefore, one of the key tasks for this research project is to establish what kind of hazards can arise in public venues and then to determine how best to account for them in risk assessment. The relative unpredictability of crowd safety hazards can be a problem. Essentially, managing a public venue is about “processing” a large number of visitors. The “human factors” are important contributory factors to safety. Yet, human beings are much less predictable in terms of behaviour than engineering components and the substances/materials used in industry. Where there is a significant human involvement in the industry, human behaviour in the workplace is often much restricted by rules, work procedures and the tasks people have to carry out. There are no such restrictions in public venues. There are also other factors affecting crowd safety; for example, venue design and undesirable external circumstances. Hence, the outcomes in terms of crowd safety hazards could be wide ranging. Because of these factors, different hazards could arise in different venues at different times. The challenge, therefore, is to establish a suitable way to deal with these wide ranging and less definable behavioural factors and other factors in order to assist owners of different venues to account for hazards that are specific to their operations.

1.7.2 Evaluation of Risks

In a nutshell, risk evaluation essentially means making judgements about the possibility of an undesirable or adverse outcome(s) for a given hazard. Validating such judgements is always a problem. In many other areas where risk assessment is applied, judgements concerning the possibility of adverse events are made on the basis of failure rate/probability data of engineering components. The data is generated through experiments, trials and testing. But as discussed in Section 1.4, there are no such data available for crowd safety. The main basis for evaluation is the operational knowledge and experience of individual assessors. This is exacerbated by the rarity of accidents and the enormity of consequences, which gives little opportunity for the assessors to review and revise their judgements.
Realistically, given that there is no usable failure data and that there is little or no real prospect of getting it in the near future, it can be argued that operational knowledge and experience is probably the most valid basis feasible for passing judgements. However, the danger is that if knowledge and experience are used casually in an unstructured and ad hoc manner, risk evaluation could become merely an expression of personal opinions. There is also the danger that judgements could be unduly influenced by political factors, “hot issues” of the day, etc. What needs to be achieved in the research is to establish a way to minimise such dangers and make the judgement of possibilities less subjective and less ad hoc.

There is always an element of subjectivity in risk evaluation, even where reliable failure data is available. A key problem is how to ensure the reliability and validity of the judgements; the problem is even worse when there is no failure data on which to base the evaluation. Finding a means to ensure better reliability and validity in risk evaluation is also an important issue in the investigation.

1.7.3 Overall Methodological Issues

Even though the risk assessment principles are the same, the methods of assessment can vary depending on the applications. In some cases, a simple and loosely structured risk assessment is deemed suitable. In other cases, detailed probabilistic assessments using sophisticated risk quantification techniques are required. What method is suitable for a particular application and how sophisticated it needs to be depend only partly on being able to satisfy the hazard identification and risk evaluation needs described above. There are also other factors that need to be taken into consideration. For example, operational constraints, availability of resources, the existing practice and who the assessors are. It is important to recognise that assessors must be able to use the method efficiently if risk assessment is to be effective in supporting decision-making. A mismatch between what is required by the methods and what is achievable could render the assessment method unsuitable and seriously undermine its effectiveness. Part of the research is therefore to look into these factors to establish what the assessors’ needs (or user requirements) are.
in terms of assessing crowd safety risks and how the assessment method could help to best address these needs.

It is also worth noting that risk assessment and the subsequent risk management decision making can be affected by an array of social political factors such as public risk perception, the public’s attitude towards specific industries (e.g. the nuclear and railway industries) and public tolerance of different types of risks. Such factors are regarded as a different area of research. They are not the main focus of this investigation, although they are discussed in Section 2.3 in relation to how they may affect the choice of risk assessments.

1.8 The Research Constraints

The research described in this thesis is applied in nature, aiming to provide a usable solution to a practical problem. The subject area, i.e. crowd safety, is a very young discipline and is one that has been rarely investigated in the past. The lack of research information and the various constraints and difficulties associated with studying crowd safety discussed in the previous sections, together with a number of other factors, have posed severe constraints on how this research can be carried out. Two areas of the research project are particularly affected: data collection and the testing of the research output in relation to the hypnosis set out in Objectives (i) and (iii) in Section 1.6.

1.8.1 Data Collection

Data collection in a research project would normally involve a review of past research studies and provide an account of the current situation and wisdom in the subject area of concern. This is often achieved by means of literature review, which should be aimed at generating information relating to the nature of the research problem, the issues involved, what has already been done and so on. This would enable the researcher to identify any gaps or inadequacies in the existing research and where further research is required. A theoretical perspective can then be proposed to address the research
question. Further data collection would be carried out to gather information about the theoretical device.

However, in this particular piece of research, the subject area has posed some problems for data collection. Crowd safety is a brand new subject area. Even though people have been practising it for many years, crowd safety has received little research attention. Up until the Hillsborough Disaster in 1989, there had been no serious efforts to study crowd safety or to learn from past mistakes. In his inquiry report into the Hillsborough Disaster, Lord Justice Taylor (1990) wrote:

_It is a depressing and chastening fact that mine is the ninth official (inquiry) report covering crowd safety and control at football grounds. After eight previous reports and three editions of the Green Guide¹, it seems astounding that 95 people could die from overcrowding before the eyes of those controlling the event..._

After Hillsborough, the HSE commissioned a study into the management of crowd safety in public venues. This appeared to be the only extensive study into the subject so far. Apart from a lack of published studies, crowd safety problems and how they can be assessed is rarely discussed in public forums. This could be due to a number of reasons. For example, a lack of appreciation of the risks involved (also see the literature review on current practice in Section 2.6) and the reluctance of venue owners to share information about their mishaps and near misses for fear of adverse publicity.

Given the lack of published information, data collection on crowd safety cannot be done by means of conventional literature review alone. Alternative data gathering methods have to be used to make this research possible. Hence, it was decided that literature review should also include unpublished information. This included materials generated in the HSE study previously mentioned (Au et al, 1993), from consultancy works carried out by the author, and from documents collected in the course of these works. But this is deemed insufficient on its own, not least because the source of this information cannot be referenced for reasons of confidentiality. The amount of relevant information is also quite limited. Therefore, the literature review was supplemented, firstly by case studies

¹ i.e. Guide to Safety to Sports Grounds (Home Office and Scottish Office, 1990)
to examine the nature of public venue operations and crowd safety problems and, secondly, by a survey to talk to managers of public venues and to collect information about how crowd safety is assessed.

To a lesser extent, insufficient published research knowledge also has an impact on the review on risk assessments. In brief, there are two types of risk assessment: quantified risk assessment (QRA) and qualitative risk assessment. The former has been widely adopted in the process and the high hazard industries for years. It is well established and a lot of effort has been devoted in the development of methods and techniques and in the studies of specific risk assessment issues. There is plenty of literature on QRA but they are considered unsuitable for the vast majority of workplaces, including public venues, the main reason being a lack of data for risks to be quantified. The relative unpredictability of crowd safety problems and the fact that crowd activities are very difficult to define also make QRA unsuitable. Qualitative risk assessment, on the other hand, has received far less attention. Literature on the subject, be it on methods and techniques or on specific risk assessment issues, is few and far between. The author is aware that some studies on qualitative risk assessment and its application into different workplaces are in progress. But such information was not yet available in the public domain at the time of this research. Once again, the survey was used for gathering additional information from those venues that have attempted to do risk assessments about how they carry out the assessments and the issues involved.

1.8.2 Evaluation and Verification

The difficulties highlighted in Section 1.4 (e.g. rarity of major crowd safety accidents, a lack of failure data and unpredictability of crowd activities and problems) affect how the output of the research can be tested in much the same way as how they restrict the testing of plans and provisions. For example, to test the output against every possibility is prohibitive due to the wide-ranging outcomes in public venues. Testing is further restricted by availability of resource and suitable subjects for the test. Because of these difficulties, the methods of evaluation and verification are somewhat unconventional. Details of how these difficulties affect evaluation and verification and the alternative methods of testing are discussed in Chapters 8 and 9 of this thesis. But in a nutshell, the
evaluation process had to be carried out in stages involving, firstly, Human Factors specialists to assess the presentational aspect of the research output. This was then followed by user trials on a selected sample of public venues representing different public venue operations and different crowd safety problems.

Similarly, it is not possible to verify the research output against every outcome. Also, it is impossible to validate by reference to actual outcomes (i.e. to show that it can lead to fewer accidents or reduced severity) because of the rarity of major accidents, nor by simulation of the outcomes because of the risks to those who take part in the simulations. Though, in practice, it is possible to measure the effectiveness of the risk assessment methodology (and the subsequent risk reduction measures) from evidence such as the frequency of crowding or other dangerous occurrences, injury figures and the number of complaints from visitors. Feedback from the front line staff (e.g. during post event de-briefing) can also provide some indication on the effectiveness of the risk assessment methodology. However, these are not feasible within the context of this research. Therefore, the only viable options are through controlled experiments to compare the performance of subjects using different methods of assessment and by obtaining subjective judgements from a small sample of the end user population. On the basis of the key research questions highlighted in Section 1.7, the two criteria for the verification are (i) the number of crowd safety problems that can be identified and (ii) the reliability and validity of the judgements on the significance of the identified problems.

1.9 Research Methodology

The methodology employed in the research includes a literature review, case studies, survey and field investigations, an analysis of the risk assessment tasks and a review of existing risk assessment methods. Table 1.2 shows how these different elements of the research work together to contribute towards addressing the research questions on hazard identification, risk evaluation and ensuring suitability of the assessment methods. In brief, investigations into hazard identification issues were done mainly through case studies and the review of existing risk assessments. The risk evaluation issues were addressed mainly through the review of the existing risk assessments. Based on
information generated in the survey and the literature review. Survey and task analysis are the main methodologies used to identify the operational issues that could have an impact on assessment methods and to define the needs of the assessors in terms of crowd safety risk assessment.

<table>
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<tr>
<th>Table 1.2: Overview of the Investigation Methodology</th>
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<tr>
<td>Research Questions</td>
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<td>Hazard Identification</td>
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| What types of crowd safety problems exist in public venues and how do they differ from those in the other industries and normal workplace? | - Literature review  
- Case studies  
- Survey/field investigations |
| How to overcome the unpredictability problems associated with human behaviour? | - Review of existing risks assessments |
| How to cater for the wide-ranging hazards in different venues? | - Survey/field investigations  
- Review of existing risk assessments |
| Risk Evaluation | |
| How to make the risk evaluation process more rational and less subjective? | - Literature review  
- Survey/field investigations  
- Review of existing risk assessments |
| How to overcome the problem of a lack of failure data? | - Survey/field investigations  
- Review of existing risk assessments |
| How to enhance reliability and validity of the evaluation? | - Review of existing risk assessments |
| Overall Methodological Issues | |
| What are the operational issues affecting the assessment of crowd safety? | - Case studies  
- Survey/field investigations |
| Given the above, what do the assessors need to enable them to successfully assess the crowd safety risks in their venues? | - Literature review  
- Survey/field investigations  
- Task analysis |
| What help the assessment method could provide to satisfy assessors’ needs? | - Survey/field investigations  
- Task analysis  
- Review of existing risk assessments |

Initially, effort was directed towards collecting the necessary background information on crowd safety and risk assessment. To this end, a literature review was conducted on a range of topic areas that could be of relevance to the research. These topics include the legal requirements, the risk assessment principles, some of the specific issues concerning risk assessment, risk assessment techniques and tools used elsewhere in other contexts, existing guidance available to venue owners and the current practice in
crowd safety planning and assessments. The review is presented in Chapter 2 of this thesis.

From the reviews on legal requirements and the risk assessment principles, the notion of a “suitable and sufficient” risk assessment has emerged as a key issue. The assessment must identify all significant risks, enable the identification and prioritisation of remedial measures and be appropriate to the nature of the operations. These requirements are in line with the research questions set out in Section 1.7. The reviews on existing guidance and current practice have also revealed that both are inadequate in terms of achieving a suitable and sufficient risk assessment for crowd safety.

The literature review was therefore followed by detailed investigations into crowd safety hazards, risk evaluation and the overall methodological issues. The investigations began by looking into public venue operations, the types of safety hazards that could arise and how they may differ from those found in other industries. This part of the research is particularly relevant to hazard identification. Normally, the investigation would proceed with a review of the literature to highlight the key issues involved. However, due to the lack of published information, this review was not extensive. To illustrate the issues to be investigated, two case studies are presented in Chapter 3: a street festival and a high street/open market type environment. The case studies enable detailed examinations of the types of hazards that could be resulted from the presence of large crowds. They also give an insight into public venue operations and the operational issues involved in managing and assessing crowd safety.

Field investigations were also carried out to look at how crowd safety was assessed in different venues, the pros and cons of the different methods used, the kinds of problems the assessors encountered, the constraints within which they had to work and, thus, what help and support they may require. The field investigations were carried out by means of a public venue survey. The survey was intended primarily for identifying the operational factors and constraints that need to be taken into consideration when determining what methods are suitable for crowd safety assessors, although some of the information generated here is also relevant to hazard identification and risk evaluation.
A total of fifteen venues and organisations took part in the survey. Details of the survey and its findings are presented in Chapter 4.

To ensure that the proposed risk assessment methods are appropriate to the needs of the assessors, a task analysis was then carried out to examine the tasks involved in conducting a crowd safety risk assessment. This analysis provides a description of the high level risk assessment tasks, breaks them up into specific sub-tasks and then identifies the knowledge, information and methodological guides an assessor would need in order to complete each sub-task successfully. Chapter 5 presents the task analysis. Based on the findings of the literature review, the case studies, the survey and the task analysis, a set of criteria was developed to set out all the issues and factors that should be catered for in the development of the methodology. This is also presented in Chapter 5.

Having identified what is required, the next phase of the research project was to look at how risk assessment can be best applied to satisfy these requirements. A review of the existing risk assessments was carried out to examine what methods and techniques there are for different needs and circumstances. The review is particularly important to hazard identification and risk evaluation. By looking at the risk assessments carried out in other industries and contexts, the aim of the review was to see what can be learnt and identify where existing methods and techniques are suitable to crowd safety application and satisfy the criteria set out previously in Chapter 5. The review of risk assessments elsewhere is presented in Chapter 6.

Incorporating all the information and findings generated so far, a prototype methodology for crowd safety risks assessment was then developed. Chapter 7 discusses the rational behind its design. The final part of the development is fine-tuning; i.e. to evaluate the prototype to identify areas where improvements are required. Chapter 8 describes the evaluation methods used and the results. How much help the methodology can provide to the assessors depends not only on its validity and its suitability for purposes alone. it also depends on how the methodology is presented to the users. As in product design, the benefit of a good product could be seriously undermined if its user interface is poorly designed or the instructions badly written. Therefore, the evaluation consisted of tests
on both the validity and the usability aspects of the methodology. Usability experts and actual assessors were employed in the evaluation. Modifications were then made to the methodology following each test.

The final phase of the research was to verify the methodology. Chapter 9 gives details of the verification. As previously discussed in Section 1.8.2, the verification can only be achieved by comparing the performance of people using different assessment methodologies. It is recognised that in crowd safety assessment, the methodology used is merely one factor that could affect performance. Other factors may include the experience of the assessors on the problems that could arise and local knowledge of the venue being assessed. These factors cannot be kept as constant variables if actual assessors, who have different knowledge and experience, are used for the verification. Given this, the verification programme was done in two parts: a controlled experiment using novice assessors (i.e. university students) and user trials to obtain subjective judgements from actual assessors. The latter is an additional measure to compensate the fact that the subjects used in the experiments do not have some of the qualities of an actual assessors (e.g. in terms of venue specific knowledge and experience) and, therefore, are not fully representative of the user population in this regard.

Finally, the work carried out in this research project is only an initial attempt to apply risk assessment principles to crowd safety. Whilst the results of the verification show that the methodology has led to improvements in some aspects of assessors’ performance, it is by no means perfect. There are still some gaps in the research and outstanding issues that require further research. Also, to build on what has been done in this research, additional developments are necessary to assist assessors further in order to improve their performance. A summary of this research, what it has achieved and ideas for future research and development are presented in Chapter 10.

1.10 Definitions of Terms

The meanings of public venue, risk and risk assessment have already been set out earlier in this chapter. The following gives the meanings of other terms commonly used in this thesis:
| **Crowd safety** | Refers to the safety of individual visitors to a public venue or the visiting crowd as a whole (e.g. excessive crowding). |
| **Crowd safety assessor** | A person who is given the task of assessing crowd safety in a public venue. This person could be the venue owner himself or he could delegate this duty to, for example, his operation manager, an in-house health and safety specialist or someone external to the organisation. For the purpose of this thesis, crowd safety assessors are sometimes referred to simply as “assessors”. |
| **Hazard** | Something with the potential to cause harm (HSC, 1992). See Section 2.2. of this thesis for details. |
| **Public venue owner** | A person or organisation that owns a public venue and/or can legally seek to control the number of people entering it and the activities within it. Regarded as an employer under UK health and safety legislation, a public venue owner is ultimately responsible for ensuring the health and safety of his employees and visitors. |
| **Public venue manager** | A person or an organisation who manage the operation of a public venue. He could be the venue owner himself or he could be working on his behalf. |
| **Visitors** | People attending a public venue. They could be fee paying customers, revellers, passengers passing through a station or non-fee paying members of the public in the premises. |
CHAPTER 2
LITERATURE REVIEW

The aims of this literature review are to establish what is known about crowd safety and risk assessment practice and, generally, to collect the necessary background information and set the scene for the rest of the research. These aims were accomplished by studying the relevant legal requirements, literature on risk assessment, existing guidance publications and information about current practice.

A review of the relevant legal requirements is given in Section 2.1. Apart from setting out the legal obligations, the legal requirements also specify what venue owners and assessors are required to achieve in ensuring crowd safety and in risk assessment. Literature on legal requirements is an important information source for defining the needs of the assessors in relation to the legal obligations and the systems in which they need to operate (e.g. licensing).

Section 2.2 looks at what is meant by risks, the concept of hazards and risks and the risk assessment principle. This provides a basic understanding of risks and risk assessment. A more in-depth review on some of the specific risk assessment issues is carried out in Section 2.3. The topics covered in this review include the types of risks, different risk assessment approaches, acceptability and tolerability of risks and how to deal with uncertainties. Section 2.4 looks at some of the existing risk assessment techniques and tools. The implications of these techniques and tools are discussed later in Chapter 6 as part of the investigation into establishing suitable methods for crowd safety (i.e. to see if any aspects are suitable for crowd safety or if anything can be learnt from them).

Having looked at the legal requirements and the subject of risk assessment, the next step of the review was to discover existing provisions aimed at guiding and assisting public venue owners and assessors to achieve a suitable risk assessment for crowd safety. Section 2.5 reviews the guidance documents that are likely to be obtainable by public venue owners. The existing guidance also provides an insight into what is generally recognised as good practice in safety management and risk assessment. Finally, a review was carried out on the current practice, in Section 2.6, to establish how crowd
safety is assessed in practice and identify where the problems may be and what improvements may be required.

2.1 The Legal Situations

The health and safety law in the UK regards operating a public venue as a work activity. Hence, the health and safety legislation, which covers almost all workplaces, also applies to public venues.

2.1.1 General Requirements on Ensuring Crowd Safety

The main piece of legislation which sets out the legal requirements on ensuring health and safety in the workplaces, including public venues, is the Health and Safety at Work etc. Act 1974 (HSW Act). The 1974 Act places a duty on employers to ensure, so far as is reasonably practicable, the health, safety and welfare at work of his employees and non-employees who may be affected by their undertakings. In particular, Section 3 of the Act specifies the health and safety requirements concerning non-employees. This is applicable to anyone who could be affected, such as contractors in the premises, visitors and members of the public. The full text of Section 3 of the 1974 Act is as follows:

*It shall be the duty of every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety.*

Under this Act (and other health and safety legislation), the owner of a public venue is regarded as an employer whose works involve the attendance of crowds. It is therefore clear that the legal responsibility to protect the visitors lies with the public venue owner. Whilst he may delegate this duty to his employees (e.g. operation or safety manager) or to an outside body (e.g. stewards from a security company), he is ultimately responsible for ensuring that the visiting crowds and anyone else who may be affected are, so far as is reasonably practicable, not exposed to safety risks. In general, the venue owner will
need to provide and maintain an environment where the risks to health and safety are kept as low as possible and take the necessary actions to ensure the health and safety of the visiting crowds.

A key principal emerging from the 1974 Act is that employers have to ensure, so far as is reasonably practicable (SFRP), that people are not exposed to risks. This is perhaps better known as the ALARP principal - i.e. employers must keep the risk as low as reasonably practicable. As discussed in Section 2.1, what the law requires here is not about asking employers to do everything to ensure absolute health and safety. The ALARP principal serves to "qualify" the duties on employers; i.e. in terms of what is practicable and what is reasonable to do to ensure health and safety. It has become one of the most important principals behind the UK health and safety law. But what does "reasonably practicable" mean? The following was quoted by Cohen (1982) and Kletz (1982) as the definition of the phrase:

'Reasonably practicable' is a narrower term than 'physically possible', and implies that a computation must be made in which the quantum of risk is placed in 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 - the risk being insignificant in relation to the sacrifice - the defendants discharge the onus upon them. (Fife & Machin, 1976)

It follows that an employer should assess the risks associated with his undertaking so as to enable him to determine in an informed manner, what reasonably practicable actions to take to reduce the risks as much as possible.

2.1.2 Legal Requirements on Risk Assessment

In addition to the general requirements of the HSW Act, the Management of Health and Safety at Work Regulations 1992 (MHSWR) place a more specific duty on employers to assess the risks posed by their undertakings. This is in line with the ALARP principle of
doing what is “reasonably practicable” to avert risks. Regulation 3 of the MHSWR sets out the risk assessment requirements as follows:

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.

for the purpose of identifying the measures he needs to take to comply with the requirements and prohibitions imposed upon him by or under the relevant statutory provisions.

For public venue owners, this means that they are required to carry out an assessment of, amongst other things, the risks to the safety of the visiting crowds. This is to ensure that they think carefully about the nature and the extent of the hazards at their venues. The ultimate aim of the assessment is to identify the measures required to minimise the risks and to comply with the appropriate statutory requirements. For most public venues, the appropriate statutory requirements may include those set out under the fire safety and precautions legislation and, for venues where hazardous substances are stored and used, the Control of Substances Hazardous to Health Regulations 1988 (COSHH). Section 3.1.3 will look at legislation concerning specific areas relevant to crowd safety and those concerning specific venue types.

Apart from conducting risk assessment, Regulation 3 also requires employers to review their assessment if there is a reason to suspect that it is no longer valid or there has been a significant change in matters to which it relates. Where necessary, changes to the risk assessment will then have to be made. It also requires employers who have five or more employees to record the significant findings of the risk assessment and any group of his employees identified by it as being especially at risk.
The text of Regulation 3 specifically states that the risk assessment the employers carry out must be “suitable and sufficient”. The MHSWR Approved Code of Practice (HSC, 1992) provides clear guidance on what this means; namely that a suitable and sufficient risk assessment should:

- identify all significant risks;
- enable the identification and prioritisation of the measures that need to be taken; and
- be appropriate to the nature of the work such that it remains valid for a reasonable period of time.

The first two points set out what public venue owners need to do to improve their safety planning and provisions. They also provide the basic criteria for the development of the crowd safety risk assessment methodology. The last point specifies the need for the risk assessment methodology to be relevant to venue operations and the sorts of crowd safety problems that could take place there.

The MHSWR is the main legislation as far as risk assessment is concerned. There are other pieces of legislation that also require risk assessment to be carried out for specific areas of health and safety (e.g. fire safety, COSHH, manual handling). But the principle of what they require is exactly the same.

2.1.3 Other Requirements

Together, the HSW Act and the MHSWR set out the general requirements for owners of public venues to ensure the safety of their visiting crowds and conduct crowd safety risk assessment. Depending upon the circumstances and the nature of their operations, some venues are also subjected to other legislation that covers specific areas or applies only to certain venue types. In terms of safety and risk assessment, the requirements imposed by such legislation are very much in line with those specified in the HSW Act and the MHSWR.
Fire safety is one area which is particularly relevant to crowd safety and where the legal requirements on fire risk assessment are very similar in nature to those in the MHSWR. The main piece of fire safety legislation is the Fire Precautions Act 1971. It applies to all types of public venues except tents and other moveable structures and some open air venues. Regulation 4 of the proposed Fire Precautions (Places of Work) Regulations 1994 also requires a risk assessment to be made on fire safety. As in the MHSWR, the assessment should be revised whenever there is a reason to believe that it is no longer realistic or there is a significant change in the activity. Also, findings of the assessment have to be recorded if five or more persons work there at any one time.

Some venues such as railway stations, sports grounds and places of public entertainment are also subject to legislation that is designed specifically to ensure the safe operation of these venues and to introduce extra protection to the health and safety of the public. In addition to the general requirements mentioned previously, owners of these venues also have to satisfy other requirements before they are allowed to operate. They can be in the form of a safety case to prove the adequacy of their safety provisions or in the form of terms and conditions specified in a safety certificate or a licence. The requirements on different public venue types are dictated by different legislation. The Railways (Safety Case) Regulations 1994, for example, require operators of trains, stations, etc. to prepare and secure the acceptance of a safety case. The safety case will then have to be accepted by the infrastructure controller or, in certain cases, by the HSE before starting to operate. There is a requirement to conduct a crowd safety risk assessment under the regulations. Schedule 1 specifies that the safety case should deal with the risks that can arise from congestion and the movement of people within the station and the evacuation of persons from a station in an emergency. It also requires the safety case to include a satisfactory record of the risk assessment made under Regulation 3 of the MHSWR. But the 1994 regulations go further than the MHSWR in that they require a risk assessment record to be made regardless of whether the station operator employs five or more employees.

Sports grounds and most places of public entertainment, on the other hand, are subjected to licensing laws. In order to be allowed to operate or to admit visitors, owners of public venues need to obtain a licence or a safety certificate from the relevant authority and must abide by the terms and conditions on the licence. In the case of sports venues, the
relevant legislation is the Safety at Sports Grounds Act 1975, which is amended by the Fire Safety and Safety of Places of Sport Act 1987. The safety control imposed by the 1975 Act is primarily through the issuing of safety certificates to designated sports grounds - i.e. grounds which, in the opinion of the Secretary of State, have the capacity to hold more than 10,000 people and where football, rugby and cricket are played. The 1987 Act has extended the safety certificate system and inspection to regulate stands - i.e. stands that are able to accommodate under cover 500 spectators or more at sports grounds not designated in the original 1975 Act. Under both the 1975 and 1987 Acts, the terms and conditions of the safety certificate are at the discretion of local authorities. The local authorities also have the power to prohibit admission of spectators to a sports ground or part of a sports ground if, in its opinion, the admission of spectators would involve a serious risk to them. Applications for the certificates are usually considered by a “safety team” consisting of the appropriate local authority, the building authority, the police and the fire authority (Graham, 1993).

Under the Local Government (Miscellaneous Provisions) Act 1982 and the London Government Act 1963, local authorities have powers to license certain places of public entertainment. Under the Licensing (Scotland) Act 1976 and the Civic Government (Scotland) Act 1982, local authorities in Scotland have powers to grant an entertainment licence to this type of venue only when the public has to pay to get in. The terms and conditions of the licence, by which the venue owner must abide, are again determined by the local authorities and are prescriptive.

Exactly how the licensing and safety certificate requirements link to the risk assessment requirements made under the MHSWR may require further consideration. This issue is particularly relevant to venues such as sports grounds and places of entertainment. This is because these venues are often subject to overlapping legislation, namely the HSW Act (and the MHSWR under it) and the relevant licensing law. According to the Guide to Health, Safety and Welfare at Pop Concerts and Similar Events (HSC et al, 1993), the licensing legislation will normally be regarded as the more appropriate legislation in these circumstances. Whilst such an arrangement may be necessary to avoid duplication of enforcement, it could also mean that in practice, the only mechanism to control safety in these venues is the prescriptive measures determined entirely by the relevant licensing
authorities. Since the licensing law does not require the venue owners or the authorities to assess risks when deciding on the terms and conditions, there are no mechanisms in place to ensure that the terms and conditions are themselves adequate. Furthermore, such an arrangement could encourage venue owners to aim at satisfying only the terms and conditions on the licence instead of looking afresh at what safety problems could arise and how people could be harmed.

2.2 Risk and Risk Assessment

This section looks at the basic ideas concerning risks and the risk assessment principles. A more in-depth review on some of the issues concerning the application of risk assessment will be conducted in Section 2.3. A further literature review on methodological issues and specific techniques for different risk assessment tasks will be carried out later in Chapter 6 when detailed requirements of the risk assessment methodology have been defined.

2.2.1 Definitions of Risks

A simple way to summarise what has been said in the literature about risk is that it arises from a hazard, it represents something that is undesirable and unwanted and that there is an element of chance in it. There are many types of risks affecting many aspects of our life; for example, financial risks, social risks (e.g. crime), risks to the environment, public health and safety risks that affect a large population overall (e.g. travel risks, risks associated with smoking). But the focus of this thesis is on safety and, in particular, the risks to visitor safety in a public venue. It is within this context only that the review and investigations on risk, risk assessment and risk assessment methodological issues were conducted.

Hazards

The term “hazard” represents some forms of danger. The HSC (1992) defines hazard as something that has the potential to cause harm. Under this definition, a hazard could be
a substance, an item such as a piece of machinery, a work method, aspects of the work organisation, the circumstance, an event, an activity, etc. In this respect, the undesirable and unwanted outcome is that people are harmed by the hazard. In safety, harm usually means injuries or fatalities. The British Medical Association (i.e. BMA) (1987) gives a slightly different definition; namely, hazard is “a set of circumstances which may cause harmful consequences”. For example, a car travelling through a crowd of pedestrians can be regarded as a hazard under BMA’s definition. Shrader-Frechette (1985) has provided more examples of natural and man-made hazards. The former includes floods, droughts, famines, infectious diseases and fire. The latter, which are also regarded as technological hazards, include nuclear war, toxic chemical, explosive materials and automobile accidents. All these are events, circumstances or substances that could cause harm to those who are involved.

**Risks**

Unlike hazard, there are more variations in terms of exactly how the term “risk” is defined. Dunster (1985), for example, takes it to mean the probability of a specified adverse event or consequence. This definition is close to our everyday use of the word when we say the risk of a fire, the risk of an accident, the risk of skin cancer, etc. This definition tends to give an impression that risk is equal to chance, likelihood or probability. From the risk assessment viewpoint, however, this interoperation is not correct. Health and safety analysts generally understand risk as a measure of the probability and the severity of loss or injury (Whipple, 1986). The definition given in the MHSWR Approved Code of Practice (HSC, 1992) is consistent with this:

- **Risk expresses the likelihood that the harm from a particular hazard is realised**
- **The extent of the risk covers the population which might be affected by a risk; i.e. the number of people who might be exposed and the consequences for them**

Risk therefore reflects both the likelihood that harm will occur and its severity.
The Royal Society Study Group on Risk (1983 and 1992), on the other hand, gives the following definition:

(Risk is) the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge.

The study group also pointed out that:

As a probability in the sense of statistical theory risk obeys all the formal laws of combining probabilities. Explicitly or implicitly, it must always relate to the ‘risk of a specific event or set of events’ and where appropriate must refer to an exposure to hazards specified in terms of its amount or intensity, time of starting or duration. ... All risks are conditional, although often the conditions are implied by context rather than explicitly stated.

The Royal Society’s definition is rather similar to that by Dunster. There are two important properties in the definition; i.e. probability and adverse event. In its report to the European Commission on risk assessment for hazardous installations, J.C. Consultancy Ltd (1986) argued that an adverse event is an occurrence that produces harm, and harm is a loss to a human being or a population of human beings. So this definition actually incorporates the concepts of both probability and consequences. The term “probability” can be taken to mean a numerical measure, on a scale from zero (i.e. impossible) to one (i.e. certainty), of the degree of confidence in the occurrence of an (adverse) event. In some areas of health and safety, the probability of exposure to an adverse event for a stated period of time can be based on failure data of system components, obtained through repeated tests and past statistics. This type of method is already in use within the process industries as part of a Quantified Risk Assessment (QRA). For many other workplaces, however, QRA is not practicable because of the lack of failure data. The extensive expertise and effort required also make this type of method prohibitive for smaller employers. Section 2.3.4 of this thesis will look into this issue further in relation to crowd safety.
Despite the differences in emphasis and wordings, the various definitions are essentially the same in principle; namely, risk signifies the likelihood of occurrence of an adverse event that could cause a certain amount of harm to people. The HSC definition makes it more explicit that risk should also reflect the severity or intensity of the adverse event. This is very much in line with what Covello and Merkhofer (1993) have said. They also point out that “risk” implies something that is uncertain and undesirable. This point of view is in agreement with that of Rowe (1977) and Moore (1983) who said that risk should consist of two elements, an unwanted outcome and an uncertainty over its occurrence; e.g. the risk of losing money in the stock markets. But paying the bills, paying tax and making monthly repayments on a loan is not a risk. Although they are undesirable, there is no uncertainty, as people should know how much and when they have to pay. On the same token, winning the Lottery or winning a gamble cannot be regarded as risk. Although there is uncertainty, the outcome is by no means undesirable. Therefore, a risk assessment can also be regarded as a process to determine the degree of uncertainty of an undesirable event and how undesirable it is. The assessment outcomes can then form the basis for decisions on what needs to be done and prioritise the remedial measures in a more rational manner.

Definitions elsewhere are generally in line with those given by the HSC and the Royal Society. For example, in the medical field, the BMA (1987) regards the word “risk” as an expression of the probability or likelihood that something unpleasant will happen:

A hazard is a set of circumstances which may cause harmful consequences, and the likelihood of its doing so is the risk associated with it.

Kinchin (1982) also pointed out that “risk” in risk assessment should refer to both the magnitude of the hazard and the probability of its occurrence.

With this in mind, the HSC definition will be used for the purpose of this research. This is because, firstly, their definition is largely in line with the other definitions reviewed. Secondly, it is the “official” definition given in association with the regulations on risk assessment (i.e. the MHSWR). Thirdly, it is used by the HSE, which is one of the main
enforcing authorities in crowd safety. It is also widely used in government guidance and hence should be more familiar to venue owners and assessors.

2.2.2 The Risk Assessment Principles

On the basis of the definitions of risk described above, risk assessment can be regarded as a systematic examination of the risks in terms of their likelihood and severity. According to the HSC definition, it should involve identifying the hazards and evaluating the likelihood that harm will occur and its severity (or the extent of the risk). Based on this principle, the HSE (1994) has set out a framework for risk assessment and what it entails. It consists of the following five steps:

- Look for the hazards.
- Decide who might be harmed and how.
- Evaluate the risks and decide whether existing precautions are adequate or more should be done.
- Record the findings.
- Review the assessment from time to time and revise it if necessary.

To comply with the legal requirements, all risk assessment must follow these principles. But other than that, there are no fixed rules on exactly how it should be carried out. In general, the assessment required will depend on the nature of the undertaking, the type of hazards and the extent of the risks (HSC, 1992). For a workplace where the work activities are straightforward and well understood and the hazards are few and simple, the risk assessment required can be a simple, common sense process. At the opposite end of the scale, however, a risk assessment can be a very sophisticated process. It often requires specialist expertise and can be very time consuming and resource intensive to do. An example of this is QRA. In the type of workplace where QRA is appropriate, complex systems are used in conjunction with human inputs to perform complicated operations involving hazardous materials. A QRA process may involve the following (Edmondson and Manfield, 1989; HSE, 1992; R M Consultants Ltd, 1994):
• Identify potential safety hazards.
• Identify the causes and estimate the consequences of hazards.
• Establish the logical combinations of events which could lead to the hazards.
• Estimate the probability or frequency of occurrence of each event.
• Calculate the overall probability of the occurrence of each hazardous situation and the costs of such an occurrence to form a basis for decision making.

Shrader-Frechette (1985) suggested that generally risk assessment tends to include three processes: risk identification, risk estimation and risk evaluation. Risk identification is essentially hazard identification. Risk estimation aims to determine the magnitude of risk. For chemical hazards, once a substance has been identified as a hazard, risk estimation involves two main tasks: to determine the dose-response relationship and to estimate the population at risk and the dose it receives from that substance. Finally, risk evaluation is to decide whether the estimated risk is acceptable. This could be done through risk-cost-benefit analysis or comparisons against standards, legal requirements or good practice.

Rowe (1977) suggested that risk assessment should consist of risk determination and risk evaluation. Figure 2.1 below gives an overview of the risk assessment hierarchy:

**Figure 2.1: Risk Assessment Hierarchy** (Rowe, 1977)
Covello and Merkhofer (1993), on the other hand, gave a slightly more complex model of risk assessment. They used the term risk analysis instead of risk assessment and saw risk assessment as one component of risk analysis. In this model, there are three stages of risk analysis: hazard identification, risk assessment and risk evaluation. The hazard identification stage is about identifying risk agents and the conditions and events under which they potentially produce adverse impacts to people or the environment. The risk evaluation stage is about comparing and judging the significance of the risk. The middle stage of risk assessment, is about describing and quantifying risks. This, in turn, consists of the following four assessments:

- **Release assessment** – i.e. to describe and quantify the potential of a risk source to release or otherwise introduce risk agents into an environment accessible to people, animals, plants or other things that people value.
- **Exposure assessment** – i.e. to describe and quantify the relevant conditions and characteristics of human and environmental exposures to risk agents produced or released by a given risk source.
- **Consequence assessment** – i.e. to describe and quantify the relationship between specified exposures to a risk agent and the health and environmental consequences of those exposures.
- **Risk estimation** – i.e. to integrate the results from the above assessments to produce quantitative measures of health and environmental risks.

There are minor discrepancies between authors in terms of what a risk assessment is and what it should consist of. There are also differences in the use of terms and some of the risk assessment principles were clearly given with specific applications in mind. But despite all these, a general picture emerges whereby a risk assessment can be regarded as something that consists of the following basis elements:

- **Hazard identification** – to establish what hazards could arise to harm people (or the environment or things that people value).
• Consequence analysis – to identify the severity of the consequence or the extent of the harm (i.e. who might be harmed, how they might be harmed and how many of them might be harmed).
• Risk estimation – to determine the risk associated with a specific hazard in terms of the likelihood (or probability) to cause harm and the severity/extend of harm.
• Risk evaluation – to judge and decide how significant the risk is; i.e. whether or not it is acceptable or should more be done, to what extent risk should be reduced and what actions need to be taken to reduce the risk.

Chapter 6 will review different risk assessment methods and techniques used elsewhere to determine how these principles could be best fulfilled in the context of crowd safety.

2.3 Specific Issues Concerning Risk and Risk Assessment

This part of the review looks at some of the specific issues concerning risk assessment and risk management. Without taking too much for granted concerning the legal requirements on risk assessment, the aim of this section is to take a step back and look at the kinds of issues that could affect the kinds of risk assessment required for crowd safety.

Firstly, Section 2.3.1 looks at the distinctions between risks that people take voluntarily (i.e. voluntary risks) and imposed risks (i.e. involuntary risks). The significance of this issue is that it may impact on whether certain regimes for safety management and risk assessment are acceptable if the risks are of one type or another. For example, it may well be necessary to adopt a tougher regime to deal with risks that are involuntary and have a severe effect on a large number of people. Secondly, Sections 2.3.2 and 2.3.3 explore two related topics associated with decision making in risk management. In reality, there is no such thing as absolute safety. Decisions have to be made as to whether one can live with certain risks or not. The issue is on what basis such decisions should be made. Section 2.3.2 looks at the concept of acceptability and tolerability of risks. Although the literature review in the previous section suggests that there is a general consensus amongst many authors that risk assessment should reflect both the
likelihood and severity of consequence, there are also other views. For example, it may be argued that in some circumstances, the hazards rather than the risks should be the main determining factor. In other circumstances, cost effectiveness should be the basis for decision-making. The different approaches to risk assessment and decision-making are examined in Section 2.3.3. Section 2.3.4 is concerned with the issue of dealing with uncertainty. Risk assessment comes in different shapes and forms when applied in different contexts. Some are based on experimental data, some use statistics, some employ risk quantification techniques and some are qualitative and rely on subjective judgement and experience. Also, in different applications, risks are expressed in terms of level of exposure, costs of life, the number of people killed (or its equivalent) or, simply, a rating level (e.g. high, medium or low). The section looks at which of these approaches are more appropriate to crowd safety. Finally, Section 2.3.5 looks at the issue of latent failures and incubation of crisis as a contributory factor to crowd related disasters. Of particular interest is some of the works carried out within the football industry.

2.3.1 Voluntary Risks vs. Involuntary Risks

Risk taking is an inseparable part of our everyday life. For example, crossing the road, travelling to work, playing sports, going on holiday, etc. all involve taking risks. Yet, we all do it without any hesitation even though we know that we could be run over by a bus whilst crossing the road, be involved in a road accident on our way to work, injure ourselves when playing sports and our homes could get burgled while we are away. But there are some risks that we decide not to take. Also, people do not always agree with each other on what risks to take and what not to. For example, investing in the stock market can be rather risky. Putting your money in the bank, on the other hand, is generally recognised as a safer option (although you could still lose some or all of your money through bank error or if the bank collapses). Yet some people decide to invest heavily in shares, some decide to keep their money in the bank, some decide to do both and a few choose to do neither – instead, they keep it at home under the mattress (and risk being burgled). So, the question is why we do what we do despite the risks and, more importantly, on what basis do we decide whether we should accept the risk or not? Risk taking behaviour is a complex issue and is a subject that is probably of great
interest to behavioural scientists. It could be a combination of subjective judgement and rational decision influenced by factors such as risk perception, rewards, personality (i.e. are you a risk taker?), experience (e.g. bad experience with banks in the past may lead some people to not trusting them and to keep their savings at home), personal preference and value, circumstances and so on. But ultimately, the answer to the above question is that we choose to do it (or not to do it). We make the decisions (sometimes subconsciously) that we should do these things despite the risks. They are generally regarded as voluntary risks.

However, not everything is of our choosing. There are risks that are already there and there are risks that are imposed on us regardless of whether we, as individuals, feel that they are acceptable or not. These are generally referred to as involuntary risks. According to Rowe (1977), a voluntary risk involves some motivation for gain whereas an involuntary risk is imposed on the risk takers without regard of their own assessment of benefits or options. Shrader-Frechette (1985) describes voluntary risks as risks through voluntary activities (e.g. smoking, rock climbing). In general, these risks are assessed in terms of individual’s own value system and each person has a relatively large degree of freedom in deciding to accept them (although regulations and government policies on, say, smoking do limit the degree to which one’s decision to take risk is freely chosen). On the other hand, an involuntary risk (or a social risk as Shrader-Frechette also calls it) is involuntarily imposed rather than voluntarily chosen; for example, the location of a gas work or a chemical plant. This type of risk is not assessed on the basis of each person’s value system. Instead, it is in the hands of governments, political groups, etc. What is significant about the issue of voluntary vs. involuntary risks is that whilst people may be prepared to engage themselves in high risk activities voluntarily, they are less tolerant of involuntary risks. To give an insight of why this is the case, the HSE (1999) quoted the findings of several studies by social scientists on factors affecting risk perception. The key factors identified in these studies include: how well the process that gives rise to hazard is understood, how equitably the danger is distributed, how well individuals can control their exposure and whether risk is assumed voluntarily. Other factors that have also been suggested include culture, ethical and social considerations and degree of trust to those creating the risk and in the regulator in ensuring adequate measures are in place. Involuntary exposure and the lack
of personal control over the outcomes are also among the eleven negative attributes of hazards that influence risk perception and risk acceptance listed in the Royal Society report (1992). Other interesting attributes include man-made hazards rather than those from natural causes, fear of unknown, exposure that threatens future generations and infrequent but catastrophic accidents. The last attribute appears to have a particular influence on how we decide if a risk is acceptable. This will be discussed further in the following sub-section.

There is, however, a grey area as to whether certain risks are voluntary or involuntary. From the definition by Shrader-Frechette, the criterion for determining this appears to be how much freedom an individual has in deciding whether to take the risk or not. If a person has a high degree of freedom to decide, then it is voluntary. Otherwise, if the decision is taken elsewhere and the individual exposed to the risk has very little influence over it, then it is involuntary. But how large or small does the degree of freedom need to be before one can say it is a voluntary or an involuntary risk? Rowe gave an example of someone living in a house near the approach runways of a busy airport to illustrate this problem. Even if the airport was built after the person settled in the runway area, he does have the option to move away from this source of risk at some cost. And what if people move into the area well aware of the airport or, in some parts of the world, people knowingly live in (natural) disaster-prone areas. Are these risks still involuntary? The same argument applies to people living near a chemical, gas or nuclear installation, employees in a hazardous workplace, or visitors to an unsafe public venue. At least in theory, they too have the option to move away, to work elsewhere or not to go to the venue.

In crowd safety, there is no firm evidence to show whether people go to a public venue knowing the risks involved but still choose to do so (e.g. because of the atmosphere, the entertainment value) or whether they are simply not fully aware of the risks. If it is the latter, it can perhaps be argued that this is like someone moving into an area without being told of the plan for a new airport nearby. Would this be an involuntary risk and is therefore less acceptable?
Another way of looking at voluntary vs. involuntary risks is by considering who makes the decisions concerning whether the risk is acceptable or worth taking and who would be affected or exposed to the risk as a result. This would determine the basis on which such decisions need to be made. For example, to take up a dangerous sport, to adopt a certain lifestyle, to smoke or to live in a natural disaster-prone area are decisions that, by and large, are likely to be a personal decision and the consequences are likely to affect only the decision makers and the people they value (e.g. their families). In this case, it may be perfectly acceptable that one can base their decisions on subjective judgement and personal preference alone. If, however, the decision is likely to affect others, then it can be argued that a tougher set of criteria should apply. The decision must therefore be more rational and justifiable. People who are affected need to be satisfied that risks are properly controlled and, as the law requires, kept “as low as reasonably practicable”. On this basis, crowd safety risk assessments should be sufficiently robust because visitors to public venues, regardless of whether they are fully aware of the risks or not, are usually not involved in decision-making. What remains to be established is how robust the risk assessment needs to be for crowd safety. Other factors such as operational constraints will need to be taken into consideration.

2.3.2 ALARP and Tolerability of Risks

An underlying principle of risk assessment is the recognition that there is no such thing as absolute safety. The notion that as long as the problems and the remedial actions are identified, employers would be able to completely get rid of all problems is unrealistic. There is a whole host of reasons why this is so. Financial considerations and resources limitations are perhaps the most commonly used reasons. Other reasons may include engineering constraints, design limitations, disruption to services and political pressure. For public venues, there are further reasons - public order/security concerns, fire safety requirements, staff’s health, safety and welfare, disruptions to the normal traffic and the activities of non-visitors, reduced entertainment value, etc. In other words, there are a lot of gives and takes involved in making such decisions. For example, if the costs of remedial measures exceed the means of the venue owner, a decision will then have to be made on whether to go for a cheaper alternative or to take the drastic measure of closing a part or the whole of the venue. But even if the costs are within the means, there are
other considerations. The types of questions one would probably ask may include: is it
cost effective to spend a large amount of money on problems that may only happen only
rarely or would it be better to use the resource on something else? Does the problem
warrant a remedy that brings disruptions and inconvenience to the visitors/local
residents, reduce the enjoyment and entertainment value of the event, undermine the
security arrangements, increase public dissatisfaction, create problems elsewhere, etc.?
In short and to quote from Shrader-Frechette (1985), how safe is safe enough and how
much we ought to pay for safety? A more realistic notion, therefore, should be one that
venue owners are able to strike this balance in order to achieve an optimum level of
crowd safety (as opposed to absolute safety).

This view is shared by Kletz (1982) who pointed out that providing for everything to
remove every possible risk, however slight, is impossible. Even if we decide to try to do
so, we cannot do everything at once. The question is how to decide what to do first and
what can be left until later on? In other words, how do we best allocate the resources
available? This is also in line with what the law says. As discussed in Section 2.1, the
law does not demand for absolute health and safety. Instead, the requirement is for
employers to do what is “reasonably practicable” (HSW Act, 1974). This implies that
whilst the employers still need to achieve a high standard of health and safety, they can
do so taking into account things like time, money and cost effectiveness. Whilst this
principle is fine, the issue that emerges from this is that how can we decide what actions
are reasonable to take to deal with the identified problems.

Following the public inquiry into the Sizewell B Nuclear Power Station, HSE published
the document “The Tolerability of Risk from Nuclear Power Stations” (1992c). It sets
out a framework that describes the HSE’s philosophy of risk control for a nuclear power
station, illustrated by the “carrot diagram” (e.g. HSC, 1991; HSE, 1992c). It has since
been known as the Tolerability of Risk or TOR framework and is being increasingly
used in other industries. Figure 2.2 reproduces the “carrot diagram” for illustration
purposes. According to the TOR framework, risks can fall into three levels: the
Intolerable Region where risks cannot be justified on any ground, the ALARP Region
where risks have to be kept as low as reasonably practicable and the Broadly Acceptable
Region where there is no need for detailed working to demonstrate ALARP.
The following definition of tolerability was given in the document:

"Tolerability" does not mean "acceptability". It refers to the willingness to live with a risk to secure certain benefits and in the confidence that it is properly controlled. To tolerate a risk means that we do not regard it as negligible or something we might ignore, but rather as something we need to keep under review and reduce still further if and as we can.

As for acceptability, the following was said:

For a risk to be "acceptable" ... means that for purposes of life or work, we are prepared to take it pretty well as it is.
Tolerable implies neither absolutely safe or unsafe but the range in between. Tolerable does not mean acceptable, instead it refers to a willingness to take a risk so as to secure certain benefits (HSE, 1999) – sometimes one has to take risks even if one is not entirely happy in doing so. For example, vehicles cause road traffic accidents that injure and kill people. We do not like the risk (therefore it is not an acceptable risk) but generally we are willing to take it (i.e. to tolerate it) because we need and like our vehicles for the benefits motorised vehicles bring. However, because this is not something we are happy to live with as such, we demand continuous improvements and seek to keep our roads as safe as possible (i.e. ALARP). An informed balancing act between risks and benefits is of prime importance to decisions on whether the risks are tolerable (or “safe enough”). The HSE (1999) argues that the TOR philosophy is applicable across the full range of risks whether they are quantifiable or not (and even if there are uncertainties).

2.3.3 Basis for Decision Making

The need to balance between risks and other factors is well recognised. There are some risks that we can live with, some we need to do something about and some are simply unacceptable and therefore not a matter for compromise or optimisation (Engineering Council, 1993). The subsequent issue is on what basis we can decide. There appears to be at least four ways upon which risk decisions could be based:

- Risk based approach.
- Hazard based approach.
- Target setting and de minimus.
- Cost effectiveness.

Risk based

The principle of the risk based approach is very much in line with what has been said so far in this document about risks and the ALARP principle. The determining factor for decision-making is how much risk a hazard/event poses to people. The general idea is that the higher the risk, the more serious the problem is and therefore there is a higher
priority for doing more about it. As identified previously, risk reflects both likelihood and severity of consequences. Therefore, under the risk based approach, the degree of control required for the hazard is decided purely and simply by whether the combined result of likelihood and severity is unduly high, tolerable or broadly acceptable. When used in conjunction with ALARP, the risk based approach allows considerations to be given to the costs of controlling risks.

This is a “purist” approach whereby decisions on allocation of resources for health and safety are made based on the assessments of how likely and how much people could be harmed alone. Risk based decisions do not get influenced by factors such as politics and public perception. Therefore, it can be argued that this is a more objective approach that would lead to more rational decisions. But on the other hand, it can equally be criticised as not sufficiently sensitive to public concerns and public inputs. Despite the fact that the public do not have the necessary expertise and knowledge to make professional judgement, their concerns are sometimes well found and justified (Kletz, 1988). Another pitfall of this approach is that it does not relate benefits clearly enough to tolerability (Royal Society, 1992).

Hazard based

If the risk based approach for resource allocation represents the conventional way of risk assessment, then there are situations in which it may be necessary to deviate from such a convention. For example, if we look at “risk” in a wider context, it could be argued that it should encompass more than just physical harm but should also take into account of other factors such as ethical and social considerations and, hence, public concerns and public opinions (HSE, 1999). Similarly, public perception too can be a key influence to decision making. This is acknowledged by the HSC who stated that the judgement on what is tolerable is not a scientific but a political matter (1991).

In the previous sub-section, infrequent but catastrophic accidents were identified as one of the negative attributes of hazards that influence risk perception. Another attribute is exposure that threaten future generations. These go some way in explaining the public concerns on, for example, nuclear accidents despite the fact that major accidents are
The public demands a higher safety standard from the nuclear industry not because they pose high risks but because they are "high hazard"; i.e. the consequence of an accident could be catastrophic. Influenced by risk perception and public demand, decisions on priority and resources allocation are sometimes made on the basis of high hazards rather than high risks.

A specific example of hazard based decision making is the construction of the Thames Barrier. In early 1953 there were the great floods on the east coast. By good luck rather than good management, London escaped. There was a great worry over how one might protect the city from another such disaster. The barrier was suggested and it was built at Woolwich. The structure was expensive and the likelihood of London being flooded was deemed to be rather small. Nevertheless, it was decided that it must not be allowed to happen at all because of the catastrophic consequences. Apart from human casualties, the tube system, the telephone network, the sewer system, etc. would all be out of action because of the mud and water damages. The thinking behind the decision was therefore that if it was possible to avoid such a thing, it had to be avoided. The cost, though high, was affordable and, as such, the exact value of the structure, for all practical purposes, was deemed irrelevant (Bondi, 1985).

Another situation whereby the hazard-based approach may be used is when there is a high degree of uncertainty about likelihood (HSE, 1999). Infrequent but catastrophic accidents such as those mentioned above also fall into this category. The issue of how to deal with uncertainty will be looked at in Section 2.3.4.

A problem with the hazard-based approach is in knowing when it should be adopted. So far, the literature does not offer any clear guidance or even rules of thumb. It appears that decisions to use a hazard-based approach instead of a risk-based approach is very much based on subjective judgement and political considerations rather than some form of fixed rules or the outcome of a more objective analysis of the situation. For example, aircraft falling from the sky hitting a football stadium (or any buildings under a flight path) too is a rare but catastrophic accident that could result in large number of casualties. Yet it does not attract anything like the amount of attention and public concerns as nuclear accidents - this is despite the fact that a similar accident occurred in
Amsterdam fairly recently. Public venues under the flight path can be reinforced to withstand the impact, though it is very costly to do. But unlike the Thames Barrier, the argument that “if it is possible to avoid it then it has to be avoided” does not seem to apply in this case. Therefore, for the purpose of crowd safety risk assessment, it is felt that a hazard-based approach should be kept out of the risk assessment process. For the meantime, it is perhaps best left as a management/political decision for venue owners and managers to make on the merit of the individual situations.

Target Setting and De Minimus (or Probability-Threshold)

Apart from the risk-based and hazard-based approaches, Kletz (1988a) has highlighted two approaches for decision-making: "target setting” and “cost-effectiveness”. Target setting is perhaps the most widely used in industry. The basic principle is to remove or reduce first those risks that exceed an average or specified value (e.g. level of exposure, dose received). When it involves the public, if the average risks to life to those living nearby or risks to hypothetical persons (HSE, 1999) are above the target, actions must be taken to reduce them. For risks to employees, Kletz (1982) pointed out that within the Chemical industry, actions would be taken as a matter of priority for activities that contribute more than 0.4 to the FAFR (fatal accident frequency rate, i.e. the number of fatal accidents in a group of 1,000 men in a working lifetime (100 million man-hours)). But when we consider risks to the public, Kletz argued that the target should be much lower on the basis that the public may have the risks imposed on them without their permission (i.e. involuntary risks). If we benchmark it against the various involuntary risks people tend to accept with little or no complaint, we could have a target figure of about 1 in 10 million per person per year or less (a FAFR of $10^{-3}$).

De minimus or probability-threshold can perhaps be regarded as a form of target setting. But instead of saying something must be done about any risks that are above the target, proponents of the de minimus view claim that hazards whose probabilities are below a given level, ordinarily $10^{-6}$ per person, are unimportant or insignificant from the point of view of risk assessment (Shrader-Frechette, 1985). According to Whipple (1986), “de minimus” is a term used in law to describe trivial issues not deserving of a court’s time and attention. When applied to health and safety risks and regulation, the term refers to
a risk that avoids regulatory attention by virtue of its small size. From a regulatory view point, the de minimus rationale could be used either to determine the regulatory standard or to decide that no standard is required. For risk assessment, de minimus is effectively a risk threshold below which no review or risk assessment ought to be required.

For target setting to work, we need to be able to set targets or standards in the first place. There is some general guidance around for crowd safety, e.g. holding capacity of 4.7 persons/m² for football stadium (Home Office and Scottish Office, 1990) and 0.5 metre/person for pop concerts and similar events (HSC et al, 1993). But these are by no means universally applicable standards. For crowd safety, there are two problems with regard to target setting. Firstly, it is obvious from the above figures that they do not appear to be in agreement with each other. It could be argued that because the circumstances are different between a football ground and a pop concert, different targets are required. If this is the case, the implication is that neither of these figures can be accepted as targets for other venue types. Secondly, as will be demonstrated in the case studies in Chapter 4, holding capacity is not the only factor affecting crowd safety. It is apparent that crowd safety is still an extremely young discipline and many of the risk factors involved are still not fully understood. Much further research is required before we are in the position of setting targets (and perhaps risk targets) that are applicable to different venues and different circumstances.

At present, although neither target setting nor de minimus are applicable to crowd safety per se, the principles of these approaches together are essentially the same as the HSE framework on risk level and the general principle behind the “carrot” diagram (also see Figure 2.2). The principles of the two approaches are also in line with the views of many authors (e.g. Cohen, 1982; Dunster, 1985); namely that there should be an upper risk limit that should not be exceeded and some cut-off in the deployment of resources to further reduce risks that are already trivially small.

Cost effectiveness

Allocation of resources according to how many risks there are and determining the level of control required based on the ALARP principle do allow the costs of remedial actions
to be taken into consideration. However, this is not necessarily the most efficient way to reduce risks from a cost effectiveness point of view. Whether a risk-based approach, a hazard-based approach or target setting is adopted, the focus is on safety. The more "unsafe" it is (or if it goes beyond a certain safety level), the more we need to do to make it safe. The cost effectiveness approach approaches the need to improve safety from a different angle; namely, to ensure that our money, resource and effort are spent to achieve the greatest effect. The emphasis is on saving more lives per money spent. In his paper about setting priorities in safety, Kletz (1988a) discussed two possible approaches of this kind.

The first approach is to remove first the risks that are cheapest to remove. Kletz argued that road safety, for example, may benefit - more lives would actually be saved if money is spent in a more cost effective way. However, in the industry particularly, the pitfalls are, firstly, moral. People are prepared either to accept a risk because it is extremely small or to tolerate it because the benefits outweigh the risk. Experience suggests that they would not accept the risk just because it is expensive to remove or reduce. This is especially so if it is an involuntary risk. Secondly, there is a temptation in practice for venue owners to use the cost argument merely as an excuse for unwillingness to take action. Apart from the costs of implementation, there are other reasons a venue owner could use to avoid taking the necessary measures, such as practical difficulties in their implementation or that they could make the venue less attractive to the visitors.

The second possible approach is called by Kletz as "weighing in the balance". It looks at costs and benefit together and gives priority to those remedial actions that can remove or reduce the most risks (per unit cost). This approach takes into account benefits and it is very cost effective. However, the clear danger is that people are left exposed to high risks because removing or reducing them is not sufficiently cost effective. Nevertheless, there are some things about this approach which could be of interest to this project. In crowd safety, there is often more than one contributory factor to a hazard and therefore several remedial measures may be required. But at the same time, the same factor could contribute to more than one hazard. If a particular action can control this factor, several risks could be removed/reduced at the same time. But, in reality, experience suggests that venue owners tend to go for the immediately obvious solutions and, thus, tackle the
symptom rather than the cause of a hazard. Unless they start looking into the underlying causes, the benefit of this approach could be lost. There are also practical difficulties in adopting this “weighing in the balance” approach. In order for it to work, it is necessary first of all to express the costs of various courses of action and the benefits in a common unit, usually money, so that they can be compared. This cannot be achieved at present because the cost of action is more than just financial. It could also be in the form of, for example, compromised architectural design, reduction in enjoyment value, etc. For the moment at least, it is impossible to convert them into monetary terms or another common unit. On the benefit side of the equation, there is the issue of cost per life saved (and the cost of saving someone from various degrees of injury and suffering). The value placed on a life in different industries varies over a large range (Kletz, 1982). Also, apart from saving lives, good crowd management means good customer care and, thus, customer satisfaction. The value of this is also hard to measure.

Very similar in principle to the “weighing in the balance” approach is Risk-Cost-Benefit Analysis (RCBA) (e.g. Shrader-Frechette, 1985). According to Shrader-Frechette, this type of approach generally involves four main steps:

- Define the risk problem by listing alternative courses of action and the set of all possible consequences associated with each action.
- Describe the relationships among these alternatives and their consequences; various mathematical, economic and social models may be used to arrive at quantitative accounts of dose-response relationship, market behaviour and event probabilities.
- Evaluate all the consequences of alternative risk decisions in terms of a common unit; in RCBA, this unit is usually money.
- Integrate all the components of the analysis to produce a single number representing the value of each alternative.

As in the case of “weighing in the balance”, the need to convert various cost and benefit elements into a common unit is the main hurdle for applying RCBA to crowd safety.
2.3.4 Uncertainty

The following is a quote from the 1983 report entitled “Risk Assessment in the Federal Government: Managing the Process” by the US National Research Council (Whipple, 1986):

*The goal of risk assessment is to describe, as accurately as possible, the possible health consequences of changes in human exposure to a hazardous substance; the need for accuracy implies that the best available scientific knowledge, supplemented as necessary by assumptions that are consistent with science, will be applied.*

However, not all disciplines are well understood and well documented. So what can we do if there is insufficient knowledge or a lack of data to enable an accurate assessment of the risk? In this respect, Cohen (1982) identified at least three kinds of risk:

- Risks which clearly and identifiably lead to casualties for which reliable statistics are available.
- Those for which an effect is believed to exist but where the causal connection to the individual cannot be certain.
- Experts’ best estimates of probabilities of catastrophes which it is hoped will never happen.

The figure put out on the first kind of risk should be a reasonably reliable assessment of what actually happens. The second and third categories imply uncertainty.

Rowe (1977) pointed out that uncertainty exists in the absence of information about the past, present or future events, values or conditions. Although there are various degrees of uncertainty, the basis of the concept is the absence of information about parts of the system under consideration.

Uncertainty is not the same as risk. Whipple (1986) made the following distinction: risk measures the probability and severity of loss or injury. Uncertainty, on the other hand,
refers to a lack of definite knowledge, a lack of sureness; “doubt is its closest synonym”. If a lack of predictability arises from a well-understood probabilistic process, then it is risk. If, however, it arises from insufficient knowledge, it is an uncertainty. The HSE (1999), on the other hand, sees uncertainty itself is a state of knowledge in that, although the factors influencing the issue are known, their effects cannot be precisely described.

Moore (1983) drew the distinction between risk and uncertainty in terms of whether it is a repeatable or non-repeatable event. For example, games of chance (e.g. roulette) are repeatable. As far as assurance companies are concerned, death is also a repeatable event in the sense that the alternative events of “death” and “no death” are repeated for each person in a large population each year. For these events, the rules of probability or statistics can be used to predict the risks with a reasonable degree of accuracy. Repeated trials and experiments (e.g. the testing of a new drug to establish the probability of people adversely affected by it) can also generate sufficient data for accurate prediction of risks. However, the outcome of the next general election or the gender of the next President of the United States is non-repeatable. This distinction in terms of repeatable or non-repeatable is probably not sufficient, as uncertainties can also exist in repeatable events. From Rowe (1977) and Whipple (1986), the key distinction appears to be whether there is adequate knowledge, information or data for a reliable and accurate assessment of risk. Shrader-Frechette (1985), on the other hand, categorised risks into historical risks and new risks. Historical risks are those that have occurred often enough in the past for sufficient data to have been accumulated for analysis. Historical risks may, therefore, include those from diseases and illness, road accidents, industrial accidents, certain pollution and natural phenomena (e.g. earthquake, tornadoes, lightening, flooding, etc.). Kletz (1982) provided a list of various voluntary and involuntary risks from various sources. The following are examples of the data and statistics available at the time of his paper on the risks of death per person per year from various activities:

- Smoking (20 cigarettes per day) = $500 \times 10^{-5}$
- Drinking (1 bottle of wine per day) = $75 \times 10^{-5}$
- Car racing = $120 \times 10^{-5}$
- Rock climbing = $4 \times 10^{-5}$
- Run over by road vehicles (US) = $500 \times 10^{-5}$
- Run over by road vehicles (UK) = $450 \times 10^{-5}$
- Floods (US) = $22 \times 10^{-5}$
- Earthquake (California) = $17 \times 10^{-5}$
- Lightening (UK) = $1 \times 10^{-5}$

New risks include those from events never previously observed or those historical risks whose frequency is so low that it is hard to assess accurately; for example, exposure to previously unknown chemicals, rare but catastrophic accidents, use of new technology.

Crowd safety certainly belongs to the “new risk” category. Although the gathering of large crowds takes place many times each year and despite repeated crowd disasters (e.g. see Table 1.1 in Chapter 1), there has been very little organised effort made to study the subject and collect data and information. Our understanding of crowd safety and crowd safety risks is still far from sufficient for enabling reliable and accurate assessments.

Where the past does not provide sufficient guidance on what the risks are, then we have to rely on expert judgement and experience. There are ways in which expert judgement and experience can be formulated to estimate risks. This can be done quantitatively or qualitatively.

**Quantification of Risks**

Where there is insufficient risk data, Quantified Risk Assessment (QRA) techniques have been employed to estimate risks numerically. Often, these estimates represent no more than a complex set of expert judgements based on various factors such as failure rate of engineering components.

Human Reliability can be regarded as the human factors version of QRA, where human error probability is quantified. In the high hazard industries where Human Reliability Assessment (HRA) is most widely used, there is a need to cohere human reliability with engineering reliability so that they can be assessed together as one man-machine system.
The assessment of engineering reliability is often data based. In the early years of HRA, attempts were made to create a human error data bank but it was soon realised that the data bank approach was not working for human errors (Kirwan, 1994). Instead, the current HRA techniques such as HEART (Williams, 1988) are risk factor based, i.e. a quantification is made based on the estimation on how much effect various performance shaping factors (or error producing conditions, etc.) have on the human error of concern. Such an approach is unsuitable for crowd safety for two reasons. Firstly, unlike HRA, crowd safety is very much about human beings and their interaction with each other in public venue environments. The interaction of human beings and engineering systems in crowd safety is minimal. As such, there is no need for (and no pressure on) crowd safety to cohere with any better developed data based assessments. Secondly, the risk quantification approach requires a good understanding of the risk factors involved and the extent of their effect on safety. In HRA, years of effort have been devoted towards achieving this. Crowd safety, however, is still a very young discipline requiring much research. Also, the factors affecting crowd safety can vary from venue to venue and under different circumstances (Au et al, 1993). The case studies in Chapter 4 will show that the extents of their effect also vary. Furthermore, there are less constraints on human behaviour amongst visitors than employees in the workplace. Under the circumstances, it is not possible to develop a credible risk factor based approach that is suitable for all public venue types. Furthermore, even if such a technique were developed, it is doubtful whether it would be as useful as it might appear to be. Experience in HRA suggests that despite the sophisticated looking formulae and figures, it is fundamentally a subjective method and the accuracy of its findings cannot be validated.

Whilst the quantified approach may appear more attractive in the long run, some argue that reducing everything to “X x 10-n” is far too complex for many sectors (Kazer, 1992). From a practical viewpoint, the risk quantification approach tends to require a substantial amount of expertise and effort. In the high hazard industries where such an approach is most widely used, the level of health, safety and environmental risks they pose can justify the cost of conducting quantified assessments. The cost of the assessment is also very small for industries that require huge investment and high operating costs. In public venues, as in many other workplaces, the risks are much
lower and the costs of quantified assessment are absolutely prohibitive for smaller owners. Even for owners of major venues, the costs could be disproportionately high for their level of investment and operating costs.

**Qualitative Approach to Risk Estimation**

Probabilities and risks are sometimes expressed in verbal terms as a rating, and in terms of ranking rather than as numbers. Qualitative risk assessment is increasingly common in many industries, including certain sectors of the high hazard industries where QRA was traditionally used.

The HSC/HSE have provided much guidance on qualitative risk assessment (e.g. 1992, 1994, 1996, 1997a and 1998). This will be looked at as part of the review of existing guidance in Section 3.4. In addition, in a recent discussion document, the HSE (1999) has provided a case study of a qualitative assessment of crowd safety risks (at the Pinner Fair). The author was involved as part of the HSE study team. In this particular case, observations, together with an analysis of the safety management, formed the basis for hazard identification and risk assessment. Comparisons were made with standards in codes of practice and guidance. Good practice elsewhere and opinions voiced by local residents, the local authority and the police were taken into account. Risks were then rated qualitatively using a five-point scale from “very low” to “very high”.

Moore (1993) looked at assessments by words and argued that words are useful only if the writers and the readers agree on the meanings to be ascribed to the words. In reality, however, words do not have a generally accepted and agreed meaning. To illustrate his argument, Moore compiled a list of ten expressions of uncertainty and asked some 250 executives on the middle and senior general management programmes to rank them in descending order of uncertainty. The expressions are: probable, quite certain, unlikely, hoped, possible, not unreasonable that, expected, doubtful, not certain and likely. The results showed considerable overlapping of the ranks for many of the expressions and, thus, the inconsistent use being made of these words among the respondents. However, the author is of the opinion that this problem can be overcome if expressions are put in the context of a rating (or ranking) scale, by a careful choice of words, by clearly
defining the words and by having sufficient anchor points to enable clear distinctions to be made between each rating (ranking) level (also see Section 7.3.4).

2.3.5 **Latent Conditions and Incubation of Crisis**

As in other areas of safety, crowd safety disasters were often caused by a combination of immediate causes and latent failures. An example of this is the Hillsborough Disaster (Lord Justice Taylor, 1990) mentioned earlier in Section 1.3, whereby the contributory factors to the disaster include the circumstances on the day, the venue layout at the Lapping Lane end and the mind-set of the police. The circumstances caused the late arrival of many of the Liverpool supporters on the day, and hence a last minute rush into the stadium. The layout contributed towards the continuous influx of people into the part of the stadium that was already overcrowded. The mindset by the police on public disorder led to their failure to identify overcrowding as a potential problem. This, in turn, led to their failure to take the appropriate crowd management measures to prevent the disaster as well as their failure to respond promptly to the disaster. The last factor is regarded in some of the literature on management as latent conditions, which lead to the incubation of failure potentials or crisis.

The Hillsborough Disaster is not the only example of crisis incubation within public venues. To investigate the relationships between crisis incubation and disasters, Elliott and Smith (1993) had examined four crowd related disasters at football grounds; namely, the Ibrox Stadium Disaster, the Bradford Fire, the Hysel Stadium Disaster and the Hillsborough disaster. From the case studies, they have highlighted the four key factors affecting crisis incubation as management beliefs/mind-set, costs, inter-organisational communication and culture. They have also concluded that in all cases, "there is evidence of crisis incubation and a failure to consider the possibility of crisis amplification by those responsible for managing the stadia". In particular, it was argued that management beliefs are fundamental to the way in which an organisation processes the information collected for decision making and that this mind-set would determine the range of policy options that are deemed to be acceptable to the organisation. The rigidity of core beliefs, values and assumptions by senior management is considered as an important barrier to learning from past incidents and disasters and a key factor in
incubating potential for crisis (Elliott, Smith & McGuinness, 2000). Smith (1999) also argued that many failures and crises merge from an organisation’s system of management (i.e. core belief, culture, ineffective communication, etc.) and that potential for such failures is often built into the system by management practice, protocols and processes. The Ibrox Stadium disaster, the Bradford Fire and the King’s Cross Fire serve to illustrate that an awareness of the hazards does not always guarantee improvement in safety. Management complacency is thought to be an important factor for inadequate safety management in Ibrox and King’s Cross, where similar incidents had occurred prior to the main disasters. Equally, a similar incident occurred a year before the Hillsborough Disaster, and numerous crowd safety related disasters occurred in other football grounds (Lord Justice Taylor, 1989). In the case of the Bradford Fire, the financial situation might be a factor for inaction, although the football club had been repeatedly warned about the fire hazard and was apparently aware of the problem. A survey by Au et al (1993) on a range of public venues (see Section 2.6.1 for details) suggested that one possible reason for management complacency is their lack of appreciation of the risks. Therefore, a proper risk assessment should not only identify the hazards that could occur, but also determine the extent of the risks involved.

There has been growing concern in the football industry for crowd safety following a series of crowd related disasters such as those mentioned above. For example, there were radical changes made in response to the Hillsborough Disaster in 1989 and the industry has since implemented many of the Taylor recommendations (Lord Justice Taylor, 1990). Nevertheless, it appears that crowd safety problems continue to occur. An analysis by Elliott et al (1997) of club accident records, Football Licensing Authority (FLA) inspections, police match reports, media reports, anecdote and research experiences had revealed a multitude of examples of potential and actual disasters in sporting venues in Britain since Hillsborough. Quoting a survey carried out by Arnold and Benveniste, Elliott et al also pointed out that ground improvements were a very low priority amongst football clubs, citing only 7% of the clubs identifying this as one of their top three objectives. In recent years, many clubs have built or are planning to build new and more modern stadiums away from residential areas. This, however, is probably driven more by financial considerations rather than spectators’ safety and wellbeing.
Elliott et al (1997) argued that this is probably because the response of the legislators (and the industry) has frequently dealt with the immediate causes, such as all-seater stadiums for all upper division clubs, often ignoring the underlying management issues, such as the four crisis incubation factors mentioned previously. Other authors (e.g. Elliott and Smith, 1993; Smith, 1995) have also highlighted the danger of over-reliance on technical solutions alone. They argued that this could indeed serve as a barrier to learning (from past incidents) within the organisation, leaving the “human elements” shortfalls (e.g. communication, culture) free and active within the management system. As a result, it is argued that history could repeat itself and similar problems could re-occur despite the technical solutions. Similarly, in examining the Man-Made Disaster (MMD) model (by Turner, 1978), Pidgeon (1997) also highlighted that disasters in large scale technological systems are not chance events, nor can they be described purely in technological terms. Turner argued that instead they arise from an interaction between the human and organisational arrangements of the social technical systems set up to manage complex and ill-structured risk problems. Furthermore, over-reliance on technical solutions and technical expertise alone could also be problematic for risk managers when the issue of concern is “trans-scientific” in nature and is beyond the abilities of science to prove (Calman & Smith, 2001). A proper risk assessment should enable an organisation to identify the technical solutions and should go some way in helping to reduce mindset and complacency. But exactly how to combine technical solutions with management issues and address them in conjunction with each other will certainly require more thought.

2.4 Risk Assessment Techniques and Tools

This review looks at some of the risk assessment techniques and tools currently being employed or proposed elsewhere in a range of different contexts. The review combines a literature review with information obtained through informal discussions with other risk assessment specialists and ten years of personal experience in the field of safety and reliability. It has been necessary to include these personal observations in view of the fact that qualitative risk assessment methods tend to be widely used but are seldom discussed in the literature. Over sixty technical papers, guidance documents, training materials, reports, etc. were reviewed. They cover a range of contexts including the high
hazard industries, offshore oil and gas, occupational health and safety in general workplaces, engineering, medical, emergency response, computer security, machinery design (e.g. human-robot interface) and product risks (e.g. air bags, pharmaceutical products, poultry products).

2.4.1 An Overview of the Risk-Based Assessments

The Health and Safety at Work etc. Act 1974 requires employers to ensure that, so far as is reasonably practicable, their employees, visitors and others affected are not exposed to risks to their health or safety. In this respect, the purpose of a risk assessment is to help the employers to ensure that everything that is reasonably practicable has been done to ensure health and safety.

In the field of safety and reliability, there are a number of ways in which employers can demonstrate that health and safety risks are kept as low as reasonably practicable. The first approach is to compare the estimated risks against a set of criteria or risk thresholds that are recognised within the industry of concern and accepted by the regulators. In the nuclear industry, for example, such thresholds can be expressed in terms of dose level or the annual rate of exposure to radiation. By applying the ALARP principle described in Section 2.3, for example, it is then possible to determine whether the estimated risk is acceptable, tolerable or intolerable (e.g. HSE, 1992c). The risk criteria or thresholds are often established based on scientific knowledge or statistics. This enables judgement on how serious the risk is to be made in an unambiguous and objective manner. Another benefit is that such thresholds can be easily revised to reflect the latest standards and any new scientific development and statistical trends. This approach is commonly adopted in the high hazard industries where risks are expressed quantitatively.

The second approach is benchmarking. Where there are no definite standards or any universally accepted risk thresholds, comparisons can be made between the estimated risk and risks associated with other activities. The activities used for benchmarking purposes often range from everyday and popular leisure activities, where the risks are commonly accepted (or taken for granted) by the general public, to activities in another comparable workplace. Such an approach has been used in a variety of contexts. For
example, in their assessment of the risks at fairground rides, Holloway and Williams (1990) benchmarked them against a range of activities such as travelling by motor car, walking, pedal cycling (on local roads and the main roads), horse riding and the average risk present during waking hours. The comparison can be used to show that the risks from fairground riding were low on the basis that that they were lower than the risk of motoring to and from the fair. Again, such comparisons can only be made if the estimated risks can be expressed in quantitative terms. Furthermore, extreme care must be taken when using this approach to ensure that sufficient consideration is given to the issue of voluntary vs. involuntary risks (discussed in Section 2.3.1). For example, in the case of the fairground rides, it can be argued that a tougher criterion should be applied as leisure activities, motor car travelling, etc. are all voluntary or, at least, “semi-voluntary” activities.

The third approach is to show that due considerations and all reasonable steps have been taken to assess and, subsequently, control the risks and keep them low. This approach is particularly suitable where risks cannot be quantified and therefore cannot be compared against any standards or benchmarks elsewhere. In many cases, record of a suitable and sufficient risk assessment can be used to demonstrate to the regulators and in the courts of law that due considerations have been given to controlling risks (Barrell and Scott, 1982). This approach is not as clear cut as the other two approaches. It does not give precise answers on exactly how significant a risk is. But it ensures that risk management decisions are based on and supported by a risk assessment process that is systematic and comprehensive; and it is suitable for qualitative assessments. It also enables the prioritisation of risks and, thus, facilitates risk management decision-making.

2.4.2 An Overview of the Risk Assessment Methodologies

Risk assessment has been used in many different commercial and industrial sectors and by government departments for a variety of applications. For example, a company may want to weigh up the risks against the potential benefit before deciding whether to, say, open a new office elsewhere, build a new factory, buy more machines, introduce a new product or start a marketing campaign. Financial institutions need to constantly assess the risks they take on their investments. Insurance companies utilise risk assessment to
help set premiums (Wrightson, 1995). The pharmaceutical industry uses it to look at the risk of a new drug and the benefits it could bring to the patients. Engineers apply risk assessment to analyse their designs. Government departments also use risk assessment for various purposes such as setting safety regulations, emergency planning, decisions on investment, setting operational priority, carrying out feasibility studies and project appraisal, environmental issues and pollution control, food safety, weapons procurement and storage, licensing of medicines, IT security, setting public health policy, etc. (MoD, 1991, HSE, 1996a). There is a common purpose in all these different applications, i.e. to aid the decision making process and to enable decisions to be made on a more rational basis. This is also true in the context of health and safety.

As in other applications, the methodologies used for safety risk assessment fall into two categories: qualitative risk assessments and QRA. Even though qualitative assessments tend to have a much wider application, it is the QRA methods that have received much of the attention in the literature. Compared to qualitative risk assessment, QRA is much better established and substantially more effort has been devoted to the development of QRA techniques and tools. Issues concerning the evaluation of risks have also been a focus of attention over the years. In terms of applications, much of this effort has been devoted to the high hazard industries. Nevertheless, a number of references were found in other applications. For example, the fatigue failure of highway bridges, the delivery of poultry products, the enactment of the air bag standard for new cars, human-robot systems and the assessment of pollution. (e.g. Yazdani and Albrecht, 1988; Kumamoto et al, 1988). But the main theme of these papers is on how these areas could benefit from the use of QRA rather than tackling the issues or proposing a methodology.

Qualitative risk assessment, on the other hand, is much less well documented. Although over the years many employers may have already carried out one form of qualitative risk assessment or another, there is very little published information. It is not until recently that more attention has been paid to this type of risk assessment. This is because of the risk assessment requirements made under the MHSWR. The literature identified in this review covered a range of areas including general health and safety, machinery design, defence equipment and emergency planning.
The rest of this section looks at the existing risk assessment methods and techniques. They are summarised in two tables: the first table covers QRA techniques and tools whilst the second focuses on qualitative assessment. In each table, the left hand column presents the key risk assessment stages/issues whilst the right hand column identifies the existing risk assessment techniques and tools used in these stages to address the issues.

A Summary of QRA Techniques and Tools

Table 2.1 presents an overview of the QRA techniques and tools. They are mainly used in the nuclear and other high hazard industries. However, the recent introduction of the Railway (Safety Case) Regulations (HSE, 1994c) has led to QRA also being applied to many aspects of railway operations.

**Table 2.1: QRA Techniques and Tools**

<table>
<thead>
<tr>
<th>Risk Assessment Stages/I issues</th>
<th>Techniques &amp; Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify Hazards</td>
<td>Divide a complex plant into sections, parts and components then assess each component in turn (e.g. the pump, the valve, the pipeline, the tanks, etc.). Logic diagrams e.g. fault tree and event tree analyses to map out the relationship between components and the plant and to define the chain of events/ failures that could lead to a failure. For complex human operations, task analysis techniques (e.g. HTA, tabular task analysis) to break down a task into sub-tasks, the break down continues until the sub-tasks are at a sufficiently low level for them to be “assessable”. HAZOP I technique at the design stage when details are yet to be determined. HAZOP II technique for existing system where details of how the systems work are known and well defined. “Walkthrough” techniques and the use of hazards checklists. For human operations, human error identification techniques like Human HAZOP and PHECA.</td>
</tr>
<tr>
<td>Dealing with complex systems - i.e. how hazard identification is organised</td>
<td></td>
</tr>
<tr>
<td>Consider what could go wrong/identify failures</td>
<td></td>
</tr>
</tbody>
</table>

61
<table>
<thead>
<tr>
<th>Risk Assessment Stages/Issues</th>
<th>Techniques &amp; Tools</th>
</tr>
</thead>
</table>
| Establish causes and consequences of hazards          | Engineering knowledge.  
Data sheets.  
Past incidents/lessons.  
For human operations, various human error classification schemes. |
| Estimate Risks                                        |                                                                                                                                                   |
| Estimate likelihood of failure                        | Failure rate from sources such as laboratory experiments, repeated trials, statistics, historical data, etc.  
“World wide” averaged data.  
Generic failure data.  
Failure data for specific items.  
For complex systems, logic diagrams to pull together the failure rates or probabilities of the various components to give an overall failure rate/probability of the system.  
For human operations, human reliability assessment (HRA) techniques such as HEART and THERP. |
| Establish the consequences of failure                  | For toxic release, look at the relevant factors such as the materials released, their physical & chemical status, how much energy is released at the same time & the duration of the release.  
To determine who and/or what could be affected and how, consider the effect of the failure on operators/staff, members of the public, the environment, damage to system and equipment, loss of production, etc. |
| Estimate the severity of consequences/extent or magnitude of harm | Usually measured in terms of cost or level of exposure. Other measures suggested in the literature include:  
- individual risk (i.e. fraction of the population at risk that suffer death per unit time)  
- death per unit measure of activity (e.g. passenger-hours, passenger-miles, no. of operations, etc.)  
- loss of life-expectancy  
- frequency vs. consequence lines (fc lines) |
| Estimate the overall risk                              | Risk = likelihood x severity                                                                                                                          |
### Table 2.1: QRA Techniques and Tools

<table>
<thead>
<tr>
<th>Risk Assessment Stages/Issues</th>
<th>Techniques &amp; Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Determine Tolerability and Priorities of Risks</strong></td>
<td>Criteria can be found in some industry specific regulations and standards e.g. acceptable level of exposure per year (i.e. &quot;risk thresholds&quot; beyond which something must be done). The ALARP principle. Benchmarking.</td>
</tr>
<tr>
<td>Decide whether the risk is tolerable/acceptable</td>
<td>Based on the estimated risks; i.e. the bigger the risk, the higher the priority.</td>
</tr>
<tr>
<td>Prioritise unacceptable risks</td>
<td></td>
</tr>
<tr>
<td><strong>Decide What Actions to Take</strong></td>
<td>Risk based, hazard based or cost effectiveness considerations. ALARP. Cost-benefit analysis; i.e. the costs of taking actions vs. costs of taking the risk. HSE general guidance; i.e. in order of preference, to eliminate hazards e.g. by means of engineering solutions/design modifications (i.e. engineer out the problems), or reduce risks e.g. through improved work practice, or contain the harms e.g. by means of protective devices/equipment.</td>
</tr>
<tr>
<td>Decide what needs to be done</td>
<td></td>
</tr>
<tr>
<td><strong>Identify remedial measures</strong></td>
<td>Based on causes and consequences of failures/human errors. Application of engineering/specialist knowledge. For human operations, human error classifications schemes, the HEART technique also provides guidance on how to tackle the various human error contributory factors or error producing conditions (EPC).</td>
</tr>
<tr>
<td><strong>Risk Assessment Documentation</strong></td>
<td>Safety case and ancillary documents; e.g. HAZOP record, calculation sheets, fault tree &amp; event tree analyses, outputs of computer analyses, etc.</td>
</tr>
<tr>
<td>Record assessment</td>
<td></td>
</tr>
</tbody>
</table>

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*A Summary of Qualitative Risk Assessment Techniques and Tools*

Table 2.2 gives an overview of some of the existing qualitative assessment techniques and tools. Since the MHSWR came into force in 1993 (HSC, 1992), qualitative...
assessment has become more widely used in the health and safety field. It has even been applied to the high hazard industries, where QRA is traditionally used, for the ‘lower hazard’ aspects of their operations.

Table 2.2: Qualitative Risk Assessment Techniques and Tools

<table>
<thead>
<tr>
<th>Risk Assessment Stages/Issues</th>
<th>Techniques &amp; Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify Hazards</td>
<td>No specific techniques or tools per se; qualitative risk assessments are mostly used in applications where there are no complex relationships or significant ‘knock-on’ effects perceived between one part of the workplace and another or between one hazard and another. Usually by going through the workplace and looking at each geographical area, piece of machinery, item of equipment and/or material being handled. For human operations/activities, task analysis techniques can be used to break down the overall task into more assessable sub-tasks. In the context of emergency planning, divide up the evacuation process into stages &amp; examine the activities involved at each stage.</td>
</tr>
<tr>
<td>Dealing with complex systems – i.e. how hazard identification is organised</td>
<td></td>
</tr>
<tr>
<td>Consider what could go wrong/identify hazards</td>
<td>Audit. Inspection. Hazard checklists; some items on the checklist are in terms of hazard type (e.g. overpressure (process industries), acts of violence (policing) and some are from historical data (e.g. unauthorised disclosure in computer security). Both of these can be very context specific. Some checklists are in terms of areas covered by legislation or guidance (e.g. manual handling, COSHH) HAZOP type assessment using guide- words/keywords. Brainstorming. Debriefing or base on past incidents and experience.</td>
</tr>
<tr>
<td>Establish causes and consequences of hazards</td>
<td>No specific techniques or tools per se although for human operations, human error classification schemes can be used.</td>
</tr>
<tr>
<td>Risk Assessment Stages/Issues</td>
<td>Techniques &amp; Tools</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td><strong>Estimate Risks</strong></td>
<td></td>
</tr>
<tr>
<td>Estimate likelihood</td>
<td>Based on accident/injury data, past incidents, etc. Rating; e.g. “probability ranges”.</td>
</tr>
<tr>
<td>Establish the consequences of failure</td>
<td>Based on accident/injury data, past incidents, etc. Rating; e.g. “accident severity categories”</td>
</tr>
<tr>
<td><strong>Estimate the overall risks</strong></td>
<td>Risk rating; e.g. high/medium or low risk. Risk rating schemes combining likelihood rating with consequence or severity rating. “Semi-quantified” risk rating schemes.</td>
</tr>
<tr>
<td><strong>Determine Tolerability and Priorities of Risks</strong></td>
<td></td>
</tr>
<tr>
<td>Decide whether the risk is tolerable/acceptable</td>
<td>Based on legal requirements &amp; relevant standards. The ALARP principle</td>
</tr>
<tr>
<td>Prioritise unacceptable risks</td>
<td>Based on the estimated risks; i.e. the bigger the risk, the higher the priority.</td>
</tr>
<tr>
<td><strong>Decide What Actions to Take</strong></td>
<td></td>
</tr>
<tr>
<td>Decide what needs to be done</td>
<td>Based on legal requirements, relevant standards, good practice, current state of the art, available technology, etc. The ALARP principle. Some form of cost-benefit analysis. Risk of unwanted effects vs. benefit of the product (pharmaceutical). HSE general guidance; i.e. in order of preference, to eliminate hazards e.g. by means of engineering solutions/design modifications (i.e. engineer out the problems), or reduce risks e.g. through improved work practice, or contain the harms e.g. by means of protective devices/equipment. One paper suggests that consideration should be given to the following means of safeguards: “hardware”, managerial and procedural control.</td>
</tr>
<tr>
<td>Identify remedial measures</td>
<td>Based on operational experience and knowledge of the individuals involved in the assessment. For human operations, human error classifications schemes can be used to identify the cause/contributory factors of human errors.</td>
</tr>
</tbody>
</table>
2.4.3 Dealing with Complex Systems

When assessing a large and complex system, it is often beneficial to break it down first of all into smaller and more manageable parts. The break down has to be meaningful and adequately reflect the relationship between system components and between each component and the overall system. Methods for doing so can be found mainly in the high hazard/process industry contexts where such relationships are often well defined. With the exception of emergency response/evacuation, there are no specific techniques for dealing with complex systems in other contexts. The usual practice is to look at each geographical area, each piece of machinery or equipment and/or the materials stored and handled in the workplace and decide what hazards may arise. A reason for this could be because rarely in these contexts people have to deal with complex relationships of the kind seen in the process industries. For example, a tripping hazard at one corner of the shop floor is likely to have very little or no impact on what happens at another part of the shop floor. Another reason could be that where complex relationships exist, they are not as well understood or they cannot be easily defined.

In the process industries, the hazard identification process usually involves going through the flow diagrams of the plant and assessing each plant component (e.g. valve, pump, etc.) in turn. The relationships between each component and how failure of one component may affect the reliability of the whole plant are captured and defined by means of logic diagrams such as fault tree analysis and event tree analysis (e.g. Cross, 1982). Computer software packages are available for such analyses. For human operations, task analysis techniques such as Hierarchical Task Analysis (HTA) and tabular task analysis are used to break down the overall task into more manageable and more “assessable” sub-tasks (e.g. Kirwan, 1994; Stammers and Shepherd, 1995). In

<table>
<thead>
<tr>
<th>Risk Assessment Stages/Issues</th>
<th>Techniques &amp; Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Assessment Documentation</td>
<td></td>
</tr>
<tr>
<td>Record assessment</td>
<td>Tabular format.</td>
</tr>
<tr>
<td></td>
<td>Report format.</td>
</tr>
</tbody>
</table>

Table 2.2: Qualitative Risk Assessment Techniques and Tools
both cases, the methods can only be applied where the system components and sub-components can be clearly defined and their relationships are well understood.

In the context of emergency response and evacuation, it is the process rather than the plant from which an evacuation takes place that gets broken down. In this case, the process is divided into different stages (e.g. alarm, muster, evacuation, rescues, etc.) and assessments are carried out by examining the geographical areas, the activities and the systems (e.g. the alarm system) relevant to each evacuation stage. An example can be found in the method developed for identification of hazards during Evacuation, Escape and Rescue (EER) from offshore installations (Gould and Au, 1995). Such methods are applicable providing there is a clearly definable process of operations or activities.

2.4.4 Hazard Identification Techniques and Tools

The aim of hazard identification is to establish what hazards could arise in a workplace, associated with a work practice, etc. that could cause harm to people. The following summarises some of the techniques and tools that are already in used or are suggested in the literature. Strictly speaking, there are no specific hazard identification methods that are dedicated to or suitable only to QRA per se. The distinctions between the techniques and tools presented in Table 2.1 and those in Table 2.2 are that some of them tend to be used in association with the QRA approach whilst others are often used in qualitative risk assessments. It is perfectly feasible that those given in Table 2.1 could be used in qualitative risk assessments (and vice versa).

- Brainstorming – This type of technique has been widely used in many other areas outside health and safety and risk assessment. The idea is to pull heads together to fresh out, for example, good design ideas or solutions. When used in health and safety risk assessment, brainstorming allows health and safety practitioners, design engineers, operation managers, risk managers, etc. to exchange views and discuss their concerns. In this respect, brainstorming is particularly beneficial to multi-disciplinary and multi-agency projects. Apart from hazard identification, it can also be applied for establishing remedial measures. Conventional brainstorming tends to be very loosely structured.
Structured brainstorming – This type of technique tends to be more structured than conventional brainstorming, focusing the minds of the participants on one issue or one part of a system at a time. The Hazard and Operability Study (i.e. HAZOP) is probably the most well known example (e.g. Kletz, 1983). Originally developed for the assessments of engineering systems, a HAZOP study involves people from different disciplines and backgrounds. They meet and go through each sub-system or system component and ask the “what if...?” questions. There are two types of HAZOP techniques for different applications. HAZOP I tends to be more suitable for the conceptual design stage where things are still at their preliminary states. A set of more general keywords are used to help the HAZOP team to identify what could go wrong. HAZOP II, on the other hand, tends to be much more focused on the details and the specifics. Hence, it is more suitable for assessing a system that is at its detail design phase or an existing system where the system components, their functions and the operations involved are known and well defined. HAZOP II looks at how things may deviate from the design intention. Specific keywords such as “property words” and “guide words” can be used to help the participants to identify where things might go wrong and the failure modes respectively. HAZOP is a well established technique for hazard identification and its benefits have been widely recognised. More recently, development has been made to apply this kind of technique to other applications, e.g. Human Factors (Smith and Livingston, 1993) and the analysis of emergency response (Gould and Au, 1995).

Human error analysis – As the name suggests, this kind of technique is designed specifically for the assessments of human operations. Examples include Human HAZOP and PHECA (e.g. Whalley, 1987; Kirwan, 1995). These techniques are usually used in conjunction with task analysis. Assessors consider each sub-task to identify the human errors that could arise, their causes and their consequences. Depending upon the exact purpose of the analysis, other information may also be looked at (e.g. opportunities for recovery from the original error later on, time or workload implications of an error, what can be done in terms of work procedures, training or system design to reduce the error, etc.). These techniques tend to have
their own built-in tools, e.g. human error keywords and human error classification schemes, to aid the assessors through the analysis.

- Method study/job safety analysis - Used in the general health and safety context, it basically involves breaking down an operation into a number of steps, examining each step and identifying what the hazards are. The underlying principle of this technique is essentially the same as the above methods except it is more loosely structured.

- The “walkthrough” approaches - I.e. methods that involve the risk assessors going to the workplace to look for potential hazards. They could be a site inspection, a safety survey, an audit or simply walking around the workplace and looking afresh for health and safety hazards. Checklists are often used. Such methods are mainly used in conventional workplaces such as offices and light industrial premises.

- Checklists and keywords – Used either on their own in a desk-top exercise or as a tool for some of the above techniques. Checklists are much more prescriptive and there is a wide variation in their designs. Some are very extensive and detailed but others simply list the different areas covered by legislation (e.g. manual handling). The items appearing on a checklist obviously depend on exactly what the assessments are. They can be in terms of hazard types, the types of equipment (e.g. machinery, electrical, electronic), safety issues (e.g. access), operation concerns (e.g. “act of violence”, “manual handling of prisoners” for a police checklist) and/or specific hazards that have occurred before.

By comparing Tables 2.1 with 2.2, it has emerged that only those hazard identification techniques that are used in association with QRA approach explicitly require assessors to identify the causes and consequences of failures. The benefit of doing so are twofold: to enable the identification of remedial actions that tackle the causes rather than just deal with the symptoms and to provide information for estimating severity later in the risk assessment.
2.4.5 Risk Evaluation

There are a number of key features about the QRA techniques and tools. First of all, QRA techniques rely on failure data and/or past statistics for risk estimation. Perhaps the only exception is some of the human reliability assessment techniques such as the HEART technique (Williams, 1988) where human error probabilities are estimated using a series of mathematical formulae to take into account the various error contributory/ergonomics factors (e.g. the work practice, the work environment, nature of the tasks, etc.) that come into play. Although they do not directly rely on hard data because of the relative unpredictability of human activities and human behaviour, these formulae were nevertheless based on historical data and experience about what the factors tend to contribute most to human errors in a particular industry(ies). Another key feature of the QRA techniques is that they were designed for specific contexts, e.g. nuclear/chemical, and the data on which these techniques are based are specific to the components (e.g. valves, pumps) and the operating conditions (e.g. the chemical reactions, the characteristics of the substances in relation to different temperatures, pressure, etc.) used in those contexts. They tend to be not easily transferable to another context. Thirdly, all QRA are based on the principles that can be expressed through the following mathematical formula, which is very much in line with what has been said earlier in Section 2.2:

\[
\text{Risk} = \text{likelihood} \times \text{severity} \quad \text{.................................................. (Formula 2.1)}
\]

Informal discussions with safety and reliability specialists have also revealed that even QRA is not as totally objective as it may appear. As all plants are not the same in terms of their design, the plant components and how they process the materials, there are needs for some subjective judgements, for example, to select the most appropriate data and to decide whether the probabilities need to be scaled up/down to reflect the specifics of the plant/operation of concern. This is particularly so in human reliability assessment where, despite the numerical outputs, the estimation of human error probabilities can be a very arbitrary affair at times.
Because of the quantitative nature of the assessment and the amount of effort devoted to its research and development, risk acceptability/tolerability is a relatively straightforward judgement to make. Guidance such as the ALARP principle, together with established industry specific standards/risk thresholds and techniques such as cost-benefit analysis, has enabled the assessors and managers to make risk management decisions in a more rational manner. This is one area in which QRA is much more advanced and qualitative risk assessment still has a huge mountain to climb.

Compared to QRA, there is little published information in the literature on qualitative risk evaluation methods and discussions on related issues. Yet, since 1993 when the MHSWR first came into force, there are far more employers evaluating risk qualitatively than those using quantified methods. Even in the high hazard industries, there is an increasing trend to use qualitative methods for general health and safety risk assessment. So far, there appears to be a gap between the demand for qualitative assessment methods and the overall amount of effort devoted to studying them.

Rating appears to be the universal technique being applied across all applications. The ranges of the rating scales used, however, vary from simple three-point scales to what is potentially an unlimited range. Also, unlike QRA, not all qualitative techniques require the assessors to consider likelihood and severity separately. Such differences probably serve to reflect what people perceive to be the most appropriate level of sophistication for their particular applications. The purpose of this thesis, and hence this review, is not to pass judgement on whether these techniques are truly appropriate for whatever the applications are but rather to find what is suitable to crowd safety.

Rating is probably one of the most common techniques that has been used in all sorts of applications. The basic design of the rating techniques in risk assessment is essentially the same as those used in other areas. What is worth noting, however, is that the review has also identified what amounts to a deviation from the conventional rating system. For the purpose of this thesis, these are called the “semi-quantified methods”. These techniques are more sophisticated and, in the opinion of the author, appear to imitate the QRA methods. Just as conventional rating, these techniques rely heavily on subjective judgement of the assessors. Where they differ, however, is that once the judgements are
made (also by means of rating, but expressed in numerical terms), the outcomes are then
treated quantitatively. They are applied to mathematical formulae to give an overall risk
value just like other quantitative measures. An example of this is the one suggested in a
set of health and safety training materials for the NEBOSH Certificate (course notes
produced by The Rapid Results College). This technique contains many of the features
that can be found in other semi-quantified methods. Designed to be used in conjunction
with a safety audit, the technique uses the following mathematical formula to calculate
the overall risk:

\[
\text{Overall Rating} = \text{Frequency} \times (\text{Severity} + \text{MPL} + \text{Probability})
\]

(Formula 2.2)

where

- Frequency = the number of times the hazard was observed, say, in a safety audit
- Severity = the number of people at risk
- MPL = maximum possible loss (e.g. fatal, loss of limbs/eyes, loss of hearing)
- Probability = the likelihood of an accident

MPL and Probability are expressed in terms of rating. The rating ranges from 1 to 50 in
seven non-linear steps (i.e. 1, 5, 15, etc.). Another feature of this technique is the mix of
real numbers (i.e. the “frequency” and “severity” values) and the numerical expressions
of rating in the same formula. The rationale of this technique has not been explained in
the literature. But what is more important, however, is that the notion of using
subjective ratings as something quantitative in a mathematical calculation and mixing
them with real numbers to give an overall risk value is fundamentally flawed in
mathematical terms. Even though Formula 2.2 states that the final outcome is a “rating
value”, the extensive use of numerical expressions mixing with real numbers could
easily mislead many non-mathematicians into thinking that it is in fact an absolute risk
value.

The pros and cons about this and other techniques identified in this review in relation to
crowd safety will be discussed later in Chapter 6.
2.5 Existing Guidance

The aim of the literature review on existing guidance was to find out what guidance is available in the public domain to assist public venue owners and whether it is sufficient. The review focused on guidance documents from authoritative sources and documents that public venue owners are likely to be able to obtain. They include government publications and materials from established health and safety bodies; e.g. the British Safety Council, the Royal Society for the Prevention of Accidents (RoSPA) and the National Examination Board in Occupational Safety and Health (NEBOSH).

There are a number of government publications that contain guidance on risk assessment. Many of them are in guidance documents on specific legislation (e.g. MHSWR, Fire Precautions (Places of Work) Regulations 1994, Railways (Safety Case) Regulations 1994). Others are in guidance for specific types of venue operations such as the "Pop Concert Guide" (HSC et al, 1993) and guidance for fairgrounds and amusement parks (HSE, 1997). By and large, the guidance in these documents is consistent. The main sources of these guidance documents can be traced back to two publications: the MHSWR ACoP which sets out the risk assessment principles and the HSE booklet "5 Steps to Risk Assessment" (HSE, 1995) which lays down the risk assessment framework. Both publications are already reviewed earlier in this chapter.

In addition to government publications, guidance on risk assessment can also be found in: (i) publications by safety bodies (e.g. British Safety Council, 1993) and (ii) training courses provided by professional/trade associations and commercial bodies, e.g. those leading toward NEBOSH qualifications. The information given in these publications and course materials is similar to those provided in government publications. Although in some cases extra advice is given and techniques are suggested to provide further help to assessors, they too are intended for the typical workplaces such as offices, shop floor, industrial premises, and so on. There is very little information that is relevant to how risk assessment could be applied to crowd safety.

Where guidance is intended for public venues, it is either presented merely as an initial suggestion (Au et al, 1993) or simply echoes what has been said in the MHSWR ACoP.
and the “5 Steps to Risk Assessment” booklet (e.g. HSC et al, 1993; HSE, 1994c). In its guidance for fairgrounds and amusement parks, the HSE has made an attempt to adopt the “5 Steps” method into something that is more appropriate to fairground/amusement parks operations. This includes the provisions of a list of “foreseeable misuse” of ride equipment, data on main courses of accidents on fairgrounds and amusement parks during a ten year duration and an example of the risk assessment. Whilst useful for owners of such venues, the adopted method focuses largely on ride accidents and is of little relevance to other public venues.

Although the existing guidance does provide useful references to venue owners, it is not enough to address their specific needs. As already pointed out in Chapter 1, public venue operations are very different from the work activities in other workplaces, and so are the risks involved. Furthermore, public venue operations involve dealing with people, sometimes in very large numbers. Consideration should therefore be given to crowd behaviour and their interactions with the physical environment and the circumstances. These safety factors are unique to venue operations. What is needed for public venues is something that can inspire assessors to think about these factors.

The risk assessment guidance given in HSE’s “Managing Crowds Safely” (HSE, 1996) has moved some way towards achieving this. As in the “Fairgrounds Guide”, this document has incorporated some of the crowd safety issues and hazard contributory factors into the risk assessment framework set out in the “5 Steps” booklet. It gives examples of the hazards which the venue and the crowd may present. This guidance document provides useful and more relevant help especially to owners of smaller venues. However, it is felt that the examples are not exhaustive enough and that it is too crude for complex crowd safety problems that often exist in the larger venues. In these venues, tens of thousands of visitors or more can be expected and the operations involved can be very large and complex. Further assistance is therefore required for such venues.
2.6 Current Practice in the Assessment of Crowd Safety

A literature review was conducted in an attempt to find out how crowd safety is assessed in practice and what the constraints and difficulties are. The result is very disappointing. There is hardly any documented information in the public domain on how crowd safety is assessed. The only source that could have provided some insight were public enquiry reports on serious crowd safety related incidents (e.g. Funnell, 1988; Taylor, 1989; and Taylor, 1990). But this only represents a tiny sample of public venues (mainly football stadiums) where things went badly wrong back in the 1980s and earlier. Furthermore, where bad practices were identified, they concerned inadequate safety management systems and operational blunders (e.g. poor safety culture, inadequate training, sending people to the wrong escape routes, etc.). There is very little about crowd safety assessment per se. Therefore, the author had to revisit the records of the interviews previously conducted with public venue owners in an earlier crowd safety study, commissioned by the HSE (i.e. Au et al, 1993). Although these interviews were not intended for finding out about current practice in crowd safety assessment, nevertheless they give some useful insight into the matter. The following describes the results of this review.

2.6.1 Crowd Safety Management in Public Venues

As in other aspects of health and safety, crowd safety management can be affected by a wide variety of factors. They include safety culture, venue design, staffing level, staff training, roles and responsibilities, co-ordination, event planning, plans and procedures for crowd management, inspection and maintenance regimes, etc. In their guidance on health and safety management system, the Health and Safety Executive (HSE) (1994a, 1997a) have summarised these factors under the following headings:

- Policy.
- Organisation.
- Planning and implementation.
- Performance measurement.
- Audit and review.
In reality, a public venue owner is likely to have already achieved some of these factors but is lagging behind in others. Therefore, the areas that require improvement are likely to vary from venue to venue. But recent studies and inquiries, such as those mentioned above, have highlighted two factors to which the inadequacy in crowd safety provisions can be attributed. They are a lack of appreciation of the risks involved and insufficient pre-planning.

*Lack of appreciation of crowd safety risks*

A study by Au et al (1993), which includes site visits to 29 public venues and interviews with their management, has suggested that the level of appreciation that public venue owners have of crowd safety risks is often affected by:

- Whether or not there were disasters or major incidents that took place in similar venues
- Experience of the venues (i.e. were there any significant problems, injuries or near misses in the past?)
- Whether the venue owners (or the operation managers) perceive the visitor numbers as “excessive”
- The level of public/media attention the venues tend to attract

Pop concert organisers and major football clubs, therefore, tend to be more aware of the dangers of overcrowding because of past problems and previous disasters. Owners of strategic venues (e.g. key transport venues) and high profile venues or events (e.g. major shopping complexes, large theme parks) in general also appear to pay more attention to crowd safety. For many of the other venues, however, there seems to be less awareness of the potential for crowd safety problems despite the sizeable crowds they sometimes attract. It is not uncommon for venue owners and managers to think that crowd safety is a problem exclusive to certain venue types, such as football grounds and pop concerts.
The study by Au et al also found that there was a difference in understanding and degree of appreciation towards crowd safety across the management hierarchy in some venues. It found that members of the front line staff who have to deal with the crowds regularly tend to appreciate the potential dangers more than the senior management. With smaller incidents and incidents of near misses not recorded or not brought to their attention, senior managers may come to the belief that since crowd safety problems had never happened before, they would not happen in the future. Where small incidents are recorded, there is still a danger of senior management dismissing them as something that is a natural consequence of the operation, bound to happen and unavoidable. The fire at King's Cross Underground Station (Fennell, 1988) mentioned at the beginning of this thesis (i.e. Section 1.1) is an example of such belief contributing to a major disaster. Before the disaster, small fires at station escalators were regarded as inherent risk or as something that is inevitable to happen.

Another reason for the lack of appreciation of crowd safety risks could be that those involved in planning and implementation are pre-occupied by other issues. A mind-set situation could develop as a result. For example, it has been reported that, at the time of the Hillsborough Disaster, the police were more concerned about public order than public safety (Lord Justice Taylor, 1990). As a result, the initial exoduses from the overcrowded stands were seen as a pitch invasion by the senior police officers in the control room.

**Insufficient pre-planning**

Insufficient planning is another reason for inadequate crowd safety provisions. Planning is one factor that has the most direct impact on crowd safety. Good planning is essential to a safe and successful venue operation. Failure to do so, on the other hand, could lead to tragic consequences. The Consumers' Association studies and the King's Cross Fire and the Hillsborough Disaster inquiries (Fennell, 1988; Lord Justice Taylor, 1990) have all identified inadequate planning as a contributory factor. The importance of planning is also well acknowledged by many other authors (e.g. Malhotra, 1987; Irish Committee on Public Safety and Crowd Control, 1990; Home Office and Scottish Office, 1990; Health and Safety Commission et al, 1993; Wanless and Stanton, 1994; Au and Carey,
In its report to the City of Cincinnati in Ohio, USA, the City of Cincinnati Task Force on Crowd Control and Safety (1980) explicitly recommended that the city should require crowd management plans for events attracting 2,000 people or more.

An effective planning system for health and safety requires an organisation to establish and to operate a health and safety management system which controls risks, reacts to the changing demands and sustains a positive health and safety culture (HSE, 1997a). To control risks, it is necessary to identify and assess the risks in the first place. To react to the changing demands, planning and risk assessment should not be based on past experience alone but should also predict what problems could arise. In many cases, planning was lacking in prediction. For example, the study by Au et al mentioned earlier also found that many venue owners and managers tended to rely too much on their own experience alone. The focus of their assessment and planning was on preventing known significant problems from re-occurring. There was very little in the way of predicting what could go wrong. More will be said about this type of approach in the subsequent section.

2.6.2 Experience-based Approaches

The information presented here is largely based on interviews with public venue owners and managers conducted by Au et al (1993) in an earlier crowd safety study for the HSE.

Traditionally, crowd safety assessment is conducted largely based on experience and on feedback from previous operations. For the purpose of this thesis, such approaches are called the “experience-based approaches”. They are by far the most popular approaches to crowd safety assessment.

One such approach that is widely used, especially in public events, involves debriefing sessions being held after an event or a period of operation. The participants may include members of the venue staff and possibly representatives of any external bodies involved, such as the police. Depending on the size of the operation, more debriefing sessions may be held at different levels of the operation hierarchy. For example, sessions involving the front line staff and their supervisors at the ground level, sessions involving
managerial and supervisory staff at the operation level and top level meetings and inter-
agency meetings at the policy level. Usually, the aims of the debriefing sessions are to
review the previous event or period of operation, identify any problems or incidents that
need to be addressed before the next operation and collect any comments and views of
the participants and others on the operation. The information is then fed back to the
planning process for the next duration or the next event.

Another popular approach, which is similar in nature to the “feedback” approach above,
involves a review of the existing plans and procedures at regular intervals or when it is
felt necessary. The review may be carried out largely by the operation manager and his
staff. Sometimes people from other parts of the organisation and external agencies are
also involved. Instead of just looking back at what happened in the previous period of
operation, participants will examine the existing plan or procedures to decide whether it
is sufficient and what modifications/additional provisions are required. Past experience
tends to have a significant influence on decision making. The review is often carried out
on all aspects of the operations rather than just a safety review.

Both approaches tend to rely heavily on the experience of those involved in it, problems
that come to light and lessons learnt from past incidents. In addition, some public venue
owners acquire further knowledge and take into account information from the following
sources:

- Training courses, conferences, seminars, trade association meetings, etc. where
  they can learn and share experience.
- Written materials such as guidance documents.
- Lessons learnt from known incidents and disasters elsewhere.
- Intelligence reports (e.g. for policing football matches).
- Comments and complaints from staff and visitors.

Whilst past experience is critical for crowd safety assessment and planning, there are a
number of problems associated with the experience-based approaches described above.
Firstly, there is no evidence of past experience being assessed systematically under these
approaches. Instead, they appear rather piecemeal; i.e. it all depends on the views of the
participants and what they could remember most at the time of the debriefing or review. As such, secondly, comprehensiveness of the assessments cannot be assured. Thirdly, these approaches focus on past problems and on preventing them from occurring again. They fail to look at what could go wrong in the foreseeable future. For example, new hazards could arise and the risks of existing hazards could be different as the results of changes in the circumstances. Regulation 3 of the MHSW Regulations (HSC, 1992) requires employers to update their assessment to take into account such changes. Rowe (1977) also regarded the “observations” of new risks and changes in risk parameters as a key part of “risk identification”. Fourthly, there are no assessments of the risks posed by the problems identified (or how serious they are). The literature review in Section 2.2 shows that risk estimation and evaluation are important parts of risk assessment. The MHSWR Approved Code of Practice (HSC, 1992) suggests that a suitable and sufficient risk assessment should, amongst other things, enable the prioritisation of the measures that need to be taken. The experience-based approaches that fail to estimate risks do not satisfy this requirement.

Furthermore, experience, previous disasters and research (e.g. Fennell, 1988; Taylor, 1990; Donald and Canter, 1990; Wood, 1990; Au et al, 1993; Au and Carey, 1994; Wanless and Stanton, 1994) all show that crowd safety related accidents, like many accidents in other contexts, are rarely attributed to a single cause (e.g. Department of Energy, 1990; Department of Transport, 1990; HSE, 1992b; HSE, 1994b; Perrow, 1984; RM Consultants Ltd, 1994). Instead, crowd safety can be affected by a large number of diverse factors. For example, human behaviour plays an important role in emergency evacuation (e.g. Williams and Hopkinson, 1976; Canter, 1990; Building Research Establishment; 1993; Dowling, 1994). These factors could vary widely between venues. Even within the same venue, they may vary at different times and under different circumstances. A potential danger of approaches that are reactive to past problems is that the attention of the assessors could be diverted to the symptoms of the problems and could overlook their underlying causes. Whilst they will still help to prevent the same or very similar accidents from occurring, these kinds of approaches are less effective in identifying other reasonably foreseeable hazards.
2.6.3 Computer Modelling

There has been an increase in use of computer simulation by some major venues as a high-tech. tool to assist safety assessment. Whilst, strictly speaking, computer simulation alone cannot be regarded as a complete safety assessment method, it is gaining popularity and has provided the assessors with the opportunities to have a better insight into, say, crowd movement and crowd distribution. Computer modelling can also be used to try out different alternatives before deciding on the best measure to put into practice.

There are a number of software packages that allow users to build computer models of and simulate movements in public places. Many of them were built for emergency egress purposes (e.g. Ketchell, 1993; Okazaki and Matsushita, 1993; Thompson and Marchant, 1993). Others predict pedestrian flows and distribution (e.g. Hillier and Hanson, 1984; Dickie and Meghji, 1994; Okazaki and Matsushita, 1993; Toshiyuki, 1993; Hillier, 1996). Nevertheless, some of these packages have the potential to be adopted to assess crowding problems during normal operation. The use of computer simulation is particularly beneficial in that firstly, it allows the users to "visualise" their problems. Secondly, and perhaps more importantly, it enables the users to try out their solutions without putting visitors at risk. Where the solution involves making expensive modifications to the venue design, the users can test and find the optimum solution before actually carrying out the work. Thirdly, simulation can be made on existing venues, brand new venues and venues which are still at their design stage.

Despite the above benefits, computer simulation alone and in its current form cannot be regards as a sufficient crowd safety risk assessment method as such. Earlier versions were criticised for dealing only with the physics of crowd flow and giving no consideration to human behaviour (e.g. Sime, 1984). Since then, improvements have been made and some software packages have incorporated simple behavioural rules, such as those concerning people’s choice of routes, “follow the leader” and ways of avoiding collision with others. These changes make the simulated crowd movement more realistic and can help assessors to identify hazards that are introduced by certain
poor venue design. It is, nevertheless, still insufficient in the identification of hazards due to crowd behaviour or inadequate crowd management.

Another problem associated with computer simulation is validation. A simulation is valid only if it can be proved that the simulated situation is sufficiently similar to the actual situation which it is trying to model. As discussed above, factors affecting crowd safety are likely to vary in different venues, at different times and under different circumstances. Hence, it may not be enough to validate the package itself based on its applications to one or two venues. A proper validation would involve comparing individual simulations against what actually happened in a number of representative normal and emergency scenarios in the venue of concern. Given the frequency of changes in many venues, this is very difficult (if not impossible) and costly to achieve in practice. Finally, the costs involved in either purchasing a package or commissioning a simulation is currently rather high and is therefore beyond the reach of many public venues.

2.7 Conclusions and Discussions

The review of a recent study and past disaster reports suggests that the current practice is inadequate. There has been a lack of appreciation of crowd safety risks and planning is generally insufficient. Current practice in crowd safety assessment is also inadequate in meeting the legal and other requirements on risk assessment. There has been a heavy reliance on personal experience and incidents and problems that occurred in the past. Such assessments are unsatisfactory because:

- There are no mechanisms in place to help assessors to decide the importance of the problems and to prioritise the measures that need to be taken.
- They are not systematic. The outcomes depend significantly on which direction the discussions go in debriefings and what past problems the participants can remember or see as important at the time. Holding the debriefing or review on a different date could generate a different set of results.
• They are not sufficiently comprehensive. By focusing on past experience, any new hazards due to changes in circumstances or the introduction of new features could be missed. For many venues, changes, new features, etc. are normal and necessary for their operations.

• Approaches that rely heavily on experience are of little use when dealing with brand new venues.

• Some crowd safety accidents could have serious consequences and should not be allowed to happen in the first place. Experience-based approaches are reactive in nature and could be dangerous in this respect.

Furthermore, there are legal requirements for carrying out risk assessments. Although the detailed requirements vary between venue types, the overall requirements are clearly set out under the HSW Act. Namely, venue owners are required to ensure, so far as is “reasonably practicable”, the health and safety of their employees and others who may be affected and that they are not exposed to risks. To determine what is reasonably practicable, there is a need for some form of assessment of risks. The MHSWR places a specific duty on venue owners to carry out risk assessments. This is to ensure that they think carefully about the nature and extent of hazards. A key criterion for risk assessment is that it has to be suitable and sufficient. This means that the assessment should identify all significant risks, enable the identification and prioritisation of the actions that need to be taken, and be appropriate to the nature of the work (HSC, 1992).

The outstanding question is, therefore, what is a suitable and sufficient risk assessment for crowd safety? The existing guidance, which is primarily for workplaces, does not adequately address this question and, hence, further investigations are required.

The definitions of risk and the risk assessment principles are already well defined. The literature review shows that there is a general consensus over what is risk and what risk assessment should consist of among organisations such as the HSE, the Royal Society, the British Medical Association, the National Research Council in the US and among many authors (e.g. Rowe, 1977; Kinchin, 1982; Moore, 1983; Covello and Merkhofer, 1993; etc.). In a nutshell, risk should reflect both the likelihood of harm and its severity. Risk assessment can therefore be regarded as the process to identify things that have the
potential to cause harm and determine the degree of likelihood and severity of harm. Whilst the principles are clear, how they should be applied to crowd safety to satisfy the criterion of being “suitable and sufficient” still requires more thought. A further review of the risk assessment literatures has identified a few things that could be of relevance to the application of risk assessment to crowd safety.

Firstly, the HSE (1998) has set out a framework for risk assessment which consists of the following five elements: (i) look for hazards, (ii) decide who might be harmed, (iii) evaluate the risks and decide if existing precautions are enough or more should be done, (iv) record assessment findings, and (v) review and revise assessment to ensure that it remains valid. This is a general framework intended for all risk assessments under the MHSWR.

Secondly, within this framework, the actual risk assessments could range from loosely structured methods, such as those recommended for general offices (e.g. HSE, 1994), to sophisticated and resource intensive probabilistic methods, such as those used in the high hazard industries. The type of assessment required for a particular application may depend on a number of factors such as the nature of work, the types of hazards, the extent of risks and who could be affected. The issue of voluntary vs. involuntary risks could also come into play. The conclusion from the literature review on this issue is that for involuntary or imposed risks and, where risk decisions are likely to affect many people, then it can be argued that a more robust assessment regime is required so that the decisions are rational and justifiable. On this basis, it can be argued that crowd safety assessment would need to be more robust than that for an office environment because venue visitors are not involved in the decision making process and a high number of them could be affected. At the same time, it can also be said that crowd safety assessment needs not be as robust as that for the high hazard industries because the extent of the risks imposed on others in crowd safety is far less.

The third issue concerns risk management. The outcomes of a risk assessment form the basis for decision making on how the risks should be managed, and this could have implications on what kind of risk assessment is appropriate for crowd safety. Although it is accepted by many authors that risk should reflect likelihood and severity, and
therefore risk management should consider both elements, there could be circumstances where alternative approaches may be appropriate. The literature review has looked at several other suggestions to see if they would be suitable for crowd safety. Apart from the risk-based assessment described above, other suggestions include the hazard-based approach, target setting/de minimus and cost effectiveness approach. Based on the review, it is concluded that none of these can be suitably applied in their entirety to crowd safety for different reasons. The argument behind the hazard-based approach is that where the consequence is extremely severe, then hazard should be the dominating factor for decision making even though it may be very unlikely to occur. Whilst there could be circumstances in which this argument will apply, not all crowd safety risks are of that nature. Overall, it is still necessary to consider risk as a whole before deciding whether it is appropriate to use the hazard-based argument for managing some of the “extreme” risks. Perhaps it is worth noting that although the consequence of a crowd safety disaster could be high, it is nowhere near the severity of a nuclear disaster. Yet, the assessments done in the nuclear industry are risk based. If the consequence is so severe, under the ALARP principle (which is used in conjunction with the risk-based assessments), the risk will have to be controlled regardless of costs. This aspect of ALARP is effectively the same as the hazard-based argument. Hence, there seems to be no justifications for an explicitly hazard-based assessment. The main problem for target setting is that there are no universally accepted targets for crowd safety. Also, different public venue types operate differently and tend to have different problems. The same set of targets (e.g. on maximum crowd density, etc.) is unlikely to be applicable across the whole spectrum of public venues. Nevertheless, the underlying principle is quite in line with the ALARP principle in the nuclear industry and the views of many authors is that there should be a “cut-off” point or an upper limit beyond which the risk should be regarded as intolerable. Whether a similar cut-off point should be set for crowd safety in the future could be a worthwhile subject for further research. With regard to the cost-effectiveness approach, the decision still has to be based on a risk-based assessment. A clear danger of the cost effectiveness approach is that high risks could remain uncontrolled because it is not sufficiently cost effective to do so. There is also the moral argument about whether it is justified to expose people to risks on a cost basis alone. The practical difficulty in applying the cost effectiveness principle to crowd safety is that
it is necessary to express costs and risks in a common unit so that they can be compared or balanced against each other. Currently, this is not possible to achieve.

Fourthly, the QRA approach (i.e. quantification of risks) is deemed to be unsuitable for crowd safety at present for several reasons, for example: the unavailability of failure data and, hence, the issue of uncertainty discussed in Section 2.3.4; the unpredictability of human behaviour in public venues; and the unavailability of the necessary expertise for QRA. Kazer (1992) has also argued that quantified assessment is unnecessarily complex for many sectors. From a practicality viewpoint, the efforts and the costs required to conduct such assessments are also prohibitive for the vast majority of public venue owners.

Fifthly, Moore (1993) has argued that qualitative assessment, which involves the use of words rather than figures to represent the levels of risk, is useful only if the writers and the readers agree on their meanings of the words used (e.g. high, medium, low risks). In reality, words do not have a generally accepted and agreed meaning. This is a problem that needs to be addressed in order for the crowd safety risk assessment methodology to be truly useful and produce consistent results.

Finally, the review of the current practice has revealed that many venue managers tend to have a different understanding of the problems and less appreciation of the potential dangers than their front line staff. There is a need to enable the views and experience of the front line staff to be communicated to the managers and the assessors and be taken into account in assessment and planning. There is also a tendency of a mind-set towards past problems during assessment and planning and not enough forward looking. There is a need to encourage planners and assessors to not only look back at what went wrong in the past but also to consider what could go wrong in the foreseeable future.

Because of the lack of published information, the literature review can only provide an overview of the current practice in crowd safety assessment. Although it has served to highlight some of the problems and inadequacies, the information gathered so far is not enough to enable the author to identify the needs of the crowd safety assessors and what help and assistance they may require. It is felt that more precise information is needed.
A public venue survey was therefore carried out to supplement the information obtained here. The survey and its findings are described later in Chapter 4. The literature review on risks and risk assessment has provided a foundation for developing a risk assessment methodology for crowd safety. Nevertheless, a better understanding of the crowd safety problems, public venue operations and the tasks involved in crowd safety assessment are also required.
CHAPTER 3
CROWD SAFETY IN PUBLIC VENUES - CASE STUDIES

This chapter examines in more detail the subject of crowd safety in public venues. In particular, it looks at the nature of venue operations, how they differ from other workplaces and the crowd safety issues and problems that crowd safety assessors need to address in their assessment. To illustrate these issues this chapter will describe two case studies to highlight the operational and safety issues involved in running a public venue.

The two case studies concern a street festival and a high street/market environment. Due to confidentiality requirements, the identities of these venues cannot be revealed. For the purpose of this thesis, they are identified as follows:

Case Study A  -  A Street Festival/Carnival
Case Study B  -  A High Street/Market Environment

Both case studies concern outdoor environments. Although they are not necessarily representatives of all venue types, they do provide an overview of different venue operations, visitor types and the associated crowd safety problems.

3.1 Case Study A - A Street Festival/Carnival

3.1.1 The Event

This is an annual event which takes place over two days in the summer. Streets are pedestrianised for the duration of the event. Like many other successful events, it started off as a relatively small event that has become the victim of its own success. It has gained popularity and grown over the years to become one of the biggest street festivals in Europe attracting hundreds of thousands of visitors.
As in many street events, there are no official venue boundaries and no means of controlling how many people enter and leave. However, the majority of the visiting crowds can usually be found at and near the streets where the attractions are located. In this event, there are three types of main attractions: the carnival procession (e.g., costumed dancers and floats), set stages and street trading.

The procession route follows a number of streets around the venue. Apart from visitors standing along the route to watch the procession, individual floats also attract their own crowds/supporters who tend to follow them closely. Amongst the most popular areas on the procession route are the judging points where the floats stop and perform in front of panels of judges.

The set stages and most of the street trading can be found at various places in the area surrounded by the procession route. There are three set stages and numerous street traders. The attractions at the set stages include live acts and celebrity visits. In a way, each set stage is like a mini concert or show drawing a large crowd and sometimes generating emotional behaviour amongst the crowds.

In theory, street traders are licensed by the local authority and allocated specific plots within the venue. Stewards employed by the event organiser can work with the police and local authority's environmental health officers to enforce the licensing conditions and ensure that unlicensed street trading is prohibited. However, in practice, the police are reluctant to remove illegal traders once they have set up for fear of triggering public order incidents. Because of the large size of the venue, actions to prevent illegal traders from setting up during the night or in the early hours can be costly. Also, this will not stop people from setting up stalls within the festival boundaries (e.g., residents setting up at their forecourts).

A previous survey suggests that the vast majority of the visitors were under 35 years of age and that there were slightly more men than women. But the imbalance was not great.
There are variations in the types of visitors between the two days of the event. Day one is usually attended by families and people across a wide range of age groups. The visitor population in day two, and especially towards the evening, is dominated by young adults and has more of a party atmosphere.

A recent study (Au et al, 1993) suggests that the nature of an event and different types of visitors could lead to different crowd behaviour which could, in turn, have a significant impact on crowd safety. Case study A has indeed served to highlight this. Over the years, this event has developed its own distinct culture and traditions which make a significant contribution towards some of the safety hazards found here. For example, it is generally perceived to be more of a street party than an event. As such, excessive consumption of alcohol and other excesses are considered acceptable. The resultant crowd behaviour and attitudes could generate situations that give rise to crowd safety hazards and severely constraint what actions can be taken to remedy such hazards. The problem is severe and more obvious on the second day of the event when there is little “family atmosphere” and the crowds become much more rowdy.

3.1.2 Crowd Safety Planning and Management

Similar to other major public events, there are a number of bodies involved in organising, running and providing services to this event. They include:

- The event organiser.
- The local authority.
- The police.
- Other emergency services.
- Public transport operators.

A liaison group is set up to co-ordinate operations and address issues of common concern. Apart from the above, it also includes the local MP, residents and organisations that have an interest in the event.
Each of the above bodies has its own responsibility to fulfil, but none of them seems to have the overall responsibility of running the event and ensuring safety. The event organiser organises the event but has little resources to look after issues such as health and safety. The local authority has some health and safety responsibilities. Their duties include supervising and regulating trading, monitoring music level, regulating the sound systems and inspecting temporary structures, e.g. the set stages. The police are responsible for maintaining public order and traffic matters. They also provide the necessary back-up to the local authority officers in, for example, enforcing the licensing requirements. Other emergency services cover fire safety and first-aid and provide the necessary emergency response. The public transport operators are responsible for providing public transport facilities to the visitors.

Although there appears to be no single body with overall control over crowd safety matters, the police often find themselves at forefront of dealing with the crowds. Therefore, in practice, they have unwittingly become responsible for crowd management and crowd safety. Doubts have been raised within the police as to whether they have the necessary legal power to enforce crowd control measures purely on the grounds of public safety. The usual police command structure for managing events and incidents applies here - i.e. command and control is divided into “Gold”, “Silver” and “Bronze” levels. The Gold Commander is in overall control of the police operation and is usually in the control room. The Silver Commander is in forward command and can be regarded as the “site commander”. The affected area is split into a number of sectors. A Bronze Commander is responsible for operation in each sector.

3.1.3 The Crowd Safety Problems

Because of the large numbers of people attending, excessively high crowd density or overcrowding is the main crowd safety problem at this and other similar events. This could result in a dangerous build-up of crowd pressure, crushing and a pile-up of people. It has to be noted that the overcrowding problem does not necessarily have the same effect across the entire venue. Some parts of the venue can be worse affected than others. In this particular event, the southern sectors are more crowded than the northern
sectors. Furthermore, crowd distribution is not uniform even within the southern sectors. Some streets are very crowded whilst others are relatively quiet.

The reasons for overcrowding also vary between different parts of the venue. At some places, this is simply a case of insufficient capacity to cope with the demand (i.e. the numbers of people at or passing through these places far exceed the capacity). At other places, the problem could be due to combinations of their proximity to major attractions, the presence of pinch points and obstructions and cross flows (i.e. people crossing each other's paths thus slowing down crowd movement and causing a larger build-up of crowds). Overcrowding can be exacerbated by drunkenness and other undesirable behaviour. For example, problems were observed at this particular event concerning groups of young people pushing their ways through the packed crowds. This could lead to a further increase in crowd pressure and an increased chance of people falling over and being trampled by others. Relatively minor public disorder incidents and aggressive behaviour could also pose a significant safety problem. Although they can also be found in many town centres on Saturday nights, these types of incidents could have a much more severe consequence in a crowded environment, resulting from surging by people trying to move out of the trouble spot.

Crowding problems can also be the result of massive (lateral) movement within a stationary crowd and emotional behaviour. This is particularly in evidence in front of the set stages and also one of the main problems at places such as pop concerts where several accidents of this kind occurred in the past. Other key crowd safety problems found in this event include:

- The collapse of temporary structures onto the crowds below.
- Unsteady floats toppling over whilst turning a corner.
- People hit by the floats and crushed underwheels. This could be caused by unsafe vehicles, poor visibility from the drivers' cabs or drivers' errors.
- Open fire grills used by traders selling hot food being set up in crowded streets. This could result in passer-by receiving burn injuries or, more seriously, the grills could topple over due to crowd pressure.
Street traders setting up their stalls too close to main circulation routes, creating pinch points and obstructing crowd flows.

In addition, tripping and slipping hazards can also be found throughout the venue. They are often caused by an accumulation of rubbish and bottles on the floor or people tripping on pavement kerbs or, in some cases, over the feet of crowd control barriers. Tripping, slipping, etc. can also be found in other workplaces such as offices, factories and shop floors and are often treated seriously. In this and many other major events, however, tripping and slipping are often tolerated unless they occur in a particularly crowded environment. This is despite more people being exposed to the hazards in a public venue. The reason why major public events (and some major venues as well) appear to have a higher level of tolerance over safety risks than other workplaces are two-fold. Firstly, the risks posed by tripping and slipping in a non-crowded environment are low in relation to the problems already identified above. Higher priorities must therefore be given to deal with the more serious problems first. Secondly, there is often no reasonably practicable measures to tackle the problems. In Case Study A, for example, there are three possible ways of reducing the amount of rubbish and bottles on the floor but none are practicable. The first method is to put in place more rubbish bins, etc. But given the size of the venue, this can be costly and would not be very effective - experience suggests that some people will continue to leave rubbish on the floor. Furthermore, big bins could obstruct crowd movement and small bins will need to be emptied frequently. The second method is to ask public houses to stop customers leaving their premises with bottles and cans. Experience suggests that full co-operation from the landlords cannot be guaranteed as this will require extra door staff and could increase conflicts at the doors. Furthermore, this will not stop people bringing in their own bottles or cans of drink or buying them from the nearby off-licence stores. The third method is to sweep the streets more frequently. Apart from the costs involved, it is also extremely difficult, if not impossible, to sweep the streets when they are so heavily used.

Equally, although pavement kerbs also pose tripping hazards, they are very much a part of the street and cannot be removed.
The examples given above have served to illustrate some of the differences between a major public event and a workplace even when they are faced with similar safety problems.

3.2 Case Study B - A High Street/Market Environment

3.2.1 The Venue

The area consists of several large private markets, a street market run by the local authority and numerous businesses. They are located along both sides of the high street. Another key feature of the area is a canal which runs alongside some of the markets and under a road bridge that forms a part of the high street. Originally occupied by disused industrial buildings and land, the area began to take shape in the 1970s when a weekend market and craft workshops were set up. Since then, it has grown from these small beginnings to become a major attraction.

This area is a major tourist attraction because of its character and the goods on sale. The accent of the area was on arts and traditional crafts but has soon broadened to include a wide variety of goods including antiques, clothing and restaurants and coffee bars. Another reason for its popularity is the uniqueness of its locations - i.e. as part of a major city and easy to get to by public transport. But the main attractions are the private markets which are situated along the high street. They include open air markets and indoor market halls. Old buildings have been renovated to house workshops, small shops and market stalls. Stall spaces are let by the market owners on short leases.

Most shops and business are opened everyday but the area is normally at its busiest at weekends during the summer period. Many tens of thousands of visitors come to the area each weekend in this time of the year. They consist of visitors from nearby, visitors from elsewhere in the UK and overseas visitors. Unlike Case Study A which tends to attract mainly young people, visitors here consist of people of a much wider age range, from children to old age pensioners. Overseas visitors are also significant in number.
This area is chosen for this case study because it has the characteristics of both a regular venue and a street event. Visitor activities and their behaviour are similar to a large shopping venue or a busy town centre. But it also has problems that are more often seen in street events. One such problem concerns the spatial layouts. As already mentioned, the area is transformed from an old industrial setting into its current state. Whilst this gives the place its character, it also means that the area is insufficient to cope with large numbers of visitors. Small confined space and narrow passageways are not uncommon in the area. Many buildings and structures are listed and therefore the scope for making changes to the spatial layout is very limited. This has led to concerns over issues such as overcrowding and fire safety. The unfamiliarity of many visitors to the area and the large numbers of overseas visitors who may not speak English can also have safety implications especially in an emergency when the area has to be evacuated. Section 3.2.3 will look at these and other crowd safety problems that exist in this area.

3.2.2 Crowd Safety Planning and Management

In terms of its operation, this area can be regarded as a regular venue rather than an event. There are, again, a number of bodies involved in running and providing services to the area. The market owners are responsible for all operational and health and safety matters in their markets. The local authority has two different roles to fulfil. To the markets and licensed premises in the area, it is the licensing and enforcing authority. As such, its role is to ensure that they comply with the relevant health and safety and licensing requirements. To fulfil its enforcement role, officers from the local authority carry out checks and inspections during market operations. The public environment in the area also falls into local authority’s responsibility. Its duties include public safety, street parking, street trading and street cleaning and refuse collection.

The roles of the emergency services are essentially the same as in everyday situations. What is perhaps worth noting is that since the area is regarded as a regular venue, it does not have the same level of police presence as in a street event. Therefore, the command structure described in Case Study A does not normally apply here.
The interaction between different markets and the agencies involved is a key issue here. Because of the close proximity between the markets, business premises on the high street and public transport venues, any significant changes in one place could have a knock-on effect on others and on the area as a whole. Also, should an emergency arise, all businesses and the agencies involved would need to work together in a well co-ordinated manner to deal with the situation. Working groups are set up to address issues of common concern, co-ordinate responses and develop area-wide contingency plans.

3.2.3 The Crowd Safety Problems

There are two main safety problems in the area: (i) crowding/congestion and (ii) conflicts between pedestrian and vehicular traffic. Although crowding and related problems were also found in Case Study A, because of the differences in the nature of the venues and their spatial layout, both the reasons for the problems and their extents can be quite different. In this particular case, the reason for the problem is not due to the concentration of large crowds as such. Whilst the large numbers of visitors during the weekends is clearly a contributory factor, they tend to be more spread out and therefore are not the sole cause for concern. The total capacity of the area, though insufficient, is also only a part of the problem. A key contributory factor to crowding in the area is its spatial layout. Because of the old industrial setting upon which this place is developed, the layout of the area and its old buildings are even more inadequate than that in the street festival in Case Study A. There are a number of pinch points and narrow passageways that severely restrict flow capacities in the area. Large crowds and crowd pressure therefore build-up rapidly at both sides of the pinch points. In some parts of the area, the crowding problems are exacerbated by venue features such as uneven underfoot conditions (e.g. cobble stoned streets, potholes) and steep slopes. They could also lead to other hazards such as tripping and slipping. Such problems are not uncommon in old venues and historical places.

Another key concern is conflict between vehicular and pedestrian traffic. Because of the overall traffic situation in the larger area, road traffic is allowed to pass through the area even at weekends. This together with other factors such as visitors’ behaviour (i.e. the manner in which they cross the roads and standing/walking on the carriageway).
aggressive driving behaviour, motorcycles and bicycles weaving in between traffic, the road layout (e.g. the need for drivers to get in lane quickly or compete for position) and narrow pavements at some places have given rise to the danger of road traffic accidents and people being knocked down by vehicles. The road junctions on the high street also lead to a build up of crowds waiting to cross the road, thus contributing to the crowding problem.

Some of the problems identified in Case Study A also exist here, they include illegal street trading, street performers, illegal parking, street furniture, railings, pavement kerbs, ramps, obstruction by stationary crowds outside train stations or at bus stops and long queues cutting across pedestrian flow paths. Other hazards found primarily in the markets can also be seen in workplaces elsewhere. They include unstable structures, unsafe electrical wiring/installation, unsecured cables and the use of hazardous items and substances such as open fire barbecue and LPG gas.

3.3 Discussions

In their analysis of the Hillsborough Football Stadium Disaster, Jenkins et al (1991) concluded that the situation in sporting events such as that in Hillsborough is a lot more complex and diffused than in an industrial situation. As far as a safety management system is concerned, these situations require close co-operation and communication between the various parties involved and consideration to be given to many external constraints. This is also true in the case of many other public venue operations. The two case studies have highlighted some of the differences between operating a major public venue and running a workplace. In general, the differences are in terms of the nature of their operations, the work activities and therefore the safety hazards that exist.

In an office or an industrial environment, the work activities often include processing information, documentation, substances and materials. The health and safety hazards found in such a place often arise from the work practice, work environment, equipment and machinery and the substances and materials that are being handled. The hazards are usually well understood and, in many cases, rather obvious. Furthermore, people who are most exposed to the dangers are the employees. Operating a public venue, in a way,
is about processing large numbers of human beings. Therefore, the dangers can arise not only from the venue itself and the presence of hazardous hardware and substances but also from crowd dynamics, human behaviour and their interactions with the physical environment and with the ways in which they are managed. As previously pointed out in Section 1.7.1, human behaviour in a public venue environment is less constrained than behaviour in a work environment. Also, a lot more people are likely to be exposed to dangers in a public venue than in a workplace.

3.3.1 Operational Issues

The case studies also show that there are more operational constraints in a major public venue than in other types of workplaces. One of the key factors for this is the involvement of outside bodies. In a workplace, ensuring health and safety is clearly the responsibility of the employer. It seldom involves outside organisations. But public venue operations often involve the inputs of different bodies. In Case Study A, as well as many other street events, there are even uncertainties as to who has overall responsibility for ensuring crowd safety. It has to be said that this is not typical of public venues as a whole. In Case Study B, for example, responsibilities are much better defined. But even for a stand-alone venue, the activities of the nearby venues, events and businesses could, in some cases, also have an impact on its operation. A lack of commitment or willingness to co-operate by outside bodies and businesses could result in tremendous constraints on what can be done to improve safety. But such co-operation cannot always be guaranteed for political, operational and/or financial reasons.

There appears to be more practical constraints on what can be done to improve safety in a street venue than in a normal workplace. Apart from a lack of co-operation from other bodies, the fact that there is no direct control over the number of people attending also poses a major constraint. Another problem is that the street environment is not designed, nor is it suitable, for the gathering of large crowds. The situation can be worse if old historical settings are involved, as demonstrated in Case Study B. Apart from a lack of space to accommodate the volume of visitors, the scope for changing the venue design and its layout to make it more suitable are almost non-existent. The only means of ensuring crowd safety therefore is through crowd management alone. Having to rely
solely on crowd management is a handicap from the crowd safety management viewpoint and is not the ideal way of tackling the problems.

Case Study A has further highlighted some of the practical constraints facing the police (or those who are responsible for the management of crowds) in a street event. A delicate balance also has to be struck between improving safety and other aspects such as:

- **Political consideration** - e.g. police relations with members of the public, this could affect the effectiveness of police operations in all areas, not just managing crowds.
- **Measures that could cause other problems** - whilst this is also a problem for other venues and workplaces, the police in this case are particular concerned about the possibility of an apparent “hostile” measure triggering a public order incident.
- **Costs, resources, etc.** - these constraints are by no means unique to public venues, they are also applicable to most workplaces.

### 3.3.2 Crowd Safety Issues

The case studies have highlighted some of the crowd safety problems that could exist in a major public venue. These hazards must be clearly identified if the risk assessment is to be suitable and sufficient.

In general, there are two types of problem. The first is what can be described as a general health and safety hazard. Tripping, slipping, unstable structures, substandard electrical installation, the mix of pedestrian and vehicular traffic, the use of LPG gas and open fire grills in high crowd density areas are just some of the examples found in the case studies. Other such hazards may include unguarded machinery in public areas, sharp protruding objects and falling hazards. These hazards are often associated with physical objects, such as unsafe venue features and the presence of hazardous items or substances. In this respect, they are similar in nature to those found in a workplace. In general, the link between this type of hazards, their causes and consequences is quite
obvious and straightforward to establish. They tend to be relatively easy to identify in
the eye of a trained health and safety assessor. What is required is a comprehensive and
systematic hazard identification method to ensure that all objects and substances that
could cause significant harms are considered.

The second types of problems are those associated with the presence of large crowds and
their behaviour. People can be harmed by a build-up of excessive crowd pressures (e.g.
crushed against each other in the crowd or crushed against objects such as walls) or due
to the loss of body balance (e.g. a pile-up of people, being trampled by others or being
pushed over and falling from a height). The reasons for and the extent of this type of
problem tend to vary between circumstances. They are often influenced by an array of
factors such as crowd size, capacity, crowd dynamics, spatial layout, crowd distribution
and crowd behaviour and activities. For example, the crowding problems in Case Study
A are different from those in Case Study B because of the involvement of different
combinations of factors. They also differ from the overcrowding problem occurred in
the Hillsborough Disaster where the most immediate cause was the mismatch between
crowd size and holding capacity - although other factors such as weather condition also
came into play (Lord Justice Taylor, 1990). Other examples include pushing, surging
and vigorous crowd movement which can be seen in places like football grounds, pop
concerts and street celebrations.

Apart from hazards relating to the build-up of crowd pressure, there are also problems
which are made worse by the high crowd density. They include congestion, pinch
points, obstructions and cross flows. These problems are by no means unique to major
public venues. Instead, they can be found all the time in everyday life, for example, on a
high street or in a building. Usually, they would cause no more than inconvenience and
frustration. However, these problems could become much more safety critical if they
occur in an environment involving the movement of large crowds. Again, the likelihood
of people being harmed as a result and the extent of harm tend to vary from place to
place and from time to time depending on the circumstances.

Similarly, tripping and slipping can also be found in other workplaces but the
consequences tend to be more severe if they occur in a crowded environment. Problems
like drunkeness and aggression do not normally present any significant safety threats except to those who are involved, but could become more serious in a crowded environment.

Compared with hazards associated with a physical object, hazards associated with the presence of large crowds are less straight forward to spot. For example, large numbers of visitors, pinch points and cross flows on their own do not necessarily pose a danger as such. Both the case studies and experience suggest that crowding related problems are often the result of a combination of factors rather than a single factor. Depending upon the circumstance, both the likelihood of harm and its severity could vary from not significant to very substantial. Therefore, hazard identification for crowd safety cannot be done superficially. Crowd safety hazards do not necessarily associate with specific objects or substances and not all hazards are immediately obvious. Hence, a suitable and sufficient hazard identification method should encourage assessors to take a step back, consider the circumstances and the various factors involved and try to foresee what could go wrong. It should not restrict thought but it should prompt assessors to exercise their imagination and their experience and local knowledge about their operations, their venues, the crowds and their behaviour.
CHAPTER 4
A SURVEY OF PUBLIC VENUES

A public venue survey was conducted to find out how crowd safety is assessed in practice, what sort of constraints and difficulties face the assessors and what techniques or tools are used in the assessment. The literature review in Section 2.6 has already generated some information, but it was felt that more was required to provide a valid picture of current practice. Therefore, the survey aims to establish a better understanding of the assessors’ needs and how the crowd safety risk assessment methodology could meet such needs.

It is also worth noting that most of the materials covered in the literature review were documented prior to or just after the introduction of MHSWR (and its risk assessment requirements). Since then some public venues have attempted to apply risk assessments to the crowd safety context. The second aim of the survey is, therefore, to obtain more up to date information on current practice. A third aim is to identify good practice, which can be incorporated into the methodology.

The survey findings, together with the literature review in Chapter 2 and the case studies in Chapter 3, would help the author to develop a model of the tasks involved in a crowd safety risk assessment (Chapter 5), to address the research questions in Section 1.6 and, subsequently, to establish a set of criteria to set out what is a suitable and sufficient risk assessment for crowd safety and for the development of a crowd safety risk assessment methodology.

4.1 Designing the Survey

The aim of the survey was not to generate statistical data. Instead, it set out to collect information on current practice. As such, it took the form of direct conversations with people who are involved in the management and assessment of crowd safety. The vast majority of the participants were from public venues, others worked for the enforcing authorities. Interviews were carried out to discuss the following issues:
- Operational issues - the main safety problems or concerns that exist in the venues where the interviewees work.
- Current practice - what the interviewees do to assess crowd safety and any specific techniques or tools used.
- Practical constraints - what problems or constraints interviewees had experienced when assessing crowd safety and when using these techniques or tools.
- The application of risk assessment to crowd safety - interviewees’ views on what a suitable and sufficient crowd safety risk assessment should entail.
- Assessors’ needs – what support and guidance the interviewees would like to see to assist them in their assessments.

Past experience suggests that public safety can be a sensitive issue to many public venue managers. In order to encourage more people to take part and for them to be more forthcoming with information, it was decided that the interviews should take the form of informal discussions. This would also enable details and the rational behind the current practice to be discussed and explored in the interviews.

4.1.1 Questionnaire Design

Two versions of the questionnaire were developed to provide a structure to the interviews. The first version was intended for public venue managers or assessors. The second version was produced for interviews with enforcing authority personnel. The two questionnaires are essentially the same, although the wordings are different in some of the questions to reflect the nature of the jobs of the interviewees. They are shown in Appendices A and B respectively.

Each questionnaire is made up of two parts. Part A covers issues concerning current practice. The questions were designed to obtain information about how interviewees plan for and assess crowd safety in their venues and what they see are the benefits and pitfalls of the assessment methods they used. Part B of the questionnaire is only applicable to those who have carried out risk assessment, as defined in the MHSWR, or have used specific techniques to identify hazards or evaluate risks. The questions were
designed to generate in-depth discussions on the application of risk assessment in crowd safety.

Questions 1 and 2 ask interviewees to identify their main operational concerns and the reasons for the concerns. The questions are to serve four purposes. Firstly, they provide a useful introduction to the interview. Secondly, they help to identify the type of safety problems most relevant to different venue types and to establish how important they are in relation to each other. Thirdly, they give an insight into non-crowd safety concerns (e.g. public disorder, crime), which could have an impact on their practice. Fourthly, by establishing the reasons for the concerns, the author would have a better understanding on the thinking behind the setting of operational priorities.

The remaining questions in Part A aim to find out how crowd safety assessment and planning was done in various venues. Question 3 is an introductory question to turn interviewees’ attention from the previous discussions back to crowd safety. Question 4 aims to establish an overview of the planning and assessment process involved, whereas Question 6 looks at each assessment stage. As discussed in the literature review in Section 2.6, a key problem associated with crowd safety assessment is that valuable information on what went wrong previously is lost or overlooked. What information is available to the assessors may also influence what assessment methods are used. Question 5 sets out to investigate this and also to look at how information is used in the assessment process and if it is used effectively. Finally, Question 7 invites interviewees to pass their comments on the benefits and pitfalls of the assessment methods they used.

Question 8 in Part B invites interviewees to discuss any problems or constraints they encountered when trying to adopt the risk assessment principles to assess crowd safety. Under the MHSWR, employers are required to carry out a suitable and sufficient risk assessment. However, as previously stated, due to the differences in the nature of their operations, existing risk assessment guidance that is intended for ordinary workplaces could be unsuitable for crowd safety. Hence, Question 9 aims to gauge the viewpoint of the interviewees on what is a suitable and sufficient risk assessment for their specific venues and for crowd safety in general. Question 10 invites interviewees to suggest how a risk assessment methodology specifically for crowd safety may assist and support their
assessment needs. Finally, to round off the interview, Question 11 invites interviewees to pass on any further comments on crowd safety risk assessment.

The questions used in the interviews were designed to be general and open-ended for two reasons. Firstly, both the literature review in Chapter 2 and the case studies in Chapter 3 show that all public venues are different. As such, questions designed to cover a wide variety of operations, safety problems and assessment methods have to be non-specific. Secondly, the questions are intended as “prompters” to encourage detailed and unrestricted discussions during the interviews.

4.1.2 Selection of Public Venues for the Survey

Another issue that needed to be resolved is who should take part in the interviews. In order to gain a reasonably accurate picture of the situation, the interviews should cover a wide variety of public venues. For this purpose, the public venue categorisation scheme drawn up in an earlier study by Au et al (1993) was adopted. It was selected because under this scheme, venues are categorised according to the nature of their operation and the types of activities that normally take place - two of the key factors affecting crowd safety. Furthermore, no other categorisation schemes of this kind can be found in the literature review. The five categories of public venues are as follows:

- Transport venues.
- Sports venues.
- Shopping venues, exhibition venues and trade fairs.
- Fairground, festivals and leisure parks.
- Shows and entertainment venues and pop concerts.

Ideally, equal numbers of interviews should be conducted in each of the five venue categories. But in practice this was restricted by which venues were able and willing to take part.
Apart from the venue type, it was also necessary to take into consideration venue size when selecting venues for the survey. This is because although the same risk assessment principles should apply to venues of all sizes, the needs for support and assistance could vary depending upon the scale of the problems they face and the resources available. For example, the case studies in Chapter 3 show two types of crowd safety problems: general health and safety hazards and hazards associated with the presence of large crowds or high crowd density. But hazards associated with crowd density are much less likely to be a prime concern in smaller venues where only relatively small numbers of visitors are expected. A simple and straightforward risk assessment methodology is probably enough. For large venues where both types of hazards exist, however, different methods and techniques might be required. It is the latter type of venue which is of particular concern to this thesis.

A further issue that needed to be addressed was how many venues the survey should cover. Obviously, the more venues covered by the survey, the more “accurate” its findings will be. However, this has to be weighed up against the time and resources required to set up the interviews and the number of venues agreeing to take part. Arranging for an interview can be very time consuming, it often involves identifying the appropriate person(s), making many contacts to seek agreement and arranging a date and time for the interview and travelling to interviews. This is often exacerbated by the complex structure in some venue owner organisations and the amount of time the relevant persons have to spend away from their usual places of contact.

In the event, a total of 15 interviews were carried out. All interviewees were from major venues that handle large numbers of visitors. They included four transport venues, three sports venues and an enforcing authority (sports), two shopping/exhibition venues, three fairground/leisure parks and two shows/entertainment venues. The following lists the public venues and the enforcing authority who took part in the survey:

**Transport Venues**
1. Heathrow Airport.
2. King’s Cross Thames Link.
4. Tyne and Wear Metro System.

Sports Venues
5. Cheltenham Racecourse.
6. Football Licensing Authority.
8. Silverstone Circuits.

Shopping Venues, Exhibition Venues and Trade Fairs
9. MetroCentre.
10. National Exhibition Centre.

Fairground, Festival and Leisure Parks
11. Alton Towers.
12. Camelot Theme Parks.
13. Loughborough November Fair.

Shows and Entertainment Venues and Pop Concerts
15. Stall Moss Theatre.

4.2 The Survey Findings

4.2.1 Operational Concerns

Table 4.1 shows the main operational concerns identified in the interviews and the reasons for the concerns. They include evacuation, crowding problems, general health and safety, major incidents, public disorder, crime, traffic and customer care/enjoyment. Most are relevant to crowd safety, the rest concern other aspects of venue operations. Crowding related problems and evacuation appear to be the most common concerns, identified by eight and six of the venues interviewed respectively. These are followed
by general public safety and major incidents, which were mentioned five times and three times respectively.

**Table 4.1: Summary of Main Operational Concerns and their Reasons**

<table>
<thead>
<tr>
<th>Main Concerns</th>
<th>Reasons for the Concerns</th>
<th>Venue Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency evacuation</td>
<td>requirements imposed by fire certificate</td>
<td>transport</td>
</tr>
<tr>
<td>Emergency evacuation</td>
<td>so that the venue can be exempted from certain legal requirements and hence reduce operational costs</td>
<td>transport</td>
</tr>
<tr>
<td>Emergency evacuation</td>
<td>not specified, but could be because of past disaster (e.g. the King’s Cross fire)</td>
<td>transport</td>
</tr>
<tr>
<td>Emergency evacuation</td>
<td>occurred a few times in the past</td>
<td>transport</td>
</tr>
<tr>
<td>Emergency evacuation</td>
<td>do not know how people will react</td>
<td>sports</td>
</tr>
<tr>
<td>Emergency evacuation</td>
<td>venue was a known target for bomb attacks</td>
<td>shopping/exhibition</td>
</tr>
<tr>
<td>Crowding/congestion</td>
<td>venue is operating at its capacity</td>
<td>transport</td>
</tr>
<tr>
<td>Crowding</td>
<td>legal requirements, crowding causes delays and disruptions (i.e. operational problems)</td>
<td>transport</td>
</tr>
<tr>
<td>Crowding</td>
<td>a major venue nearby increases the demand on one station at times; another station is just too small to cope with occasional peaks</td>
<td>transport</td>
</tr>
<tr>
<td>Crowding/congestion</td>
<td>experience this problem in peak periods, problem exacerbated by delayed trains</td>
<td>transport</td>
</tr>
<tr>
<td>Space for visitors to view and move around</td>
<td>insufficient space for visitors to move around during their stay and problems at the departure stage</td>
<td>sports</td>
</tr>
<tr>
<td>Crowding/congestion</td>
<td>problems exist near some rides; emergency vehicle access blocked</td>
<td>fair/leisure park</td>
</tr>
<tr>
<td>Crowd control/provision of free flows and movement</td>
<td>customer care, received complaints regarding long queues (occasionally)</td>
<td>fair/leisure park</td>
</tr>
<tr>
<td>Crowding</td>
<td>types of visitor; nature of the event</td>
<td>shopping/exhibition</td>
</tr>
</tbody>
</table>
### Table 4.1: Summary of Main Operational Concerns and their Reasons

<table>
<thead>
<tr>
<th>Main Concerns</th>
<th>Reasons for the Concerns</th>
<th>Venue Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management of health and safety</td>
<td>The MHSWR</td>
<td>shopping/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>exhibition</td>
</tr>
<tr>
<td>Public safety in general</td>
<td>general desire to provide a safe environment</td>
<td>shopping/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>exhibition</td>
</tr>
<tr>
<td>Public safety</td>
<td>image of the venue; good for business</td>
<td>fair/leisure park</td>
</tr>
<tr>
<td>Public safety</td>
<td>types of visitor; things that some artists do that could encourage undesirable behaviour; do not know how people will behave</td>
<td>shows/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>entertainment</td>
</tr>
<tr>
<td>Welfare of the public</td>
<td>past and existing problems largely due to old buildings</td>
<td>shows/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>entertainment</td>
</tr>
<tr>
<td>Major incidents</td>
<td>do not know exactly what is going to happen</td>
<td>sports</td>
</tr>
<tr>
<td>Fire safety</td>
<td>previous experience</td>
<td>shopping/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>exhibition</td>
</tr>
<tr>
<td>Ability to deal with a problem</td>
<td>image of the venue; good for business</td>
<td>fair/leisure park</td>
</tr>
<tr>
<td>Traffic management/access for emergency vehicles</td>
<td>insufficient road access</td>
<td>sports</td>
</tr>
<tr>
<td>Crimes, esp. car crimes</td>
<td>previous incidents</td>
<td>sports</td>
</tr>
<tr>
<td>Public disorder</td>
<td>previous incidents, types of visitor, nature of the game</td>
<td>sports</td>
</tr>
<tr>
<td>Customer care and enjoyment</td>
<td>image of the venue; good for business</td>
<td>fair/leisure park</td>
</tr>
</tbody>
</table>

Those concerns that are crowd safety related include crowding, public safety, evacuation and major incidents. The first two types of crowd safety related problems are broadly in line with those highlighted in the case studies in Chapter 3; namely, hazards associated with the presence of large crowds and general health and safety hazards. Most of the interviewees gave crowd safety related problems as their main concerns. To what extent this was due to people trying to give the “correct answer” is unclear. Nevertheless, their willingness to take part in a research project on crowd safety despite their busy schedule suggests in some ways that the subject is of some importance to them.
Amongst those who identified crowd safety related issues as their main concerns, the reasons given for their concerns are past/existing problems, operational reasons, legal requirements, uncertainty on what could happen/how people would behave, the desire to provide a safe environment and maintain a good image of the venue. For the public venue owners, operational reasons and legal requirements are the two factors that have probably the most direct impact on their business. It is therefore perhaps not surprising that they are amongst the top answers given. What is of interest, however, is that “past/existing problems” is actually by far the most mentioned reason for concerns. This has served to confirm what has been said earlier in the thesis (e.g. the literature review in Section 2.6). Namely, that the current practice is reactive in nature and assessments are often influenced by experience and previous problems. This also suggests that crowd safety problems may be more serious than people may have believed when, overall, past and existing problems are seen as more important reasons for concern over crowd safety than operational and legal reasons.

Uncertainty on what could happen, how people would behave, etc. was mentioned three times by two interviewees as a reason for their concerns. Such concerns are often associated with circumstances that are relatively rare, e.g. a major incident. Some venue managers realised that however rare they may be, these circumstances could arise and are therefore feeling anxious about not knowing what to expect and not being able to predict what problems there could be. For example, evacuation was a main concern to one of the interviewees, simply because of his uncertainty about how people may behave in these situations. Unable to predict what could happen in rare events was also identified as one of the main problems many assessors have experienced when estimating risk. This will be discussed in more detail later in Sections 4.2.4 and 4.2.5.

A general desire to provide a safe environment and to maintain a good image was given four times by three interviewees as their reasons for their concerns on crowd safety related problems. This suggests that some venues have adopted a more positive attitude towards crowd safety and do not see it merely as a legal requirement that needs to be fulfilled or a problem that has to be dealt with. For example, one interviewee sees crowd safety as an important part of customer care. This, in turn, helps to promote the
image of the venue and its business. Similarly, in another venue, crowding is seen as an important issue not because of any previous safety problems per se but because of the perceived business needs to provide a pleasant environment where visitors can move around freely.

A more in-depth examination into the reasons given for crowd safety related concerns has also given an insight into the types of hazards that cause the concerns. They include:

- Mismatch between venue capacity and crowd numbers.
- Visitor behaviour.
- Inadequate venue design.
- Problems associated with movements of large crowds, including pinch points and obstructions.

4.2.2 Current Practice

The current practice on crowd safety assessments amongst the public venues surveyed can be categorised into the following two categories: the experience-based approaches and the risk assessment approaches. The former refers to those already described in the literature review in Section 2.6.2. They are often non-systematic and rely heavily on experience, past incidents and previous problems. These are the traditional methods of assessment. The latter refers to approaches that are in line with the risk assessment principles set out by the HSC (1992) and the HSE (1994). Amongst the fourteen venues interviewed (i.e. excluding the enforcing authority), the numbers of venues using the former and latter approaches are six and eight respectively - although the sampling methods adopted in selecting these sites means that no generalisation to the wider population is possible. Also, at the time of the interview, one of those using the former was in the process of adopting risk assessment.

Although the number of venues that have already adopted a risk assessment approach is greater than those who were still using the experience-based approach, a significant proportion of them (i.e. three) could only manage a partial assessment. For example, in
one venue, assessment was made on the building alone. Such an assessment will only cover physical hazards posed by the building itself and the items within it. Other hazards such as those associated with large crowds and crowd behaviour will be missed. Therefore, it cannot be regarded as an adequate assessment. In another venue, it was reported that the crowd safety part of their assessment could not proceed beyond the hazard identification stage.

Given the relatively small sample size of the survey, it is impossible to say categorically why some venues use risk assessment but not others. However, a number of interesting factors have emerged from discussions with the interviewees. Firstly, it is believed that legal requirements which have the necessary mechanism in place to ensure compliance is a major factor for making some public venues adopt the risk assessment approach. An example of this is train stations where the Railways (Safety Case) Regulations 1994 apply. Under the regulations, a station owner has to prepare and secure the acceptance of a safety case, of which risk assessment is a vital part, before starting to operate. Therefore, the needs for the owner to conduct a risk assessment on all key aspects of his operations (including crowd safety) become imminent. As a result, all three of the rail transport venues interviewed have made a risk assessment or were in the process of doing so.

Secondly, there seems to be a link between availability of health and safety expertise to the venue owner organisations and the approach used. Those who have used risk assessment or were in the process of doing so all have available to them one or more of the following: in-house safety officers, advice and guidance from the parent organisations and external health and safety consultants. In most of the remaining public venues, the responsibility of assessing crowd safety falls to people who have other demanding duties to perform (e.g. venue manager, event promoter) and have none of the support mentioned above.

Thirdly, it appears that a lack of understanding or a misunderstanding of risk assessment and how it works might have something to do with the use of the traditional experience-based approach. This and the second factor above are, to some extent, related. Whilst in general, professional health and safety practitioners and experts tend to have a good
grip on risk assessment, others seem to have difficulties in understanding it. It is those who did not have the relevant knowledge and expertise on risk assessment who tend to use the experience-based approach. This impression was reinforced by comments made by one of the interviewees. At the time of the interview, he was responsible for all safety and risk matters in an organisation that owns a variety of public venues. He pointed out that when risk assessment was first introduced in the organisation shortly after the MHSWR came into force, the greatest difficulty he experienced was to help venue managers understand what risk assessment is and correct any misconceptions. There was also a reluctance to change to risk assessment. He believed that this was mainly due to a lack of understanding. Furthermore, to overcome this difficulty had been a very time consuming process.

4.2.3 Experience-based Approach

The characteristics of such approaches and their pitfalls have already been discussed in Section 2.6 and therefore will not be repeated here. What is worth noting is that because of their heavy reliance on past problems and incidents, a lot of emphasis has been placed on gathering information from different sources. The ways in which this is achieved are laudable and could form a useful part of the risk assessment process. The following paragraphs outline some of the information gathering methods used by these venues.

Debriefing is the most popular way to gather information on previous incidents and to identify problems. Information and experience can be exchanged through meetings with people throughout the venue owner organisation and with other agencies. In particular, brainstorming was identified by two interviewees as an effective way of bringing together different experience and viewpoints. Also, routine monitoring and inspections, feedback from external agencies, feedback from the front line staff and comments and complaints from the visitors can provide valuable material for hazard identification.

Another way of improving the information gathering process is by setting up a reporting system so that problems identified are recorded and are made to the relevant persons. A reporting system can take many forms. For example, log books, comment cards, checklists, etc. were used by front line staff in some venues to record any problems. In
another venue, duty managers who are in charge of particular operations are required to produce post event reports. They, together with the comments and complaints from the visitors, are then analysed regularly. It was also suggested that the information gathered can be used to build up a bank of experience and a history of past problems which could be of great value to future assessment. Some problems and comments are immediately dealt with, others are considered later in future planning. This way, the operation is constantly assessed so that any problems and significant changes in circumstances can be quickly spotted and improvement can be made where necessary.

The experience-based approaches tend not to have a formal risk evaluation method per se. Establishing how serious a problem is and what further measures are required are often ad hoc decisions made based on personal judgement. At times, the following factors are taken into consideration: the nature of the problems, the dangers they pose, whether they can be dealt with quickly or require a longer term solution, whether any realistic measures can be found, safety vs. the needs for the venue to remain attractive to visitors, costs and new problems caused by the implementation of remedial measures for the original problems.

4.2.4 Risk Assessment Approaches

Table 4.2 outlines the important features of the approaches adopted by the eight public venues where risk assessment has been used to assess crowd safety. All of them are in line with the principles in the MHSWR ACoP (HSC, 1992). The assessment can therefore all be described in terms of the same basic assessment stages. However, the methods used for each stage of the risk assessment vary from venue to venue. The differences are particularly obvious in hazard identification and risk evaluation stages of the assessment. The rest of this section therefore focuses on the methods used at these two stages.
### Table 4.2: Summary of Risk Assessment Methods used by Various Venues

<table>
<thead>
<tr>
<th>Venues</th>
<th>Hazard Identification</th>
<th>Risk Evaluation</th>
<th>Other Information</th>
</tr>
</thead>
</table>
| Transport | • In terms of area (e.g. forecourt), feature (e.g. stairs, escalators, etc.) and specific issues (e.g. disabled persons) | • Mainly subjective, but also use accident data  
• Risk: H/M/L  
• Priority: 1/2/3 | • A general public safety assessment which applies to all buildings to ensure a common set of standards throughout.  
• The following are recorded in tabular format: location/hazards; existing control measures; risks; action required and priority; person responsible.  
• Actions required are categorised into immediate, long term or further research. |
| Transport | • Go through various parts of the venue; also consider what could happen outside | • Hazard Grade A to D | • Assessment covers all aspects of the system, including crowd safety.  
• The importance of hazards and the actions required are decided based on: hazard priority; value for money; seriousness of problem; whether it is a high profile problem.  
• Solutions that involve policy changes are dealt with at corporate level. Venue feature changes are dealt with locally. If re-development is needed, the exact action required will be decided by the relevant dept. (e.g. Engineering). |
| Transport | • HAZOP technique | • Unable to estimate risks | • Assessment covers all aspects, incl. crowd safety.  
• Use established techniques e.g. HAZOP and Fault Tree Analysis.  
• Assessment consists of two parts: the 1st part is to decide which hazards require further analysis; the 2nd part is detailed assessment of certain hazards. |
<table>
<thead>
<tr>
<th>Venues</th>
<th>Hazard Identification</th>
<th>Risk Evaluation</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shopping/Exhibition</td>
<td>• Through inspections and health and safety meetings.</td>
<td>• Subjectively</td>
<td>• A health and safety assessment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• By trained staff and H&amp;S advisors in a H&amp;S meeting</td>
<td>• Conducted by an external consultancy firm, no info. on the detailed approach.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• By trained staff and H&amp;S advisors in a H&amp;S meeting</td>
<td>• Assessment includes: description of activities; description of risks; measure rating and actions required.</td>
</tr>
<tr>
<td>Fairground/Leisure Park</td>
<td>• First, identify types of problem.</td>
<td>• Risk rating: 1 to 5 (i.e. very unlikely to very likely)</td>
<td>• The following are recorded using a tabular format: hazard; activity (e.g. arrival at park, entrance area, etc.); risk and actions.</td>
</tr>
<tr>
<td></td>
<td>• If necessary, break them down into finer elements; e.g. fire hazard will be broken down into fire at shop, at catering area, etc. Then assess each element</td>
<td>• Risk only reflects likelihood of hazard</td>
<td>• Benchmark against other major venues, e.g. NEC, the police, major airports and Disney World in Florida, for setting performance targets and helping to identify the actions required.</td>
</tr>
<tr>
<td>Fairground/Leisure Park</td>
<td>• Consider all aspects of operation; e.g. the equipment &amp; machinery; the rides, employees’ tasks; the general public; storage; etc.</td>
<td>• Risk: H/M/L</td>
<td>• The following are recorded using a tabular format: items of interest/concern; whether the items on the checklist are applicable or not and/or risks; actions.</td>
</tr>
<tr>
<td></td>
<td>• A checklist type assessment form is used for each of those.</td>
<td></td>
<td>• The actions required are decided based on training, experience, local knowledge and “feel”</td>
</tr>
<tr>
<td>Show</td>
<td>• Mainly focus on the buildings because they are old and thus cause a lot of problems</td>
<td>• Effect of hazard: 1 to 3 (i.e. low to high)</td>
<td>• General risk assessment (mainly on staff H&amp;S).</td>
</tr>
<tr>
<td></td>
<td>• Also look at specific hazard types such as the use of stage effects, back stage H&amp;S</td>
<td>• Estimate risk: 1 to 3</td>
<td>• Assessment includes description of hazards, estimate effect of hazard, estimate risk and method of control.</td>
</tr>
</tbody>
</table>
Table 4.2: Summary of Risk Assessment Methods used by Various Venues

<table>
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<tr>
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</thead>
</table>
| Show   | • Through checking building, post-show report, comments and complaints from staff and customers | • Rating scales for likelihood & severity  
• Risk = likelihood rating x severity rating | • A tabular form is used which has the following columns: area/item; causes; results (consequences); severity; likelihood; risk rating; existing measures; recommendations for future improvement; changes to procedures; training needs and general.  
• If an incident occurs after existing measures are in place, then it is insufficient. Otherwise, assume it is sufficient.  
• Additional measures are decided mainly through brainstorming; but will call in external experts to help if necessary. |

Hazard identification methods

Several hazard identification methods and techniques were mentioned in the interviews. The most popular method involves going through each part of the venue in turn to look at what hazards could arise. This is in accordance with the guidance given by the HSE (1994) and others (e.g. British Safety Council, 1993), which is intended for workplaces in general rather than the public venue environments. Only a few venues have adopted different methods or used additional tools. In one case, hazards are identified in terms of different areas of operation (e.g. traffic management, admission of visitors). Another venue reported the use of a HAZOP type technique whilst a third venue used a set of checklists to assist their hazard identification.

Different venues also take different factors into consideration when identifying hazards. As already pointed out on several occasions throughout the thesis, hazards could arise from a variety of factors such as venue design and crowd behaviour. The survey shows that emphasis was given to different factors by different venues. What factors are accounted for in the assessment are perhaps restricted somewhat by the hazard identification methods used in the first place. Given that the most popular method
involves examining the venue, it is perhaps not surprising that the factor that receives most attention is building and its physical features (e.g. stairs, escalators). Six of the eight venues who used risk assessment are known to have taken this particular factor into consideration. The second most considered factor is hazardous objects; such as hazardous substances or items and machinery (e.g. rides in a fairground). The presence of people with special needs (e.g. the disabled) is another factor taken into consideration. What is of concern, however, is that although what the visitors do and their behaviour are usually amongst the main contributory factors to hazards, there is only one venue whose hazard identification involves some form of description of visitors’ activities.

The differences in hazard identification methods and the different factors being accounted for, to some extent, reflect the differences in the nature of operation between venues (and hence the types of hazards they have encountered). It follows that a crowd safety risk assessment methodology should be sufficiently flexible to cater for such differences. These differences also highlight a fundamental problem currently facing the assessors. Namely, a lack of risk assessment guidance suitable for crowd safety. As a result, assessors have to improvise using guidance intended for workplaces in general. Whilst their methods may be sufficient for identifying physical hazards associated with the venue building and objects, the survey shows that they are clearly insufficient to account for hazards associated with the presence of large visiting crowds and their behaviour.

The survey also shows that hazards associated with the presence of large crowds (i.e. the “human factors”) are not sufficiently straightforward to be identified even by experienced venue managers - a point already raised in the case studies. The combination of unsuitable methods and the complexity in the identification of crowd related hazards often leads to serious omissions. Many interviewees have recognised the inadequacy of their methods but are unable to find a better alternative.

To overcome this problem, the risk assessment methodology ought to be better structured, more specific to crowd safety and cover both physical hazards and hazards associated with the presence of large crowds. Also, because of the relatively complex nature of crowd safety problems, additional guidance or tools, such as the HAZOP type
keywords used by one of the venues, could be useful in helping to reduce serious omissions in hazard identification. A HAZOP type tool, for example, may also help to encourage lateral thinking. In turn, this may encourage venue managers to question their existing core beliefs, become more open minded, reduce mind-set and improve management foresight and, particularly, their ability to identify potential safety problems that may not have occurred before in their venues.

Risk evaluation methods

With the exception of one venue, where it was reported that the assessors were unable to carry out assessment beyond the hazard identification stage, all other venues estimate risks qualitatively by means of rating. But different rating regimes have been used by different venues. The most commonly adopted and the simplest regime is one where the risk of a hazard falls into one of three levels, usually high, medium or low. Again, this is in line with the advice given in HSE guidance booklet: 5 Steps to Risk Assessment. As for other venues, risks were graded from A to D in one case and from one to five in another. In the latter, risk was expressed in terms of the likelihood of a hazard (i.e. from very unlikely (1) to very likely (5)). Its severity was not reflected in this regime. In fact, amongst the various rating methods used, only one where both likelihood and severity are assessed explicitly. Under this regime, the assessors have to rate each hazard for its likelihood and its severity separately. The overall risk is then determined by multiplying the two ratings.

The findings here have given rise to two points of interest. Firstly, some of the venues interviewed appear to be of the view that the basic “high/medium/low” rating regime is probably too crude for their purposes and has opted for something more sophisticated. What is of interest is that a similar situation can also be found in the general health and safety scene where alternative risk rating schemes have been proposed. Details on some of the alternative schemes are discussed in the review of the existing risk evaluation methods and techniques later in Section 6.4. This appears to suggest that whilst the basic HSE regime may be sufficient for some workplaces, others feel the need for more consideration and finer categorisation to reflect the wider variations of the risks in their
workplaces. This often resulted in risk rating schemes that are more sophisticated and more complex to use.

Secondly, it is arguable whether any of the regimes mentioned are appropriate to the assessment of crowd safety. Apart from one venue, none of the methods used require the assessors to explicitly consider both the likelihood and the severity of a hazard. The case studies in Chapter 3 show that the risk posed by similar hazards could vary in different venues and under different circumstances. The variations could be significant. For example, a change in the circumstance could affect how likely something is to occur or how severe the consequence would be or both. Furthermore, as reported above, there were some misconceptions amongst the interviewees on what is meant by risk. Some interviewees tend to equate risk with chance and disregard what consequences the hazard could have when estimating risks. Experience suggests that this is also true amongst the wider venue assessor population. A methodology that requires the assessors to explicitly judge the likelihood and the severity could help to reduce this problem.

Methods on deciding risk reduction measures

The methods used to decide what further remedial actions are required and to prioritise them also vary between venues, but to a lesser extent. The decisions on what remedial actions to take are made subjectively based on experience. Priority is set according to the perceived seriousness of the problems (i.e. their risk levels). Some venues also take into account other factors such as costs, value for money, best practice, relevant standards or guidance, whether it is a “high profile problem” and what effect these actions may have on other parts of the venues and other operational needs. The pros and cons of some of these factors are already discussed in the literature review on alternative approaches in Section 2.3.3 (e.g. cost-effectiveness, target setting). One venue reported that it benchmarks itself against other major venues and organisations. Benchmarking can be used to measure how well one does and for setting criteria and performance targets. For example, by using the response time of the emergency services as a benchmark, a venue can decide how fast it needs to be to respond to an incident. This would also help the assessors to determine whether existing arrangements are sufficient.
However, it cannot be used as a basis for comparing which hazards are more important and prioritising what remedial measures to take first.

In some venues, the identification of remedial actions were done by the assessor on his own. In other venues, this was done collectively through meetings or brainstorming. In the case of one organisation, which owns a number of venues, it was reported that local changes were decided at the venue level but any significant changes in the procedures and venue design were considered at the corporate level.

*Alternative approaches for multi-venue owners*

It is worth noting here that some venue owners have adopted what can be referred to as a “two-tier” risk assessment approach. They are usually owners of venues where one-off events are held either as a normal part of or in addition to their operations. The first tier is a general/high level risk assessment. It focuses on problems that are common to most circumstances (e.g. poor venue design, crowd flows and aspects of emergency management/egress). The second tier assessment looks at problems that are specific to individual events. For example, problems associated with visitors’ behaviour tend to vary between visitor types and therefore have to be considered in the context of each event. The main benefit of this approach is that instead of carrying out a full-scale risk assessment every time an event is to be held, the assessors only have to focus on things that are not covered in the general assessment or where its findings are not applicable to the particular event being assessed.

Multi-venue owners (i.e. those who own a number of similar venues) could also benefit from using a similar approach. A general assessment, which addresses the problems that are common to most venues, can be done at the corporate level. Venue managers can then modify the general assessment and focus on problems that are specific to their own venues. This would reduce the workload on venue managers and place less reliance on their ability to carry out sufficient risk assessment whilst retaining their local knowledge and experience. It also helps to ensure that common standards are applied throughout the owner organisation.
4.2.5 Problems and Constraints Facing Risk Assessors

Setting aside the time needed for the assessment is a common problem for many interviewees. This is especially so for those who have to carry out the assessment in addition to their main or normal duties. Out of the eight venues where risk assessment has been carried out, five have identified this as one of the major problems facing them. However, many of them also recognised the benefits of a thorough risk assessment and believed that it is a worthwhile exercise. This problem calls for a methodology that is, on the one hand, sufficient in addressing all significant crowd safety risks that could exist in a venue but, on the other hand, kept simple to use. Furthermore, because every venue is different, it is important that the methodology should also be sufficiently flexible to allow assessors to take into account in the assessment their experience and information which they gain from the day-to-day running of the venue.

Apart from keeping the methodology simple, the survey has identified two other possible ways of reducing this problem. Unfortunately, both methods are only suitable to some venues. The first one is to make the assessment during a quieter period. Such a practice has already been adopted in two of the venues interviewed. The second method is to develop a general risk assessment that reflects the core hazards and risks. Each assessor can then apply it at his own venue/sector. An example of this is the two-tier approach described in Section 4.2.4. Another example is the use of a hazard checklist and a standard risk assessment form. At least two venues have carried out their assessment this way. This approach is largely in line with the suggestion in paragraph 20 of the MHSWR ACoP. Obviously, it is suitable only to owners of a number of similar venues or if similar things could go wrong in different parts of the venue.

As far as risk assessment methodology is concerned, the problems encountered by the interviewees mainly concern hazard identification and risk estimation. No significant problems on other parts of the assessment were reported. However, it was suggested by one interviewee that the methodology should also address the issue of acceptability of risk, i.e. whether a particular risk can be contented with or if something has to be done about it.
Hazard identification is regarded by many as the most important part of the risk assessment because any hazards that are not identified will not be assessed, thus leaving a gap in the assessment. Yet, five of the eight venues surveyed have encountered difficulties. Some of them considered this to be the most difficult task to do. As previously discussed, the main problem is omission. It could be due to the inadequacy of the hazard identification methods currently in use to account for the types of hazards that are common in public venues but are rare in ordinary workplaces.

Another reason for the omission is that many assessors find it difficult to assess behaviour. Three of the five interviewees who have experienced difficulties in hazard identification explicitly pointed to this factor. In the words of one interviewee, visitors’ behaviour is not as “assessable” as the other factors such as the physical hazards. Apart from inquiry reports on major accidents and disasters, there is little information in the literature on visitor behaviour, what causes it and what hazards could arise as a result. In an attempt to look at how behaviour may be affected, Au et al. (1993) have developed a crowd behaviour model. Figure 4.1 shows the model. In this model, behaviour is considered to be a continuous process that is made up of the following four key elements:

- To sense - i.e. to obtain information from the surrounding environments.

- To interpret - i.e. to consider the meaning of the information received.

- To plan - i.e. to decide upon the actions required in response to the interpreted situation.

- To act - i.e. to execute the plan or decision.

In addition, the behaviour of individuals combines and interacts with each other to give a collective or group response to a situation.
Hence, factors affecting crowd behaviour are categories in terms of:

- Factors affecting the physical ability of people obtaining and receiving information (e.g. see, hear, etc.) from the surroundings. This would normally depend on what and how much information is available, its clarity and environmental factors such as lighting level, glare, noise, echoes, etc.
• Factors affecting how the information is interpreted. Interpretation of information is a cognitive process that could be affected by the content of the information (e.g. is it sufficient, general or specific, open to misinterpretation?), where the information comes from (e.g. how serious people are likely to take it and are they going to trust it, comply with it, ignore it or take it to mean something else?) and the people themselves (e.g. experience on similar events/situations and expectation of what is to happen).

• Factors affecting decision-making. This is also a cognitive process whereby people decide what to do next or the responses required to the information. This could be affected by a wide range of factors such as what people’s knowledge and experience tell them, their goals and objectives (i.e. what they come here for, what they want to do, what immediate needs and desires they may have and whether, and to what extent, what people are required to do complement or contradict their goals and objectives), what the alternatives and choices are (e.g. other things to do instead of queuing for a busy ride, alternative routes to take, etc.), what people think are the consequences of doing or not doing certain things and the mental and emotional state of the people (e.g. aggressiveness, fright, emotional fever, etc.).

• Factors affecting their physical ability to execute whatever they decided to do. This would often depend on the physical ability of the people themselves (e.g. influence of alcohol, injury, etc.), the venue design (e.g. layout, space and capacity, etc.) and any temporary features and characteristics (e.g. maintenance and construction, temporary barriers and fencing, weather conditions, emergency situations, etc.).

• Factors influencing the transition from individual behaviour to collective behaviour. They may include any common objectives and expectations the crowd as a whole have, the convention and acceptable norms, the atmosphere, group bravado, “follow the leader”, etc.

Whilst the model provides some ideas as to how crowd behaviour could be affected in general, more work is still needed to establish how best this could be applied to predict behaviour in specific venues under specific circumstances. At present, a crowd safety
risk assessment is restricted somewhat by our inability to accurately predict behaviour. However, it is worth noting that it is not the aim of this research project to investigate crowd behaviour as such but rather to develop a methodology that helps the assessors to capitalise the existing knowledge and experience they have on visitor behaviour in their risk assessments.

It is believed that a risk assessment methodology for crowd safety could help to reduce omission in two ways. Firstly, it provides a systematic framework to ensure that considerations are given to all significant parts of the venue and aspects of its operation and, secondly, it provides suitable tools, such as checklists or keywords, to prompt or to encourage assessors to think of the possible hazards. Such a tool would enable a more comprehensive and better-organised examination of the various factors affecting safety. It would also help assessors to identify hazards that have not happened before and could therefore be particularly useful to assessors of new venues.

Risk estimation also gives rise to some concerns to three of the interviewees. For some hazards, this can be done based on experience, accident data and other data and figures (e.g. those gathered for statistical or marketing purposes). However, the problem arises when they have to deal with hazards that have low likelihood but high severity (e.g. a major incident). By their nature, these hazards are out of the "ordinary" and may have never happened before. This leaves the assessors with nothing to work on. To tackle this problem, one venue looked at relevant incidents elsewhere and tailored them to its specific circumstances. Another venue reported that assumptions would have to be made where information or data was unavailable.

4.3 Conclusions and Discussions

The survey has highlighted a number of problems associated with the current practice in crowd safety assessment. It has also identified the constraints and difficulties facing the assessors and, consequently, the help and assistance they require to conduct a suitable and sufficient risk assessment for crowd safety. Several good practices have also been revealed in the course of the survey, this information could be useful for later on in the
development of the risk assessment methodology for crowd safety. The following summarises and discusses the key findings of the survey.

A total of fourteen venues and one enforcing authority took part in the survey. Together, they cover a wide range of venue types. Although the sample size may be too small for it to be wholly representative, it has given an insight into the needs of the assessors and has generated valuable information for the research. The survey also represents what is probably the best that can be achieved in data gathering given the research constraints highlighted in Section 1.8. The focus of the survey, as with other aspects of this thesis, is on major venues that generate large numbers of crowds.

Crowd safety and related problems are the most important operational concerns amongst the participating public venues. Crowding, in particular, is the most mentioned concern. Past and existing problems are the main prompter for the concerns. This finding serves to confirm once again the important role previous experience has played in assessment and planning in public venues. Further examinations suggest that the types of hazards that give rise to the concerns include the mismatch between venue capacity and crowd size; visitor behaviour; inadequate venue design; and problems concerning movements of crowds and the pinch points and obstructions created by them. These findings, together with those of the case studies, highlight the types and nature of crowd safety hazards that could arise in public venues. What is also of interest about this particular finding is that the vast majority of the hazards that give rise to interviewees’ concerns over crowd safety are those associated with the presence of large crowds rather than physical hazards (also see Section 3.3.2). Yet, as shown in the later part of the survey, it is hazards due to the presence of large crowds that assessors find most difficult to assess.

Amongst the fourteen public venues surveyed, six of them were using an experience-based approach along the line of those described in the literature review in Section 2.6.2. The other eight venues have assessed crowd safety in a manner that is largely in line with the risk assessment principles set out in the MHSWR ACoP (HSC, 1992). The availability of health and safety expertise to the venue owners appears to be a factor. What is worth bearing in mind is that not all public venues (including the major venues) have access to qualified health and safety practitioners. In many cases, assessments are
carried out by operational personnel (e.g. venue managers) whose background, expertise and, thus, the main duties are not in safety. This could have a significant bearing on assessors’ needs from the crowd safety risk assessment methodology viewpoint.

Discussions with the interviewees have also revealed that there appears to be a lack of or incorrect understanding amongst many on what risk assessment is. The experience of one of the interviewees serves to confirm this view. Responsible for all safety and risks matters in an organisation that owns a variety of public venues, this interviewee reported that the greatest difficulty was to make his venue managers understand risk assessment and to deal with misconceptions.

The experience based approach that relies on individuals’ local knowledge, experience and information on past problems has been the traditional method for assessing crowd safety. No evidence has been found from the literature review or the survey to suggest that such assessments were anything other than ad hoc in nature. Through talking to the interviewees, however, it becomes more apparent that these are important not only to the experience based approach but also to risk based assessment as well, especially given that there are no data or universally applicable guidance on how large crowds and visitor behaviour may contribute to crowd safety risks. This reinforces one of the conclusions drawn from the case studies (i.e. Section 3.3); namely, what is required is an assessment method that enables the assessors to capitalise on their knowledge and experience about their specific venues in a systematic and comprehensive manner.

Amongst the eight public venues that carried out risk assessment on crowd safety, the vast majority of them use methods that are in line with those recommended for workplaces. The case studies in Chapter 3 have already highlighted the differences in risks between public venues and workplaces. Many have reported problems concerning hazard identification and risk evaluation. For hazard identification, the main problem is that, by and large, the emphasis of the assessment has been on physical hazards (i.e. those associated with the building, hazardous materials/substances/items, etc.). Interviewees generally find it difficult to account for the hazards associated with the presence of crowds. The behaviour of the visitors is a particularly difficult area to address, 60% of those who said that they had experienced difficulties in hazard
identification explicitly pointed to behaviour. Only one of the eight venues that carried out risk assessment explicitly considered visitor activities during hazard identification. This is perhaps a further indication that the existing risk assessment methods are not suitable for crowd safety. Many interviewees reported that although they recognised the inadequacy of their methods, they were unable to find a better solution. Their main concern is with omissions. Any hazards that are not identified will not be assessed, thus leaving a gap in the assessment resulting in necessary remedial actions not being taken. Another danger is that omissions in risk assessment may give a false sense of security to venue managers and the front line staff. They could become ill-prepared for the hazards associated with behaviour and hence could be wrong-footed should visitor behaviour become problematic.

In terms of risk evaluation, what is of interest is that all except one venue evaluate risk qualitatively by means of rating. The remaining venues reported that they were unable to assess crowd safety risks beyond hazard identification. Not even the railway operators, who use QRA for other aspects of their operations, assess their stations quantitatively. Beyond that, however, there is little agreement between venues on which rating regime is most appropriate. One method is to categorise risks into three rating levels (e.g. high, medium or low risk). Once again, this is in line with the guidance given for workplace risk assessment. Other venues have expanded their rating scale to four or five points to reflect the complexity of the problems. The main concern about these methods is that they do not require assessors to consider likelihood and severity explicitly. Given the problem reported earlier on people’s misconceptions over what risk and risk assessment are, a single rating scale for the overall risk could be a recipe for human errors. In fact, the survey has found that, at least in one venue, risks were definitely expressed in terms of likelihood only, thus failing to comply with the risk assessment principles given in the literature in Section 2.2. Another concern associated with a single rating scale for risk is demonstrated in the survey where interviewees reported that they had problems dealing with hazards that have low likelihood and high severity. As discussed in the literature review in Section 2.7, this should not be a problem if risk evaluation requires the assessors to devise risk through estimating likelihood and severity separately. This way, the final risk, devised from both estimates, should be able to cater for a whole range of likelihood and severity levels. This problem
also serves to reinforce the argument, also in Section 2.7, that crowd safety risk assessment needs to be more vigorous than what the existing guidance has provided, which is intended for the ordinary workplaces. Whilst a single risk rating scale may be appropriate for many workplaces, a more sophisticated method is required to cater for the more “extreme” cases that may occur in public venues. However, amongst the eight public venues that have undertaken risk assessments for crowd safety, only one of them have used a risk evaluation method that explicitly requires the estimate of both likelihood and severity.

Table 4.3 summarises the problems and constraints experienced by the interviewees and highlights some of good practices revealed in the course of the survey. It also identifies what the assessors need in order to overcome the problems and constraints in different parts of risk assessment.

<table>
<thead>
<tr>
<th>Assessment Stages</th>
<th>Problems and Constraints</th>
<th>Good Practice</th>
<th>Assessor Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>To set aside the time for the assessment. This is especially so for those who have to carry out the assessments in addition to their normal duties e.g. to manage the venues.</td>
<td>A “two-tier” approach to risk assessment or carry out assessment during quieter periods</td>
<td>• A simple assessment method that is not too time consuming to do.</td>
</tr>
<tr>
<td>Heavy reliance on past problems</td>
<td>Brainstorming</td>
<td></td>
<td>• A pro-active method that encourages users to exercise imagination &amp; prompt thoughts on what could go wrong.</td>
</tr>
<tr>
<td>Failure to understand or misconceptions over the concepts of risk and risk assessment.</td>
<td></td>
<td>• Training/explanations of the concept of risk and risk assessment principles.</td>
<td>• A step-by-step guide to risk assessment.</td>
</tr>
<tr>
<td>Assessment Stages</td>
<td>Problems and Constraints</td>
<td>Good Practice</td>
<td>Assessor Needs</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Stages</td>
<td>A lack of guidance/data on how large crowds &amp; behaviour could affect safety</td>
<td>Information gathering methods e.g. debriefing brainstorming, venue inspections, monitoring, comments/complaints, front line staff inputs, exchange information with meeting relevant bodies and agencies, incident reporting, etc.</td>
<td>• A method that enables users to better utilitise their local knowledge and experience.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazard Identification</td>
<td>Omissions; esp. hazards associated with large crowds and behaviour; emphasis on physical hazards only</td>
<td></td>
<td>• A method appropriate to the types of hazards encountered in public venues.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Some forms of crowd dynamic &amp; behavioural hazard “prompters”.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Different venues face different hazards</td>
<td></td>
<td></td>
<td>• A flexible method that cater for different types of venues.</td>
</tr>
<tr>
<td>Risk Evaluation</td>
<td>Some tend to equate risk with chance</td>
<td></td>
<td>• Training/information on the concept of risk.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• To consider likelihood &amp; severity explicitly.</td>
</tr>
<tr>
<td></td>
<td>Problems dealing with low likelihood but high consequence hazards</td>
<td></td>
<td>• Estimate likelihood &amp; severity separately to devise the overall level of risk.</td>
</tr>
<tr>
<td></td>
<td>Ad hoc judgements on significance of problems &amp; what needs to be done</td>
<td>Some consider factors such as costs, value for money, what effect the actions may have on other parts of the venue, etc. Benchmarking</td>
<td>• Guidance/principles for risk prioritisation, e.g. ALARP.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• To consider tackling the causes of hazards or their consequences.</td>
</tr>
</tbody>
</table>
CHAPTER 5
AN ANALYSIS OF THE CROWD SAFETY RISK ASSESSMENT TASKS

The interview survey reported in Chapter 4 was aimed at establishing the types of approach and the techniques used by venue management in assessing risk concerning crowd safety. The present chapter is concerned with utilising the information generated so far to set out the strategies and activities involved in crowd safety risk assessment using a task analysis approach. The aims of the analysis are firstly, to highlight the needs of the assessors in terms of successfully completing a suitable and sufficient hazard identification, risk evaluation and risk assessment in general. Secondly it is to identify what assistance and support a crowd safety risk assessment methodology should aim to provide. The task analysis is a proposal for the risk assessment tasks that should be carried out, based on the risk assessment principles in Sections 2.1 and 2.2, rather than an analysis of what assessors do currently. This chapter describes the analysis and its rational. The analysis was carried out in two parts. The Hierarchical Task Analysis (HTA) technique was used firstly to systematically describe the overall risk assessment task in terms of its goals and sub-goals. This was followed by a Tabular Task Analysis where lower level sub-tasks were analysed to establish what is required in order to successfully accomplish them. The two parts of the analysis are presented in Sections 5.1. and 5.2 respectively. Based on the analysis and the findings in previous chapters, a set of criteria for the development of the methodology was then drawn up. They are presented in Section 5.3.

5.1 Hierarchical Task Analysis (HTA)

HTA was used to break down the assessment task into more manageable sub-tasks. This particular technique was chosen because it enables the examination of the task in terms of its goals and sub-goals, thus allowing analysis to be conducted on what the assessors should aim to achieve without pre-empting the specific task activities involved.

Figure 5.1 presents the top three levels of the HTA of the risk assessment task. The full HTA is given in text format in Appendix C-1.
At the top of the HTA, the overall goal of conducting a crowd safety risk assessment was broken down into several sub-goals:

- Identify hazards.
- Decide who might be harmed.
- Evaluate risks.
- Record findings.
- Review and revise assessment.

This was done based on the HSE framework on risk assessment and the risk assessment principles described in Section 2.2.2. Each sub-goal represents the key objective that risk assessors in any safety contexts should aim to achieve.
Beyond the top two levels, there are no fixed rules about how a risk assessment should be conducted (HSC, 1992). Indeed, a review of existing risk assessments later in Chapter 6 shows that a variety of methods and techniques are used in different contexts. This suggests that a risk assessment method that is suitable to one application may not necessarily be appropriate to others. QRA is a good example. This type of method has been widely used in the high hazard industries and in some applications within the railway industry. But, for reasons highlighted in the literature reviews (in Section 2.3.4 and Section 2.7), it is deemed unsuitable for many other applications.

The rest of the HTA is, therefore, more crowd safety specific, taking into consideration the kind of safety issues that are particularly relevant to public venue operations, such as those identified in the case studies and venue survey in Chapters 3 and 4 respectively. The analysis also takes into account existing guidance and current thinking on qualitative risk assessment (e.g. Kletz, 1988a; MoD, 1991; Royal Society, 1983 and 1992; HSC, 1992; British Safety Council, 1993 and HSE 1995) and the author’s own experience on previous crowd safety assessment for public venues. The following looks at the HTA of each of the five top level sub-goals in more detail.

5.1.1 Identify Hazards

Many assessors involved in the venue survey regarded hazard identification as the most important part of risk assessment in that any hazards that are not identified here will not be assessed. This could result in serious omissions in the assessment. In order to ensure an adequate and sufficient hazard identification, the assessors must be able to identify all hazards that could have a significant effect on crowd safety. Some form of taxonomy of crowd safety hazards is therefore needed for the development of the HTA and, possibly, the assessment methodology itself. Such a taxonomy can be found in a recent research report by Au et al (1993). The research covered a wide range of public venues including sports grounds, shopping centres, concerts, transport venues, outdoor events and others. Based on a series of interviews and observations carried out at these venues, the report has identified the factors that could affect crowd safety and suggested that crowd safety problems are often due to a combination of the following categories of contributory factors:
- Inadequate venue design or design limitations
- Visitors’ behaviour.
- Breakdowns in crowd management (including staff errors).
- Equipment failures.
- Undesirable circumstances.

A sufficient hazard identification would therefore require assessors to give adequate considerations to all these factors. This requirement is reflected in the HTA under Task 1.1 where its sub-goals are defined in terms of these factors. It is worth noting that the last two factors were included under the heading of “interruptions to normal operations”. The rest of this branch of the analysis sets out what assessors should aim to do in order to identify the hazards associated with each factor. These sub-goals include identifying the main sources of hazards and deciding what hazard(s) could subsequently arise.

5.1.2 Decide Who Might be Harmed

Not all hazards affect everyone who is exposed to them. For example, a piece of machinery may be perfectly safe for its operators but some of its design features could pose safety hazards to those who maintain it or vice versa because of the different ways in which a maintenance person and an operator interact with the machine. Also, some everyday items that pose little or no risks to most adults could become hazardous to young children (e.g. tiny objects and medicine containers). The society we live in demands these people also need to be protected from such hazards.

Similarly, in public venues, some people are particularly vulnerable to things or situations that are not normally hazardous to the vast majority of the visitor population. For example, young children or disabled persons could find manoeuvring through high (but not dangerous) crowd density areas, stairs and steep slopes more difficult and hazardous than other visitors. The aim of this part of the assessment is therefore to determine whether the hazards affect the visitor population as a whole or whether they tend to affect certain types of visitors. The information generated here can be used at a
later stage of the risk assessment to help to determine whether a more focused remedial measure is more appropriate.

The venue survey revealed that, in practice, this part of the assessment was either not carried out at all or carried out in conjunction with hazard identification (i.e. Task 1). However, for the purpose of the analysis, this is treated as a separate task so as to enable the author to identify whether extra assistance or support is required to fulfil this part of the assessment.

5.1.3 Evaluate Risks

This part of the assessment has been broken down into three sub-goals: estimate the risk associated with each hazard, evaluate risks for the prioritisation of remedial actions and identify the measures required to reduce risks. As stated in the literature review in Section 2.2.1, risk should reflect both the likelihood of hazard and the magnitude of the consequences should it occur. As such, risk estimation should involve the estimation of the likelihood and severity of each hazard and then determine how much risk the hazards pose to safety based on their likelihood and severity. They are included as Tasks 3.1.1 to 3.1.3 respectively.

As QRA is neither possible nor appropriate to crowd safety assessment, risk estimation can only be done subjectively. Based on the findings of the venue survey and from the literature, a number of factors that need to be considered have been identified. For likelihood estimation, they include past experience, information on previous accidents and near misses and relevant guidance. These factors are listed under Task 3.1.1. For severity estimation, consideration should be given to human costs of an accident (i.e. human suffering such as anxiety and stress, injuries and death) and costs to the venue owner (e.g. increased insurance costs, prosecutions, loss of revenue and adverse publicity). They are listed under Task 3.1.2. The above factors should also be taken into consideration when deciding on what actions to take in order to keep the risks as low as reasonably possible (i.e. Task 3.3).
Ideally, actions should then be taken to eliminate all risks. But absolute safety is simply impossible to achieve in reality. Furthermore, it is important to realise that what can be done in practice is very often restricted by financial, resource and other constraints. This is a fact of life that applies not only to public venues but also industries and other aspects of everyday life (e.g. HSE, 1992a). In recognition of this, all that the law requires is therefore to take reasonably practicable measures to keep the risk as low as possible. This involves setting priorities and deciding what is reasonably practicable (i.e. Task 3.2).

Priority setting would involve, first of all, deciding whether, with reference to the provisions already in place, the risks posed by the hazards are still unacceptable and then setting out the relative importance of the remaining hazards according to the safety risks they pose. They are represented in the analysis as Tasks 3.2.1 and 3.2.2. The prioritisation would enable assessors to ignore the trivial risks and concentrate on those hazards that need to be addressed most.

5.1.4 Decide What Remedial Actions are Required

Task 4 in the HTA is to determine what actions need to be taken to minimise the risks. This would involve firstly the identification of ways in which the risks could be minimised (Task 4.1) and then deciding what are the most appropriate action(s) to take. The general requirement (HSE, 1994) is to take whatever actions necessary, in order of preference, to completely eliminate the risks (e.g. by removing the sources of the hazards), reduce the risks as much as possible or control the harm (e.g. by protecting those who are particularly vulnerable to it). Therefore, the identification of possible remedial measures would require a good understanding of what causes the hazards in the first place and the harm to people exposed to them (see Tasks 4.1.1 to 4.1.5).

Where there are a number of options available, decisions have to be made on the most appropriate remedial actions. This can be a complex decision involving subjective judgement to weigh up the financial and other costs of implementing the measures against the benefits. As such, it is difficult to precisely define what sub-goals are involved. However, the venue survey has revealed a number of main factors which the
assessors would have to take into account. They include the priority of the risks, the effectiveness of the measures, other problems that could be introduced as the results of taking the actions, the direct and indirect costs of taking the actions and other trade-offs that have to be made (e.g. reduction of visitors’ enjoyment, making the event less attractive, etc.). These factors are listed under Task 4.2.1.

5.1.5 Record Findings

The MHSWR requires all employers with five or more employees to record the significant findings of their assessment. This requirement applies to the vast majority of public venues. In general, the assessors should show on the assessment records that a proper check was made and that reasonable precautions have been taken to ensure public safety. The former can be achieved by recording the significant hazards identified in their assessment, indication of their risks and the population which may be affected. Where necessary, the assessors should also cross-reference to other documents and records where detailed information can be found. The latter can be achieved by recording any existing control measures in place, any actions to be taken and, if it has been decided that no further actions are required, the reasons for such a decision. Again, the assessors should, where necessary, cross-reference to other documents and records for more detailed information. They are listed in Tasks 5.1 and 5.2 respectively.

5.1.6 Review and Revise Assessment

The MHSWR also requires employers to review and, where necessary, revise their risk assessment to ensure that it remains valid. To accomplish this task, decisions have to be made on the timing of the review (Task 6.1) and, where necessary, which parts of the assessment need to be revised (Task 6.2). Appropriate modifications then have to be made to the affected parts in order to ensure that the assessment is up-to-date with the current safety situations (Task 6.3).
5.2 Tabular Task Analysis

A tabular analysis was then carried out to examine in detail each lower level sub-task. The aim was to establish, firstly, what the assessors need to be able to achieve in order to accomplish each sub-task and the overall crowd safety risk assessment task successfully, what are the problems of the assessment and, thirdly, what help and support the crowd safety risk assessment methodology could provide to address these problems. The tabular format was chosen for its suitability for such detailed analysis.

Task analysis can be used for a wide range of applications, such as design evaluation, training need analysis, job design and reliability analysis. A full analysis can cover all aspects of a task, which is unlikely to be necessary in every application (Stammers and Shepherd, 1995). What is therefore required is to decide what aspects we need to look at in this particular analysis.

Whether a task can be successfully accomplished depends on a combination of factors. Shepherd (1989), for example, has identified four categories of contributing factors: the training received, the equipment to do the task, the information required and the material provided. Whalley (1987), on the other hand, has identified a total of 146 “performance shaping factors” that could influence the reliability of human performance. At the top level, these performance shaping factors grouped under the following categories:

- **Process**: sub-categorised into technology, chemistry and process material.
- **Personnel**: sub-categorised into training, experience, mental model, personality and health.
- **Ergonomic**: sub-categorised into environment, personnel interactions, man-machine interface, equipment and work demands.

Obviously, not all factors are relevant to every task type. Risk assessment is primarily a cognitive/analytical task often carried out as a desk-top exercise. Therefore, factors such as equipment, technology, chemistry, material and man-machine interface are of little or no relevance. Factors such as personality, health, environment, personnel interactions and work demands could be relevant but they cannot be provided for by
means of a risk assessment methodology or a guidance document. As such, they are also not considered in this analysis. The types of factors that are covered in the analysis include knowledge (including training that can be provided by means of a risk assessment methodology), experience, information and procedural matters.

Figure 5.2 shows an extract of the analysis. The full tabular task analysis is presented in Appendix C-2.

**Figure 5.2: Tabular Analysis of the Crowd Safety Risk Assessment Task**

<table>
<thead>
<tr>
<th>Task no.</th>
<th>Sub-task description</th>
<th>Task requirements</th>
<th>Potential problems</th>
<th>Implications to crowd safety risk assessment methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Identify hazards associated with poor design</td>
<td>Consider each part of the venue</td>
<td>Ensure that all parts of the venue are considered</td>
<td>Too much emphasis on what happened in the past, insufficient effort to predict what could go wrong; Experience-based approaches only focus on past experience &amp; hence not sufficiently comprehensive</td>
</tr>
<tr>
<td>1.1.1</td>
<td>Consider each part of the venue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.2</td>
<td>Identify undesirable design features &amp; the hazards/harms that could arise</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Identify hazards associated with visitor's activities &amp; behaviour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2.1</td>
<td>Identify undesirable activities/behaviour &amp; the hazards/harms that could arise</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The tabular analysis has five columns of information. The first two columns contain a list of sub-tasks and their task numbers. The third column looks at what the assessors need to achieve to accomplish each of the sub-tasks (i.e. task requirements). This part of the analysis focused on knowledge and experience, information requirement, assessment methods and procedures. The fourth column highlights the problems the assessors may encounter when fulfilling the needs. This is partly based on information gathered in the venue survey in Chapter 4. The fifth and final column identifies what implications these
problems could have on crowd safety risk assessment methodology and the help and support the methodology could offer to fulfil the task requirements.

Table 5.1 provides a summary of the main task requirements and the potential problems in achieving them.

**Table 5.1: A Summary of Task Requirements and the Problems Involved**

<table>
<thead>
<tr>
<th>TASK REQUIREMENTS</th>
<th>POTENTIAL PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure that all parts of the venues are covered in the assessment.</td>
<td>This could be difficult to achieve esp. for large venues with complex layouts.</td>
</tr>
<tr>
<td>Ensure that all significant hazards are identified and be able to recognise those designs, venue features, activities/behaviour, substances, etc. that could cause significant harms to people.</td>
<td>• Concentrate too much on past problems and not enough forethought on what could go wrong.</td>
</tr>
<tr>
<td></td>
<td>• The experience-based approaches are not sufficiently comprehensive for reasons that are already given in Section 2.6.2.</td>
</tr>
<tr>
<td></td>
<td>• Incomplete information - assessors may not have sufficient interaction with visitors or first hand experience on what happens on the ground.</td>
</tr>
<tr>
<td></td>
<td>• Info. on some near misses, past problems, etc. may not reach the assessors.</td>
</tr>
<tr>
<td></td>
<td>• Omissions.</td>
</tr>
<tr>
<td></td>
<td>• Mind set/unduly influenced by factors such as personal experience, hot topic of the day, politics, etc.</td>
</tr>
<tr>
<td></td>
<td>• Assessors often find it difficult to account for hazards associated with the presence of large crowds and, esp. crowd behaviour (also see venue survey in Chapter 4).</td>
</tr>
<tr>
<td>Make accurate and reliable estimates of risks.</td>
<td>• Assessors may not have daily interaction with the visitors and first hand experience about what actually happens on the ground.</td>
</tr>
<tr>
<td></td>
<td>• High level of uncertainty; i.e. a lack of data, statistics, etc.</td>
</tr>
<tr>
<td></td>
<td>• QRA is unsuitable for reasons already given in Sections 2.3.4 &amp; 2.7.</td>
</tr>
<tr>
<td></td>
<td>• Qualitative assessments tend to have a lower level of reliability &amp; consistency.</td>
</tr>
<tr>
<td></td>
<td>• Different interpretations of the words used in qualitative assessments, such as high/ medium/low risks.</td>
</tr>
<tr>
<td></td>
<td>• Risk estimation scheme too crude or too sophisticated to adequately reflect the full spectrum of risk.</td>
</tr>
</tbody>
</table>
Table 5.1: A Summary of Task Requirements and the Problems Involved

<table>
<thead>
<tr>
<th>TASK REQUIREMENTS</th>
<th>POTENTIAL PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make accurate and reliable estimates of risks. (cont.)</td>
<td>• Misconceptions over the concepts of risk and risk assessment (also see Section 4.3 venue survey).</td>
</tr>
<tr>
<td>Risk estimation should take into account any precautions that are already in place &amp; past experience.</td>
<td>• Incomplete information - assessors may not have sufficient day-to-day contact or front line interactions with the visitors. • Info. on some near misses, past problems, etc. may not reach the assessors.</td>
</tr>
<tr>
<td>Ensure that risk reduction decisions are valid and justifiable.</td>
<td>• Ad hoc decisions. • Decisions unduly influenced by personal experience, hot topic of the day, politics, etc.</td>
</tr>
<tr>
<td>Identification of remedial measures should be rational; according to the HSE principle (1994), actions need to be taken, where practicable &amp; in order of preference, to eliminate the hazards or to minimise the extent of risk.</td>
<td>• Only tackle the symptoms, not the cause of the problems. • Ad hoc decisions/rely on gut feelings. • Unduly influenced by own experience, hot issue of the moment, politics, etc.</td>
</tr>
<tr>
<td>Demonstrate that all significant risks have been considered. Record all risk reduction actions or reasons for non-action.</td>
<td>• Omissions in risk/risk assessment record.</td>
</tr>
<tr>
<td>Make sure that risk assessment is always valid.</td>
<td>• Out of date risk assessment/assessment fails to reflect changes in circumstances, work practices, etc.</td>
</tr>
</tbody>
</table>

From the tabular task analysis, a number of key requirements for the development of the methodology were established. They include:

- A systematic hazard identification method is particularly important assessing complex problems such as crowd safety. Being able to identify all significant risks is a key requirement in risk assessment. A structured and systematic approach will help to minimise the chance of missing something important.

- There should be guidance in the methodology on methods for dealing with complex venues. As part of a structured and systematic approach to risk assessment, the current best practice is to divide a complex system into smaller, more manageable sub-systems. This is very much in evidence in Human Factors (i.e. task analysis) and in industries where complex systems are involved. For public venues, one way of doing this is to break them down into smaller, more assessable parts or functional areas (Au et al., 1993). Further discussions can be found in Section 6.1.2.
The importance of information gathering needs to be highlighted. There should also be guidance on methods of information gathering included as part of the overall risk assessment and planning methodology. Information is key to risk assessment and decision-making. Relying on one's own experience alone is insufficient, as discussed in Section 2.6.2. Venue inspection, observations, incident reporting, input from front line staff and customer feedback, discussions with other relevant bodies, etc. are useful information gathering methods identified in the venue survey.

Risk assessment (hence crowd safety planning) should be pro-active, not simply reactive. The aim of a risk assessment is to establish what could go wrong as well as what went wrong in the past. Whilst past experience is a valuable source of information, it is vital that assessors should not restrict their thoughts on what happened in the past alone. It needs to be sufficiently forward looking.

Some form of hazard identification tool kit to provide additional help to assist assessors to account for crowd related hazards is important. As illustrated in the case studies in Chapter 3, crowd safety can be a complex problem. The venue survey in Chapter 4 has highlighted the difficulties assessors found in identifying crowd related hazards and the associated problem of omission.

The methodology should include a systematic risk estimation scheme with an explicit requirement to estimate both likelihood and severity. This is essential to overcome the misconception many of the assessors have over risk (i.e. risk = chances). It is also important to ensure that risk estimation is done in a rational rather than an ad hoc manner and to reduce any undue influences such as “the hot issues of the moment” and politics.

There should be a requirement to consider what precautions are already in place and to assess their effectiveness during risk estimation. Existing precautions can be regarded as “counter-risk contributory factors” and therefore need to be taken into account when estimating risks. If an existing precaution is highly effective and the residual risk is already very small, there may not be any need for further actions. Resources can be better used to tackle the more important risks.

The risk estimation scheme should be sufficient to reflect the full spectrum of crowd safety risks that could arise in a major public venue, ranging from the very low risks to the very serious.
• The risk estimation scheme should aim to improve reliability and consistency of risk judgements. More thought is still required on how this can be best achieved (e.g. carefully chosen and clearly defined words).

• The risk assessment method should require/encourage assessors to think about what causes a hazard and its consequences. For a complex problem, understanding the problem is important for identifying the correct remedial measures. Crowding due to different contributory factors/ reasons may require different solutions. Where it is not possible to tackle the cause of a problem, knowing the consequences would help to identify means to protect people from the harm it causes. The severity of the consequences is also a key consideration in risk estimation.

• Decisions on risk reduction measures should be risk based to avoid ad hoc decisions and undue influences. Some form of guidance on TOR could be useful.

• A comprehensive “tool” for recording risk assessment is required (e.g. a sample risk assessment record form).

• There should be general guidance on when to review and revise risk assessment.

### 5.3 Discussions and Criteria for the Development of a Risk Assessment Method for Crowd Safety

By systematically examining the tasks involved in assessing crowd safety risks, the task requirements and the potential problems that could prevent assessors from successfully completing their tasks, the task analysis has identified a large number of methodological issues. It is clear from the list in the previous section that in order to assist assessors to achieve a suitable and sufficient risk assessment for crowd safety, a systematic method for hazard identification must be provided. In addition, guidance, tools and other help are also required especially for hazards associated with the presence of large crowds and behaviour. Less help is required for the identification of physical hazards. In terms of risk evaluation, a risk estimation scheme is clearly required to guide assessors through the process. As highlighted previously in the venue survey, there is a need to explicitly require assessors to consider both likelihood and severity when estimating risks. This requirement has been reinforced in the analysis. Another important issue concerning risk estimation is how to improve the reliability and validity of the judgements people
make on risks. Literature review suggests that qualitative assessments in general tend to have a lower level of reliability and validity. The need for the risk estimation scheme to adequately cover the whole range of crowd safety risks, from the very minor risk to the highly significant risks, is also an important requirement. When deciding what actions need to be taken, the main problems appear to be ad-hoc decisions, undue influences and the tendency to tackle the symptoms rather than the underlying causes. The assessment method should, therefore, be designed to restrain assessors from going down these routes. Finally, to satisfy the legal requirement and the risk assessment principles identified in Chapter 2, tools and guidance are required on recording the assessment and ensuring that it remains valid.

By pulling together the findings from the literature reviews, the case studies, the venue survey and the task analysis, it becomes possible to identify what the risk assessment methodology needs to provide in order to help assessors to conduct a suitable and sufficient assessment for the types of crowd safety risks that could arise in major public venues, to tackle the issues associated with the assessment of such risks and to address the need of and the operational constraints facing the assessors. From these, a list of key criteria for the development of a crowd safety risk assessment methodology is drawn up below.

**Overall requirements**

The crowd safety risk assessment methodology should take into account the following.

(a) It should comply with the risk and risk assessment principles highlighted in Section 2.2 and the legal requirements set out in the relevant legislation (in Section 2.1); i.e. risk should reflect both likelihood of harm and its severity and the methodology should enable the identification all significant risks, prioritisation of measures to be taken and be appropriate to the nature of the work in public venues; it should, therefore, consist of, broadly, hazard identification and risk evaluation.
(b) It must be more robust than the risk assessment for an ordinary workplace (such as an office or a light industrial environment) because of the nature of the risks and who might be affected; but for the same reason, it need not to be as sophisticated as that for the high hazard industries. QRA methods are deemed unsuitable and, perhaps, unnecessarily complex for crowd safety.

(c) It should be simple and easy to use and suitable to be used by people with relevant H&S knowledge as well as those who are from an operational background. For the latter group, there is also a need to correct any misconceptions over risk and risk assessment.

(d) It must be applicable to existing as well as new public venues.

(e) It should take into account the lack of crowd safety failure data and stress the importance of information gathering as part of the overall approach to good risk assessment and planning. The inclusion of good practices in information gathering is beneficial.

(f) It should cater for the time constraints facing many assessors; the inclusion of advice on time saving measures, such as conducting assessments during quieter times of the year or a “two-tier” approach, should make risk assessment more practicable to many public venues.

Hazard identification

(g) It should provide a systematic method for hazard identification that caters for the different hazards that could arise in different venues.

(h) It should enable assessors to account for physical hazards and hazards associated with the presence of large crowds. The latter hazard type (and particularly visitor behaviour) is less predictable and most assessors find them very difficult to identify. Some form of hazard identification tool is required to overcome this difficulty. It may be useful to encourage assessors to consider the key hazard
contributory factors/crowd safety hazard taxonomy such as venue design, visitor behaviour, crowd management, hazardous substances and items and disruptions to normal operation (including equipment failures, delays and undesirable circumstances).

(i) It must be proactive and forward looking in order to overcome any mind-sets on past problems and over-reliance on personal experience; the provision of some forms of “prompters” to encourage assessors to predict what could go wrong is beneficial, this may be in the form of a checklist, keywords, etc.

(j) It should provide guidance on how to deal with complex venues. One way of doing so is to break it down into smaller, more manageable parts.

(k) Encourage inputs from other sources; e.g. the involvement of the front line staff, the outside bodies involved and, possibly, external expertise.

Risk evaluation

(l) It should provide a systematic risk based evaluation method. There should be an explicate requirement on assessors to estimate both likelihood and severity.

(m) It should be sufficient to cover the full spectrum of crowd safety risks highlighted in the case studies in Section 3.3.2, i.e. ranging from risks that present no significant threats to major disasters such as Hillsborough.

(n) It should enhance the reliability and consistency of the risk estimation process; the provision of some forms of likelihood and severity criteria/categorisation (or any other suitable means). Using clearly defined words should help to achieve this.

(o) It should provide a scheme that enables the assessors to work out the risk level based on the estimated likelihood and severity.
(p) It should require assessors to take into consideration the precautions that are already in place.

*Deciding what remedial actions to take*

(q) It should require/encourage the assessors to think about what causes the hazards in the first place and to identify the consequences when determining the appropriate remedial measures for each significant risks.

(r) It should provide guidance or other suitable tools to help assessors to prioritise measures to be taken. Such decisions should be risk based to avoid ad hoc decisions and undue influences; some forms of guidance on TOR may be useful.

(s) It should highlight the need to also consider whether a risk reduction measure could introduce any new problems elsewhere.

*Others*

(t) It should suggest a format for recording assessment or provide a sample ‘risk assessment record form’.

(u) It should provide general guidance on when to review an existing assessment and on the circumstances under which a revision of the assessment may be required.

*Presentational issues*

(v) It should provide a glossary of the key terms (e.g. hazard, risk) and explain the concept of risk and risk assessment principles.

(w) It should be written in a “down to earth” manner, avoiding the use of technical jargon with which some assessors are likely to be unfamiliar. The provision of examples to illustrate how the methodology works could be useful.
CHAPTER 6
ADMINISTRATION OF RISK ASSESSMENT METHOD – A REVIEW OF SPECIFIC ASSESSMENT TECHNIQUES AND TOOLS

Chapters 3, 4 and 5 have examined the nature of crowd safety risks, the tasks of assessing crowd safety risks, the needs of the assessors and associated issues. A set of criteria for crowd safety risk assessment has been established. This chapter will review how these criteria can be best fulfilled. A review has already been carried out in Section 2.4 on some of the risk assessment methods, techniques and tools currently employed in or proposed for applications elsewhere in other contexts. This chapter is to look at these techniques and tools and discuss how relevant they may be in fulfilling the criteria and addressing the risk assessment and practical issues identified in previous chapters. The aim of this chapter is also to see what can be learnt from risk assessments elsewhere. Once again, the main focuses are on hazard identification and risk evaluation.

6.1 Hazard Identification

6.1.1 The Criteria and the Issues

The key requirements for hazard identification are that it should be systematic and that it should account for all significant safety hazards. In crowd safety, such hazards generally include physical hazards as well as hazards associated with the presence of large crowds and their behaviour. An adequate and sufficient hazard identification process should, therefore, be able to deal with all these hazards. It has been established, through the venue survey, that the latter hazards are especially difficult to identify. How best to help assessors to overcome this difficulty is an issue that needs to be addressed. It has also been demonstrated in the case studies in Chapter 3 that hazards tend to vary from venue to venue. Venue specific circumstances and experience are therefore important for hazard identification. However, whilst taking into account past experience, hazard identification should also be proactive and forward looking in order to identify any new hazards that may not have occurred before. This is particularly important for new venues and venues that have just undergone significant modification. It can also be
beneficial to take on board a range of views and experience, such as those of the front line staff and emergency services. How to combine all these in a hazard identification process is another issue that needs to be looked at.

The existing qualitative risk assessment methods are for general health and safety in the ordinary workplaces, such as offices and shop floors. Many of the hazard identification methods are loosely structured (e.g. walkthrough/venue inspections, safety meetings and debriefings/reviews) and are found in the venue survey to be inadequate particularly in identifying crowding and behaviour related hazards for public venues. It can be argued that because of the complexity of crowd safety hazards and the extent of the risks (i.e. crowd safety risks could affect a large number of visitors whereas most health and safety hazards in an ordinary workplace tend to affect the individuals involved), a more robust method is required. On the other hand, there is a need for the method to be simple and easy to use as many assessors are not full-time safety risk professionals and have to carry out risk assessments in addition to their normal duties as operational managers or event organisers. Time constraint is also a factor. Consequently, striking a balance between a more robust method and one that is simple and easy to use is also something that needs to be considered when deciding on a hazard identification method.

Finally, the size of some venues and the complexity of their layouts mean that it may no longer be appropriate to assess the entire venue all in one go. In other contexts where an assessment is carried out on a complex system or task, the assessor often has to first break a system down into a number of smaller sub-systems or sub-tasks before assessing each sub-system or sub-task. A similar method will have to be found to enable assessors to break down a complex venue in order to make the assessment more manageable.

6.1.2 Hazard Identification Techniques and Tools

Dealing with complex venues

Section 2.4.3 considered how a complex engineering system, operation or human task can be broken down into smaller and more manageable components for risk assessment.
A common feature amongst them is that their components are clearly definable and the relationships between individual components and how they interact are well understood. But for public venue operations, things are not as clear-cut. Although in an earlier study Au et al (1993) has suggested that risk assessment could be made through examining the human activities involved (and their interaction with venue design, crowd management, the circumstances, etc.) in a manner similar to task analysis for human operations, this is likely to be extremely difficult and cumbersome to achieve in practice. The suggestion was made based on the notion that visitors’ activities and behaviour are a main factor affecting crowd safety, just as operator activities and human errors are to the safety and success in the workplace. However, unlike in the workplace where people’s activities are very much defined and restricted by the tasks they are employed to do and the procedures they have to follow, visitors in public venues do not have such restrictions and they are much freer to do what they desire to. Defining their activities in the ways described in Section 2.4.3 can be a major problem. This also means that, in practice, there can be a whole host of activities going on at any one time. For many venues, there could be different mixes of activities at different times in different places. The sheer variety of activities, in itself, can make the detailed analysis of each activity impractical. But apart from what visitors do per se, the interaction between different activities can also be an important issue. For example, in the two public venues used in the case studies in Chapter 3 there are certain times where there are people arriving and departing at the same time. Similar situations can also be found in other venues including transport venues, shopping malls, exhibition centres, fairgrounds and others. The interaction between the arriving and the departing crowds can lead to problems such as excessively high crowd volume and cross flows along the routes. Furthermore, visitor behaviour can also be influenced by a wide variety of factors, such as weather conditions. For these reasons, it is concluded that to break down visitor activities along the lines of the methods identified in Section 2.4.3 is not a viable option for this particular application.

What is more definable, however, is the geographical make up of a public venue; i.e. the different areas of the venue. A public venue is often made up of different “sectors”. They are situated in different areas or at different parts of the venue and are used for different functions. For example, the access routes to the venue, the forecourt, the
concourse, the check-in/ticket area, the main stadium/viewing area etc. are all different aspects of a public venue. For the purpose of this thesis, they are called "functional areas". As they are designed to serve different purposes, these functional areas are likely to each have their own distinctive characteristics, visitor activities and, hence, the types of hazards. For example, crowd flow is likely to be more of an issue on the access routes than inside the viewing area, whereas queues are more likely to develop in the check-in/ticket area of the venue. It is therefore feasible that a complex venue can be broken down not in terms of visitor activities but into smaller functional areas instead. Risk assessment can be made by systematically examining each area, its design and layout, the types of activities that are likely to take place and their interactions. This is roughly in line with the guidance given by the HSE (1994) for workplace assessment - i.e. to walk around and look afresh at what could reasonably be expected to cause harm.

Identifying safety hazards

The review in Section 2.4.4 has identified several techniques and tools that are in use or being proposed for hazard identification in other contexts. They include brainstorming, structured brainstorming such as HAZOP, human error analysis, the "walkthrough" type approaches and the use of checklists or keywords. These methods and techniques all have their benefits and pitfalls. HAZOP (especially HAZOP II), human error analysis and logic diagrams are all well established, highly structured and very systematic and thorough. But they could be time consuming and resource intensive to do. Human error analysis and logic diagram, in particular, require the object of the assessment (i.e. tasks, engineering systems, etc.) to be broken down into well defined elements in the manner described in Section 2.4.3. As discussed above, this is not viable in crowd safety. Also, they are often carried out by specialists (such as human factors specialists and safety and reliability engineers) and require certain expertise that the vast majority of public venues do not possess. In comparison, method study, brainstorming and walkthrough methods are relatively simple, easy to use and inexpensive to carry out, but they are not as systematic and comprehensive. Significant hazards could therefore be missed. Checklists, on the other hand, tend to be more comprehensive but, at the same time, they are very specific and thought restrictive. Checklists are also more insensitive to any changes in the work practice and circumstances. HAZOP and the keyword approach.
however, is not restricted to a particular situation, workplace or set of circumstances. It is useful in that it prompts assessors to also think about what could go wrong in the future rather than just searching the past. It is therefore a structured and a forward looking hazard identification method. But it remains the case that a full blown HAZOP (again, HAZOP II in particular) is time consuming and costly to do and requires some specialist expertise.

Whilst the existing hazard identification methods and tools may not be entirely suitable for the crowd safety for one reason or another, there are a few features of these methods that could be useful and relevant and from which something could be learnt. Firstly, the systematic approach and the comprehensiveness of the HAZOP type techniques, human error analyses, logic diagrams and methods of this kind are particularly useful for detailed in-depth investigations for complex systems/activities. Secondly, the relative simplicity of the walkthrough type methods means that they are generally less time consuming to do and that they can be done in-house without acquiring specialist expertise. This could therefore encourage more venues to take up risk assessment. These methods also tie in better with some of the things many venues are already doing to assess crowd safety (see venue survey in Chapter 4). Thirdly, the ability of HAZOP and brainstorming to be pro-active and forward looking is particularly useful for new venues and for the frequently changing nature of venue operation in general and visitor behaviour in particular. Such methods are also good at drawing together different viewpoints and experience. Finally, the thought provoking nature of the keyword approach, HAZOP and brainstorming can be especially beneficial for crowd safety where things are not as nicely defined as in the case of an engineering system or human task activities in the workplace. They are also sufficiently non-restrictive to be applicable to a wide variety of venue operations.

Despite their useful features, human error analysis, logic diagrams and checklists are fundamentally unsuitable for crowd safety. Human error analysis relies on the output of a task analysis. As discussed in the previous paragraphs, in public venues where visitor activities are wide ranging, it becomes extremely difficult to define activity in the same way as work activities are defined in task analysis. Another key difference between work activities and visitor activities is that the former take place where the
circumstances are not frequently changeable. For the latter, as illustrated in the case studies in Chapter 3, even the same activity could give rise to different hazards in different parts of the venue at different time and in different circumstances. In public venues, the circumstances can vary from time to time (e.g. times of day, weekdays vs. weekends, time of the year, the types of visitors, the nature of the performance, arrival vs. departure, etc.). This makes human error analysis or similar methods, which involve analysing each activity for all possible circumstances, extremely complicated and very clumsy to do. Logic diagrams are used to define how different factors could contribute to a hazard. Although they could help the assessors to have a better understanding of the hazards (and hence more able to identify the most appropriate remedial measures), the techniques are intended mainly for engineering processes where the functions of plant components are well defined and the manner in which failures could occur is relatively restricted and hence more predictable. It is doubtful whether they are workable in the crowd safety context where visitors’ behaviour can be influenced by the interaction of so many factors. The manner in which crowd safety “failures” could occur is much more wide ranging. Checklists are prescriptive in nature and this gives rise to a number of problems when applied to crowd safety. Firstly, they tend to restrict the thoughts of the users to specific problems, issues or items on the checklist. Whilst they may be useful for audit purposes, checklists are generally much less suitable for predictive assessment. Secondly, any significant changes in the circumstances could easily render a checklist invalid. Thirdly, a hazard checklist intended for all types of public venues is likely to be extremely long and cumbersome and hence virtually unusable.

6.2 Risk Evaluation

6.2.1 The Criteria and the Issues

A main criterion for a risk evaluation method is that it should be systematic to provide a rational basis for decision-making. An explicit requirement within the method is for the assessors to take into account both the likelihood of the hazard causing harm to people, and the severity of the consequences is also essential. This is because, firstly, it is an
important and fundamental concept of risk as applied to risk assessment and, secondly, it is one which is widely misunderstood, as shown in the venue survey.

As in other similar methods and tools that enable/assist people to pass judgements on an issue, an event or the quality of an item or services, a key issue in risk evaluation is how to ensure that risks are estimated in a valid and reliable manner. This issue is particularly important for qualitative risk assessment where risks cannot be quantified and estimates have to be made by judgements. Another important criterion is that the risk evaluation method has to be sufficient to reflect the full spectrum of crowd safety risks. Because of the complex nature of crowd safety problems, the risks they pose to people's safety and well being could be wide ranging. Like crowd safety hazards, the risks associated with these hazards can also be different in different places at different times and in different circumstances. As illustrated in Chapter 3, the risk of, for example, a fast moving crowd or a tripping hazard may have a minimal impact on safety in one case but could turn into a disaster with multiple fatalities in a different environment and set of circumstances. A suitable risk evaluation method should therefore cover the whole range of risks (or how people could be affected) and also allow meaningful distinctions to be made between the variety/different levels of risks within the range. This issue is addressed later in Section 7.3.4.

6.2.2 Risk Evaluation Techniques and Tools

The review of existing risk assessment methods in Section 2.4 shows that rating is used universally for qualitative assessment. Risk rating has the potential to satisfy all criteria identified in Section 5.3. It enables assessors to determine and categorise how important the hazards are so that they can be prioritised. It is also easy to use, it is not time consuming to do and does not require any specialist expertise. What is perhaps of more interest and hence worth a further examination is the "semi-quantified" methods. Section 2.4 has already pointed out that in mathematical terms, the notion of using what is essentially subjective ratings in mathematical calculations and then mixing them with real numbers to give an overall risk value is fundamentally flawed. Also, because of the involvement of mathematical formulae and their apparent sophistication, the semi-quantified methods can mislead people into treating the overall risk values in terms of
real numbers, rather than just an indication of the level of the risks. This is particularly so for public venue assessors and managers whose understanding of mathematics and probability is rather limited or has become somewhat rusty. There are also other problems associated with this kind of method:

(a) These risk rating schemes are very arbitrary. For example, in the example given in Section 2.4, a rating of 5 is allocated if an accident could happen once a year and a rating of 10 is given if it could occur once a month. This seems to suggest that the latter is twice as “risky” as the former. If the risk rating scheme is meant to truly reflect the risk involved, the latter should be given a “value” which is 12 times as much as the former (i.e. once a month = 12 times a year). In another part of the scheme, the MPL scheme appears to suggest that, for example, losing two limbs or both eyes (i.e. rating = 45) is 1.5 times as serious as losing one limb or an eye (rating = 30) or it is nearly as bad as a fatality (rating = 50). Whether one would agree with such an analysis depends on personal views and is subject to dispute. But what it shows is that the rationale behind the allocation of these likelihood and human suffering “values” appears to be highly arbitrary with little or no means of justification.

(b) In general, the use of figures in a rating scheme could be confusing and could lead people to perceive the scale as an interval scale or a ratio scale, even where they are merely intended to indicate a ranking.

(c) The use of actual numbers as an indicator of severity is inappropriate to public venues where there are large numbers of people. For certain hazards, such as overcrowding, it is difficult, if not impossible, to predict exactly how many people would be harmed. Any figures given are likely to be highly speculative.

On the basis of the above, the inevitable conclusion is that semi-quantified methods are fundamentally flawed and unsuitable for the evaluation of crowd safety risks.
6.3 Conclusions

The review of the existing risk assessment methods, techniques and tools has not found anything that is directly applicable to crowd safety risk assessment. But much can be learnt from the ways in which risks are assessed elsewhere. This exercise has identified a number of useful features and ideas that could be adopted to satisfy the criteria set out in Section 5.3.

In hazard identification, for example, the use of keywords and HAZOP type techniques could help to ensure that this part of the risk assessment is systematic, comprehensive, thought provoking and brings together different experience and viewpoints. Amongst the risk evaluation methods found in this exercise, rating appears to be most relevant to qualitative assessment. It is also the most widely used method. However, this exercise also identified many risk rating schemes where subjective rating is treated as or used in combination with real numbers to generate a numerical risk value. Whilst such methods may look more sophisticated and impressive, they are mathematically flawed.

To summarise, Table 6.1 compares the methodological issues highlighted in the criteria in Section 5.3 with the methods, techniques and tools discussed in this Chapter. This is to provide an overview of how these issues are currently addressed in other contexts.

Table 6.1: A Comparison of Criteria and Existing Methods, Techniques and Tools

<table>
<thead>
<tr>
<th>Criteria and Methodological Issues for Hazard Identification &amp; Risk Evaluation</th>
<th>Existing Methods, Techniques &amp; Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>A systematic and comprehensive method for hazard identification.</td>
<td>HAZOP, guidewords/keywords, checklists, task analysis, human error identification techniques, logic diagrams.</td>
</tr>
<tr>
<td>Dealing with hazards associated with the presence of large crowds and, in particular, behaviour.</td>
<td>Human error identification techniques, human error classification schemes, task analysis, Human HAZOP/keywords.</td>
</tr>
<tr>
<td>Proactive and forward looking method so as to prevent mind-sets and over-reliance on past experience alone.</td>
<td>HAZOP, brainstorming, keywords.</td>
</tr>
</tbody>
</table>
Table 6.1: A Comparison of Criteria and Existing Methods, Techniques and Tools

<table>
<thead>
<tr>
<th>Criteria and Methodological Issues for Hazard Identification &amp; Risk Evaluation</th>
<th>Existing Methods, Techniques &amp; Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dealing with complex systems.</td>
<td>Task analysis, divide up a process into stages, divide up a plant into plant components, walk-through.</td>
</tr>
<tr>
<td>Encourage the involvement of front line staff and other relevant persons.</td>
<td>HAZOP, brainstorming.</td>
</tr>
<tr>
<td>A systematic risk evaluation method with an explicate requirement on considering both likelihood and severity.</td>
<td>QRA, human reliability techniques, some risk rating schemes, semi-quantified risk assessment.</td>
</tr>
<tr>
<td>Covering the full spectrum of risks ranging from those that present no or very little real threats to major disasters.</td>
<td>QRA, human reliability techniques. For risk rating and semi-quantified schemes, it depends on the detailed designs.</td>
</tr>
<tr>
<td>Reliability and consistency of risk estimation.</td>
<td>QRA, human reliability techniques.</td>
</tr>
<tr>
<td>A scheme for establishing the overall risk level based on the estimated likelihood and severity.</td>
<td>QRA, human reliability techniques, some risk rating schemes, semi-quantified risk assessment.</td>
</tr>
<tr>
<td>“Residual” risks, i.e. take into account any precautions that are already in place.</td>
<td>-</td>
</tr>
<tr>
<td>Deciding what needs to be done and the prioritisation of remedial measures.</td>
<td>Legislation, standards, ALARP, cost benefits analyses.</td>
</tr>
</tbody>
</table>

This review has generated useful information on current wisdom and current practice in risk assessment. What is now required is to build on the various ideas, techniques and tools identified here and develop a method and associated techniques and tools that are suitable and appropriate to crowd safety risk assessment and address the needs of the assessors in different public venues.
The investigation into the application of risk assessment to crowd safety has examined the nature of the risks that can arise in a public venue (Chapter 3) and has analysed the tasks involved in assessing these risks (Chapter 5). It has also looked at the practices adopted in many venues for crowd safety assessment and planning and the constraints and practical difficulties facing public venue assessors (Chapter 4). The information has enabled the assessors’ needs to be identified and a set of criteria to be established (Section 5.3). At the same time, a look at how risk assessments are conducted in other contexts (Section 2.4) has highlighted features of the existing methods, techniques and tools that could help to address the assessors’ needs and fulfil the criteria (Chapter 6). Detailed design of a risk assessment methodology for crowd safety can now proceed. This chapter describes the development of a prototype methodology and the rationale behind it.

7.1 An Overview of the Methodology

As the first step towards the development of the prototype, Table 7.1 summarises the key criteria and how they could be fulfilled. On the basis of the research findings, an overall method for crowd safety risk assessment and techniques and tools for specific risk assessment tasks are developed.

Table 7.1: Key Criteria and Potentially Suitable Risk Assessment Methods

<table>
<thead>
<tr>
<th>KEY CRITERIA</th>
<th>SUITABLE METHODS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall methodology</td>
<td>• The risk assessment principles set out by the HSE and others in Section 2.2.</td>
</tr>
<tr>
<td>• Must comply with the legal</td>
<td>• Build on existing guidance (described in Section 2.5); they are simple, readily</td>
</tr>
<tr>
<td>requirements.</td>
<td>available in the public domain &amp; hence, are familiar to most assessors.</td>
</tr>
<tr>
<td>• Must be suitable and appropriate</td>
<td></td>
</tr>
<tr>
<td>to the nature of public venue</td>
<td></td>
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<tr>
<td>operations and the crowd safety</td>
<td></td>
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<tr>
<td>risks that could arise.</td>
<td></td>
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<tr>
<td>• Should be sufficiently robust.</td>
<td></td>
</tr>
<tr>
<td>• Should be simple &amp; easy to use.</td>
<td></td>
</tr>
<tr>
<td>• Should be non-time consuming to do.</td>
<td></td>
</tr>
<tr>
<td>• Applicable to new and existing</td>
<td></td>
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<td>venues.</td>
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</table>
### Table 7.1: Key Criteria and Potentially Suitable Risk Assessment Methods

<table>
<thead>
<tr>
<th>KEY CRITERIA</th>
<th>SUITABLE METHODS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hazard identification</strong></td>
<td>- The break down of a complex system into sub-systems and components; possibly according to the geographical make up of a venue/functional areas.</td>
</tr>
<tr>
<td>- Should be systematic &amp; comprehensive.</td>
<td></td>
</tr>
<tr>
<td>- Should be pro-active and forward looking</td>
<td></td>
</tr>
<tr>
<td>- Should enable/help assessors to account for all significant hazards, incl. physical hazards and hazards associated with the presence of large crowds and especially those concerning behaviour.</td>
<td></td>
</tr>
<tr>
<td>- Should be sufficient to deal with complex venues.</td>
<td></td>
</tr>
<tr>
<td>- Encourage wherever possible inputs from other sources, e.g. the front line staff.</td>
<td>- The systematic and comprehensiveness of HAZOP type approach and other such techniques for detailed in-depth analyses of a complex system/set of activities.</td>
</tr>
<tr>
<td>- The simplicity of the “walk through” type approach, e.g. venue inspections/audit.</td>
<td></td>
</tr>
<tr>
<td>- The pro-active, forward looking &amp; thought provoking nature of HAZOP type approach, brainstorming and keywords.</td>
<td></td>
</tr>
<tr>
<td>- The ability of HAZOP type approach and brainstorming to draw together different views and experience.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Risk evaluation</strong></th>
<th>Qualitative approaches such as</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Should be systematic.</td>
<td></td>
</tr>
<tr>
<td>- Should reflect both likelihood &amp; severity of consequence and enable establishment of the overall risk on that basis.</td>
<td></td>
</tr>
<tr>
<td>- Should be sufficient to cover the full spectrum of crowd safety risks, ranging from very small risks to major disasters.</td>
<td></td>
</tr>
<tr>
<td>- Enhance the reliability and consistency of the risk estimation process.</td>
<td>- Risk rating.</td>
</tr>
<tr>
<td>- Verbally/assessment by words (Section 2.3.4).</td>
<td></td>
</tr>
<tr>
<td>- Risk matrix or simple equation to combine likelihood and severity.</td>
<td></td>
</tr>
<tr>
<td>- QRA and semi-quantified techniques are unsuitable for reasons given in Sections 2.3.4 &amp; 6.2 respectively.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Decide remedial measures</strong></th>
<th>- Identification of causes &amp; consequences during hazard identification (as in human error analysis and similar techniques).</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Should be a risk based decision.</td>
<td></td>
</tr>
<tr>
<td>- Should enable prioritisation of risks and remedial measures.</td>
<td></td>
</tr>
<tr>
<td>- Should require/encourage assessors to take into consideration the causes and the consequences of the risks.</td>
<td>- Risk-based approach (Sections 2.3.3 &amp; 2.4).</td>
</tr>
<tr>
<td>- ALARP principle and TOR framework (Section 2.3.2).</td>
<td></td>
</tr>
</tbody>
</table>

In accordance with the risk assessment principles set out in Section 2.2, the prototype methodology covers all key elements of risk assessment, from hazard identification to reviewing and revising the assessment. In order to develop a suitable risk assessment for crowd safety, the methodology and the assessment methods for each element were designed to:

- comply with the risk assessment principles and the relevant legal requirements;
- fulfil the criteria set out in Section 5.3;
• deal with all significant risks associated with crowd safety in public venues, such as those highlighted in the case studies in Chapter 3; and
• address the needs of the assessors and the problems and constraints they face, as identified in the literature review in Section 2.6 and the venue survey in Chapter 4.

The general guidance on risk assessment given by the HSC and HSE (e.g. HSC, 1992; HSE, 1994) was used to form the foundation of the prototype methodology. This was supplemented with ideas drawn from risk assessments elsewhere in other contexts and modified to make it appropriate to crowd safety risks. The HSC/HSE guidance by the HSC/HSE was chosen for several reasons. Firstly, it is very much in line with the risk assessment principles. Secondly, it ensures that the prototype will comply with the relevant legal requirements. As the main enforcing agency of these requirements, the HSE can be regarded as the authority on this matter. Thirdly, the guidance is easy to use. It is designed for office environments, general industrial premises and the like where assessors face similar constraints as venue assessors, such as resource and time constraints and insufficient expertise for sophisticated risk assessments. Fourthly, this guidance is readily available and therefore should be familiar to any competent safety practitioner or assessor. Finally, variations of the risk assessment method given in the guidance have been applied to a wide range of applications. For example, fire safety (e.g. Home Office, 1994), railways (HSE 1994c), fairgrounds and amusement parks (HSE, 1997) and in government departments (HSE, 1996a).

“Tools” were developed specifically to provide help in certain assessment tasks. They included a set of keywords for hazard identification, a complete risk rating scheme for risk evaluation and a form for recording risk assessment findings. The methodology was presented in the form of a guidance document that guides the reader through each part of the assessment. The first draft of the document is presented in Appendix D. It consists of two sections: an introduction to risk assessment and the crowd safety risk assessment methodology. The venue survey in Chapter 4 found that there were a general lack of understanding and misunderstanding amongst venue assessors on risk and risk assessment. Therefore, the purpose of the introduction section is to explain what a risk assessment is all about. It also defines the key terms used in the document
and provides the necessary background information and advice (e.g. who should carry out the risk assessment, recommend the involvement of others such as front line staff and other bodies involved). The methodology section contains a complete assessment methodology with associated guidance and recommendations, assessment “tools” and work examples. The document was then subjected to a series of appraisals, described in Chapters 8 and 9.

7.2 The Overall Approach to Crowd Safety Risk Assessment

The literature review in Section 2.2 has identified the following four basic elements of a risk assessment:

- Hazard identification.
- Consequence analysis.
- Risk estimation/evaluation.
- Decision making for risk management.

By examining the nature of crowd safety risks, it becomes apparent that merely finding out what hazards are may not be enough for risk evaluation and decision making. Crowd safety is a complex problem; this is of evidence in numerous studies and from the experience of many people (e.g. Williams & Hopkinson, 1976; Hillier & Hanson, 1984; Canter, 1985; Sime, 1988 & 1993; Proulx, 1991 & 1991a; Moore, 1992; Au et al, 1993; the Building Research Establishment, 1993; Cullen & King, 1993; Wanless & Stanton, 1994). The case studies in Chapter 3 and past incidents (e.g. Fennell, 1988; Lord Justice Taylor 1989 & 1990; Donald & Canter, 1990; Bokhary, 1993; Dicky, 1993) have shown that crowd safety problems could be caused by a variety of factors such as crowd size, crowd dynamics, spatial layout, crowd distribution, behaviour and activities, external factors, etc. What is important about a complex problem is that its risks and the solution are not necessarily immediately obvious. For a tripping hazard, a piece of machinery or a hazardous substance, the dangers are clear for all competent safety practitioners to see, and the solution is usually obvious. For a complex problem, however, it is necessary to analyse and
establish a good understanding of the problem in order to appreciate the risks and identify the appropriate solution.

In this regard, parallel may be drawn between crowd safety and human errors. Firstly, human activities, behaviour and their interaction with the environment are significant to both cases. Secondly, in human error, a “not done” (e.g. operator fails to do a task that he ought to do) could also be due to a whole host of reasons. Various taxonomies were developed by different authors to account for these reasons; e.g. error-producing conditions (Williams, 1988) and performance shaping factors (Whalley, 1997). These are all methods for identifying what contribute to the errors, or the error causes. It is important to understand what causes the error, for different contributory factors would require different solutions. Therefore, in human error, the analysis methods require the identification of not only what errors could arise but also their causes (Kirwan, 1994). A similar requirement can also be found in assessment methods for complex systems (e.g. fault tree, event tree and root cause analysis). For the same reason, there should be a similar requirement in crowd safety risk assessment to identify the cause(s) of the hazards.

Apart form identifying the causes, it is also necessary to identify any precautions that are already in place. In some cases, the risk posed by a hazard may have already been controlled to varying degrees by deliberate measures or the circumstance. This needs to be taken into account in risk assessment. Existing precautions could also have an impact on deciding what further actions need to be taken to reduce risks.

The crowd safety risk assessment methodology should therefore contain the following steps:

**Step 1:** Identify hazards.

**Step 2:** Identify causes, consequences and who might be harmed.

**Step 3:** Decide whether existing precautions are adequate.

**Step 4:** Evaluate risks.

**Step 5:** Decide what further actions might be required.

**Step 6:** Record assessment findings.
Step 7: Review and revise assessment.

Steps 6 and 7 are in line with the HSE guidance (HSE, 1994 & 1998). They are here to make the risk assessment complete and ensure that the methodology complies with the legal requirements. Step 7 is also to ensure that the risk assessment remains “alive” and valid and any changes in venue design, practice, the circumstances, etc. that could affect the risks are adequately taken into account.

These seven steps represent a logical sequence of assessment; namely, to find out what problems could arise and why; to establish who and how people might be harmed; to identify what precautions are in place that may have already controlled or reduced the risks; to work out what the residual risks are; to decide what more needs to be done, to record the findings and to review the assessment when necessary.

The principles of this methodology are the same as risk assessments elsewhere and those identified in Section 2.2 of the literature review. The key difference between this and the HSE approach (1994 and 1998) is that the former also requires assessors to identify the causes and consequences of hazards (i.e. Step 2). The reason for identifying the causes has already been explained in a previous paragraph. The identification of consequences would give assessors additional guidance for determining the severity of a hazard and thus its risk. More details about this and other steps of the risk assessment methodology will be discussed in the remaining parts of this chapter.

7.3 Methods for Specific Crowd Safety Risk Assessment Tasks

Much effort has been devoted to the details of the prototype methodology to ensure that it is appropriate to the nature of crowd safety risks and addresses the assessors’ needs identified earlier. The main focus was on hazard identification (Step 1) and risk evaluation (Step 4), as they were found to be the two key areas of risk assessment where the assessors require the most help.
7.3.1 Identify Hazards

The hazard identification method in the prototype methodology document consists of two key elements: (i) if the venue is large and complex, it should be broken down into a number of smaller and more manageable sectors, then (ii) decide what hazards could arise at each sector. The idea behind this is essentially the same as that of other hazard identification methods elsewhere, i.e., to divide a large and complex system or process or human operation into smaller elements and then to account for hazards in each element.

Deciding on a suitable hazard identification method

Section 6.1.2 has explained why it is best to account for hazards in terms of venue sectors. What is still required is a method which can best assist the assessors to account for the types of hazards that could arise in public venues. It is important that the method should not only be theoretically sound but also practical and easy to use, i.e. criterion (c) identified in Section 5.3. Trade-offs have to be made between what is best in theory and what is usable to the majority of the end users of the methodology. This means that consideration must be given to the various constraints identified in the survey and what crowd safety assessors are capable of using. It is this philosophy that underlines the development of this and other parts of the methodology.

At the initial stage of developing the hazard identification method, consideration was given to adopting a highly structured method similar to HAZOP II (i.e. the version of HAZOP for detailed assessment of complex systems). The review on existing hazard identification methods has pointed to a HAZOP type technique as one that processes the most features required to fulfil the criteria. The main benefits are that firstly it is highly systematic and comprehensive; secondly it is pro-active and thought provoking and therefore encourages forward looking and foresight; and thirdly it brings together different views and experience. HAZOP II is a highly structured method. It consists of two sets of keywords to assist the assessors to pinpoint specific hazards. They are the “property words” which identify the different properties of the system component concerned (e.g. temperature, pressure) and the “guide words” which outline how these
properties could deviated from the design intention. Under this method, a hazard can be described through a combination of property word and guide word (e.g. “pressure” and “too much”). Adopting the same feature, a “combined keywords” approach was developed. The keywords are shown in Figure 7.1 and details are given later in this section. The “combined keywords” approach was the hazard identification method given in the prototype methodology.

However, it is worth mentioning that the decision for using the “combined keywords” approach was reversed and the hazard identification method was significantly revised in the later versions of the methodology. Following the user trials in Section 8.3 and upon subsequent consideration, it was concluded that such a method is probably over complicated for the users and too refined to apply to public venues operations. There could be two reasons for this. The first reason is similar to that discussed in Section 6.1.2 for task analysis and human error analysis. Namely, a highly structured method is only suitable where things (e.g. a system, a component, an operation) can be clearly defined, their functions well understood and, perhaps more importantly, the manners in which a failure could occur are limited and can be described through a short list of keywords. For example, for an engineering failure, temperature and pressure can only be either too high or too low. A valve can either be failure to open/close or open too much/not enough. However, as previously discussed in this thesis, the “failure modes” for crowd safety can be much more wide ranging. In order to try to capture all these wide ranging failure modes, the initial “combined keywords” approach ended up with several sets of keyword combinations for physical/venue design hazards, hazards concerning the presence of large crowds and crowd behaviour and safety management related hazards. When applied in practice, it was found that such an approach simply made the hazard identification method cumbersome and time consuming to use.

The second reason is that the vast majority of assessors are not familiar with this type of highly structured method. HAZOP II is intended for engineers but venue assessors tend to deal with problems of a very different nature and they work in a different way. To cope with problems that are, in general, more wide ranging, less predictable and less well understood, as revealed in Section 2.6 and the venue survey in Chapter 4, hazard identification has often been done in a loosely structured/unstructured manner.
Whilst there are shortfalls with the current practice and there is scope for a better structured and more systematic method, a big leap forward from their current position to a highly structured and highly refined method is a totally new concept involving a huge change in convention. This is likely to have some adverse implications. For example, it may be far too daunting for many assessors. Consequently, they may simply dismiss it as an overcomplicated method unsuitable for their applications. Another danger is that assessors may revert to what they are familiar with and apply the method incorrectly. These problems were of evidence in the user trials in Section 8.3. Whilst it may seem that such problems are only practical issues unrelated to what is best in terms of risk assessment, it is well worth noting that, from a human error view point, unfamiliarity is regarded the biggest error contributory factor (i.e. Williams, 1988). A method that causes human errors when applied will not fulfil the requirement that risk assessment should identify all significant risks, no matter how theoretically superior it may seem.

Eventually, a keyword approach not dissimilar to that used in HAZOP I (intended for a more high level assessment, e.g. during conceptual design) is adopted. Although it is less refined, the keyword approach is still reasonably systematic and comprehensive, and it is forward looking in nature. At the same time, it is more suitable for systems that are loosely defined. It is fairly simple, easy to use, much more compatible with existing practice and therefore does not involve a steep learning curve. Consequently, it could be more widely adopted and with less danger of the method being incorrectly applied. It is also less time consuming and resource intensive to do. The keywords can be used as prompters in a HAZOP I type brainstorming approach, thus retaining the benefit of the initial method in terms of bringing together different views and experience in risk assessment.

The revised method could still be a bit more time consuming than the non-systematic methods currently in use in many venues. However, the extra effort required may be marginal once assessors are familiar with the method. Also, it is applicable to existing as well as brand new venues, thus fulfils criterion (d) in Section 5.3.
Develop keywords for hazard identification

This sub-section looks at the development of the keywords for the original “combined keywords” approach. As mentioned in previous paragraphs above, subsequent to the user trials of the methodology this was changed to the more conventional single set of keywords type approach. Although the method itself had been changed thus resulting in a more concise set of keywords being produced, some of the keywords remain the same. The rationales behind the keywords for either approach also remain unchanged. Namely, (i) they are to provoke thoughts and to prompt assessors to think about what hazards could arise in their particular venues; and, to achieve this, (ii) they are generic rather than prescriptive and are intended to direct thoughts into different directions or types of hazards; and hence (iii) they cover all significant types of hazards that could arise in a public venue.

The keywords were developed based on the findings in Chapter 3 and information on crowd safety from other sources. For example, major incident reports (e.g. City of Cincinnati Task Force on Crowd Control and Safety, 1980; Taylor, 1990; Bokhary, 1993), the venue survey in Chapter 4, records of venue visits and interviews carried out for a previous research (i.e. Au et al, 1993), guidance document (e.g. Committee on Public Safety and Crowd Control, 1990; Home Office/Scottish Office, 1990; HSC et al, 1993; National Outdoor Events Association, 1993; HSE, 1996; HSE 1997) and other publications (e.g. Canter, 1985; Proulx, 1991; Sime, 1991; Sime, 1993; Au et al, 1993a; Dickie, 1993; Au and Carey, 1994; Dickie and Meghji, 1994 and Wanless and Stanton, 1994). It was concluded that, generally, crowd safety hazards could arise from the following factors: (i) venue layout and features, (ii) visitors and their behaviour, (iii) adequacy of crowd safety management, (iv) presence of hazardous substances or items and (v) disruptions to normal operations.

The “venue feature keywords” and “hazard keywords” shown in Figure 7.1 are given to help assessors to account for hazards associated with the venue design. The former identifies the features that could be found in a venue whereas the latter describes how these features could give rise to a safety hazard. Hazard identification can be done by applying suitable combinations of the venue features keywords and hazard keywords.
Similarly, a set of “behavioural keywords” was developed to help assessors to account for hazards associated with the visitors and their behaviour. It is also shown in Figure 7.1. This set of keywords describes the types of activities and behaviour that have the potential to cause harm. Again, the identification of such hazards and where they may arise can be done through combinations of venue feature keywords and behavioural keywords.

**Figure 7.1: Hazard Identification Keywords**

<table>
<thead>
<tr>
<th>VENUE FEATURE KEYWORDS</th>
<th>HAZARD KEYWORDS</th>
<th>BEHAVIOURAL KEYWORDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>Insufficient: capacity</td>
<td>Uneven distribution</td>
</tr>
<tr>
<td>Access route</td>
<td>Insufficient: quantity</td>
<td>High crowd density</td>
</tr>
<tr>
<td>Entry/exit point</td>
<td>Insufficient: quality</td>
<td>Disruption to a stationary crowd</td>
</tr>
<tr>
<td>Flooring/underfoot</td>
<td>Obstruction: access</td>
<td>Rapid crowd flow</td>
</tr>
<tr>
<td>conditions</td>
<td>Obstruction: view</td>
<td>Cross flows</td>
</tr>
<tr>
<td>Slope, stairway,</td>
<td>Pinch point/funnelling effect</td>
<td>Disruption or obstruction to a crowd flow</td>
</tr>
<tr>
<td>escalators, lifts, etc.</td>
<td>Unguarded</td>
<td>Non-compliance</td>
</tr>
<tr>
<td>Step, kerb, ramp, etc.</td>
<td></td>
<td>Dangerous behaviour</td>
</tr>
<tr>
<td>Bank and edge</td>
<td></td>
<td>Aggressive behaviour</td>
</tr>
<tr>
<td>Wall, pillar, post,</td>
<td></td>
<td>People with special needs</td>
</tr>
<tr>
<td>bollard, fence, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furniture/street</td>
<td></td>
<td></td>
</tr>
<tr>
<td>furniture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>construction work</td>
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</tbody>
</table>

The principle behind this “combination of keywords” approach works the same as the HAZOP II technique described earlier in this section. This was an initial attempt to impose a firm structure to hazard identification in order to make it more systematic and comprehensive. The problems with such a highly structured method have already been discussed. However, these problems were not fully recognised at the time when this prototype was developed. The focus was to incorporate into the methodology the highly systematic and comprehensive features that make HAZOP II such a successful technique. The problems only became apparent after the method was evaluated using actual assessors. This was subsequently replaced by a single set of keywords.
As discussed in the literature review in Section 2.3.5, apart from the “technical” aspect such as crowd dynamics, crowd behaviour and physical aspects, the management aspect is also an important consideration. For example, Smith (1999) argued that many failures and crises merge from an organisation’s system of management and Pidgeon (1997) suggested that many disasters in large scale technological systems cannot be described purely in technological terms. To cater for the management factors, a list of safety management keywords was also included in the methodology. They are shown in Figure 7.2.

Unlike those concerning the venues and the visitors, hazards arising from poor crowd safety management can affect the entire venue and, therefore, cannot be addressed by means of venue features. A different approach was adopted where a different set of keywords was used. The aim of the keywords was to highlight the key issues that need to be considered during risk assessment and planning.

### Figure 7.2: Safety Management Keywords

<table>
<thead>
<tr>
<th>SAFETY MANAGEMENT ISSUES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff roles and responsibilities</td>
<td></td>
</tr>
<tr>
<td>Command and communication</td>
<td></td>
</tr>
<tr>
<td>Co-operation and co-ordination with other bodies</td>
<td></td>
</tr>
<tr>
<td>Monitoring of crowds</td>
<td></td>
</tr>
<tr>
<td>Staffing levels</td>
<td></td>
</tr>
<tr>
<td>Staff selection and training</td>
<td></td>
</tr>
</tbody>
</table>

The keywords in Figure 7.2 cover many of the safety management issues identified in earlier research by Au et al (1993); i.e., structure, communication, monitoring, liaison, and staffing. These issues are more specific to everyday public venue operations and, therefore, are more suitable as keyword prompters. Nevertheless, considerations were also given to the more generic management issues such as those highlighted by Elliott and Smith (1993). From their case studies of four football ground disasters, they identified management beliefs/mindset, costs, inter-organisational communication and culture as the four important factors affecting crisis incubation. Similarly, in the wider context of crises in organisations and man-made disasters, Smith (1995)
identified four principal organisational elements; they are: strategy, structure/organisation, culture and core beliefs/assumptions.

In the context of crowd management, the issues of organisational structure and inter-organisational communication are covered in the keywords “roles and responsibilities” and “command and communication”. The latter includes issues such as command and communication structure and means of communication. As many public events involve many agencies and bodies, “co-operation and co-ordination with other bodies” is also an important aspect of structure and communication. “Monitoring of the crowds” is a safety management issue that is relevant specifically to crowd safety; although in a wider context, monitoring is a part of an information gathering system; which helps to keep people informed about the crowds, their behaviour, how they interact with the venue and any particular problems and incidents. Reason (1998) argued that information and keeping people informed is a key factor to improving safety culture.

Currently, crowd management is a hands-on and labour intensive business that cannot be “automated”. Technology (e.g. CCTV) can assist and make the tasks of managing crowds easier and more efficient, but essentially the success of the operation relies very much on the staff. “Staffing level” is therefore an important issue. “Staff selection and training” is also important in ensuring that people have the abilities and know-how to do their parts in managing crowd safety. Again, in the wider context, Smith (1995) highlighted the issue of staff recruitment and training as a possible factor to break the cycle of compliancy and barriers to learning within an organisation. The tendency for managers to select people who share the same views could make it difficult for them to accept any challenges to their core belief, as those “organisational irritants” will not be present within the organisation in sufficient number to question the underlying logic of the managerial decisions taken.

No keywords or other assessment tools are provided for the identification of hazards associated with hazardous substances/items and disruptions to normal operations. In the case of hazardous substances, this is because guidance is already available in other HSE publications (e.g. guidance on COSHH). This guidance is equally applicable to
public venues. In the case of disruptions, it is because the deviations that could take place and their effect on operations and safety tend to be venue specific. Hence, for a methodology intended for a wide range of venues, only general guidance and a list of possible scenarios were provided.

7.3.2 **Identify Causes, Consequences and Who Might be Harmed**

Although the identification of causes and consequences (i.e. Step 2) is not required in many existing methods, it is believed that its inclusion will make the assessors give more thought about the nature of the hazard and to obtain a better understanding of it. Information about the causes and the consequences of a hazard will better equip them to estimate the risk and decide remedial measures in Steps 4 and 5 of the assessment. For example, the identification of causes would prompt the assessors to think about the underlying cause of a hazard, thus helping them to identify remedial actions that do not only superficially deal with the symptom but also address the source of the problem. The identification of consequences can serve two purposes: to enable the assessors to estimate the severity of a hazard in a less ad hoc manner and to help them to identify the measures needed to protect people against the harm. To consider who might be harmed can also help the assessors to decide whether any visitor groups require more attention and/or special safety provisions.

The possibility of providing some form of assistance, such as keywords or a checklist, for the identification of hazard causes was considered. However, this idea was ruled out eventually because the factors affecting crowd safety are venue specific and wide ranging. They can also vary in different circumstances. Therefore, it is not possible to capture all potential factors. Even if this were possible, a comprehensive set of keywords or a checklist is likely to be far too big to be useful in practice. Perhaps it is also worth noting that there is no such provision in HAZOP. However, in the case of human error analysis, there are schemes available for the identification of error causes; e.g. the performance shaping factors classification and Potential Human Error Cause Analysis (PHECA) system (e.g. Whalley, 1987; Whalley, 1998 and Kirwan, 1995). Factors or error mechanisms are categorised and presented in hierarchical form in both schemes. In crowd safety, a summary of “contributory events” is also
given by Au et al (1993). They are grouped into five categories; namely, equipment failures, design limitation, staff errors, combined activities and undesirable circumstances. Both the human error schemes and the summary of crowd safety contributory events are huge. Whilst useful for people to cross reference to if deemed necessary, they are far too big to be a part of an assessment methodology.

7.3.3 Decide Whether Existing Precautions are Adequate

To keep the risk assessment simple, Step 3 enables the assessor to disregard the trivial risks and those that are already adequately controlled. Criteria are provided to help them to exclude from the assessment those hazards that are either extremely unlikely to occur or do not cause any real harm to people. Step 3 also requires the assessors to identify any measures that are already in place and the circumstances, so that their effect is also taken into consideration when estimating risks.

7.3.4 Evaluate Risks

The risk evaluation stage is where the assessors establish how serious the hazards are. Following the literature review in Section 2.3, it has been concluded (Section 2.7) that decision making on safety provisions should be risk-based. The risk based approach, together with the ALARP principle and the TOR framework will provide guidance to enable assessors and venue owners and managers to decide the level of care required to make their venues as safe as reasonably practicable to the visitors. This is also in line with the HSC guidance (1992) on the legal requirements on risk assessment.

Risk evaluation should, therefore, be done in terms of likelihood of harm and severity of the consequences. As it is impossible to quantify likelihood and severity, the QRA techniques, though well established, cannot be applied to crowd safety. Amongst the other techniques reviewed in Section 2.4 and discussed in Section 6.2, semi-quantified methods are very arbitrary and fundamentally flawed. Instead, rating is thought to be the most appropriate method for risk evaluation. It has already been widely used in all sorts of applications including risk assessments. It is a method that is well understood and familiar to everyone. Rating also has the potential to fulfil all the risk evaluation
criteria set out in Section 5.3. A risk rating scheme was therefore developed. In line with the risk based approach, the scheme contains two separate rating scales, one for estimating likelihood and the other for estimating severity.

An issue that is still outstanding and needs to be resolved is how big each of the rating scales should be. As identified in previous chapters, the key criteria are that they should be big enough to cover the full spectrum of risks but small enough to make it simple, easy to use and enhance consistency and reliability in risk estimation. There appears to be no consensus on how big the scale should be or what the appropriate number of anchor points should be in a risk evaluation rating scale. Reviews of current practice and existing techniques (in Sections 2.4 and 2.6 and Chapters 4 and 5) have found that existing rating scales range from three to six points. A three-point scale appears to be the favourite. It is suggested by the regulators (HSE, 1989; HSC, 1991; HSE, 1992c) and by others (e.g. Cohen, 1982; Kletz, 1988a) alike that risks should fall into one of three levels; e.g. low, medium and high. Applying the ALARP principle and the TOR framework, this could mean that at the bottom level, the risks are small or negligible and require little or no further mitigating actions. At the top level are the high risks that should not be tolerated and something has to be done about them. In the middle are risks that are significant and require some attention.

A three-point scale is simple and it is easy to use. More importantly, the gap between each of the three anchor points should be sufficiently large to ensure consistency and reliability when judging/estimating risks. However, the issue is whether three anchor points are sufficient to cover the full spectrum of eventualities and to enable clear and meaningful distinctions to be made between different levels of likelihood or severity. With this in mind, it was necessary to consider how different levels of likelihood can be reasonably distinguished and, for severity, what the possible outcomes are if people get harmed.

Should a hazard be realised causing harm to people, the outcomes can be expressed in terms of the following. Firstly, how many could be affected; i.e. whether it affects individuals or results in a number of people being harmed at the same time. Secondly, what harm it would cause to those affected. The harm people may suffer has to be
expressed in such a way that it minimises ambiguity. Hence, the following categories of harm were identified: (i) no real harm done; (ii) injuries that only require first aid treatment; (iii) injuries that require hospitalisation; and (iv) fatalities. This is largely in line with how injuries and health problems in the workplace are categorised under the RIDDOR regulations. Combining the two, there are a minimum of five possible outcomes; i.e. ranging from no real harm, individual requiring first aid treatment, etc. to multiple fatalities.

The categorisation of likelihood is more arbitrary. Unlike harm and injuries, it is not possible to express precisely how likely that something is to happen except in terms of mathematical probability. It can be argued that a three-point scale of high, medium or low likelihood, similar to that described a few paragraphs ago, is sufficient. However, it can equally be argued that likelihood rating should also include very rare occasions (i.e. a 4-point scale), for example, for a stadium situated underneath a flight path. It is not inconceivable that a plane may fall from the sky and hit it although the chance of this occurring when it is occupied must be very small. Perhaps a similar argument can also be made for having a five-point scale to include something that is almost certain to happen sooner or later.

In the event, a 4-point scale for likelihood and a 5-point scale for severity were used. This was based on the rating scales adopted in some existing methods (e.g. Ministry of Defence, 1991; Au et al, 1993). It may be argued that, ideally, a 3 or 5-point scale could be used for likelihood estimation. But a trade-off has to be made to ensure that the risk rating scheme will fit in with the ALARP principle used later for determining the cause of action required for each hazard (see Section 7.3.5).

Rating is subjected to biases. The most common problems are the leniency effect and the halo effect. The leniency effect refers to the unwillingness of the respondents to be critical and hence the tendency of not selecting from either end of the rating scale. The halo effect is where the respondents have already decided that certain entities are better or worse than others and subconsciously adjust their rating to demonstrate this (Sinclair, 1995). The requirement to determine risk levels by considering likelihood and severity separately should help to reduce the halo effect. In addition, to safeguard
against this and the leniency effect, rather than assigning a number or an alphabetical label that carries no meanings, each anchor point is given a descriptive label (such as “likely”, “possible” and “catastrophic”, “severe”, etc.) so that each point on the rating scale signifies something different. As discussed in Section 2.3.4, Moore (1993) has argued that words do not have a generally agreed or accepted meaning, they are useful only if the writer and the readers agree on the meanings ascribed to them. Therefore, to underpin the meanings of the labels and to further avoid these biases, a definition is also assigned to each anchor point. All definitions are written in such a way to avoid arbitrary judgement. For example, the severity rating anchor points are defined in the manner described previously (e.g. no real harm, injuries requiring first-aid treatment, etc.). The definitions for the likelihood rating scale reflect both past experience about the hazards and how likely it is to occur in the future. This is designed to prevent any over reliance on experience and past incidents for the likelihood estimation.

The second part of the risk evaluation is to bring together the likelihood and the severity rating to establish an overall risk level. To achieve this, a “risk matrix” with the likelihood rating on one side and the severity rating on the other was used. No figures are used throughout the evaluation method. Section 6.2 has already discussed some of the problems associated with semi-quantified methods. Similarly, the reason for avoiding the use of figures all together is that people tend to perceive them as real numbers and put values to either the rating or the risk level.

7.3.5 Decide What Further Actions Might be Required

Having determined the level of risk for each hazard, the aim of Step 5 is to decide what actions need to be taken to manage the risks. The remedial measures will depend upon the nature of the risks, the causes and consequences identified in Step 2. The issue is how to prioritise these measures and hence what actions to take. The literature review in Section 2.3 has discussed some of the basis for decision making. It suggests that the ALARP principle appears to be more appropriate overall to crowd safety. On the basis of this principle, Figure 7.3 is given in the prototype methodology to help assessors to decide the appropriate level of care for each risk:
Figure 7.3: Interpretation of Risk Levels Given in the Methodology Document

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Intolerable risk. Immediate action(s) must be taken to eliminate the hazard or to eliminate its source, regardless of the cost.</td>
</tr>
<tr>
<td>B</td>
<td>Should not be tolerated unless risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained.</td>
</tr>
<tr>
<td>C</td>
<td>Should not be tolerated unless the cost of risk reduction exceeds the improvement gained.</td>
</tr>
<tr>
<td>D</td>
<td>Broadly acceptable risk. But risk reduction should still be made if an inexpensive measure can be found.</td>
</tr>
<tr>
<td>-</td>
<td>Trivial risk. No further actions required.</td>
</tr>
</tbody>
</table>

7.3.6 Record Assessment Findings and Review and Revise Assessment

In terms of Steps 6 and 7, there are no differences between the crowd safety risk assessment and a general health and safety risk assessment. The same requirements apply and the difference in the nature of the operation should have no significant effect on these parts of the assessment. As such, the guidance given here simply echoes that already given elsewhere (e.g. the “5 Steps to Risk Assessment” booklet published by the HSE (1992)). In addition, a sample “Crowd Safety Risk Assessment Record Form” is provided for recording the assessment findings. It is attached at the back of the methodology document.

7.4 Conclusions

The prototype crowd safety risk assessment methodology was developed based on information generated in previous chapters. In the course of the development, there were several methodology issues that need to be addressed; particularly with regard to the overall method and those concerning hazard identification and risk evaluation. In terms of the overall method, it was decided that it should follow the principles and use the guidance set out by the HSC/HSE as basis of the prototype; the same principles were also adopted by most existing risk assessment methodologies in other contexts. At the same time, it was also felt that assessors would benefit from the inclusion in the methodology of an extra assessment step of identifying the causes and consequences...
of a hazard. The information generated in this step should help assessors to better identify the remedial measures that tackle the source of a problem and to give them additional guidance for determining the severity of a hazard, and hence its risk. The prototype therefore consists of seven steps: identify hazards; identify causes, consequences and who might be harmed; identify existing precautions and decide if they are adequate; evaluate the remaining risks; decide what remedial measures are to be required; record the findings of the risk assessment; and review and revise the assessment.

A key issue in hazard identification was to find a method which could best assist the assessors to account for the types of hazards that could arise in a public venue context. The method has to be theoretically sound and workable in practicable. The review in Chapter 6 has revealed several highly structured methods that are comprehensive and very systematic. HAZOP was found to be most suitable in terms of fulfilling most of the criteria set out in Section 6.3. HAZOP II in particular is highly structured and is suitable for detailed assessments. However, upon further consideration and bearing in mind the nature of venue operations and the current practice, it is concluded that such a method could be unduly complicated when applied to the crowd safety context and would be too daunting for most assessors. In the event, the less structured and more conventional keyword approach was adopted. This involves the use of keywords as "prompters" to provoke thought on what problems could arise at different parts of a public venue. When used by a team of people in a brainstorming, the keywords can provide the necessary keyword prompters for a HAZOP I type assessment. HAZOP I is often used at the design stage when things are loosely defined, whereas HAZOP II tends to be used on things that are well defined and the functions of the system or the operational activities are well understood.

Keywords were then developed based on information obtained in the two case studies in Chapter 3, the venue survey and a review of past projects, major accident reports, guidance document and technical papers on crowd safety and related subjects. Three sets of keywords were developed initially to assist the assessors to account for hazards associated with venue design, visitor behaviour and crowd safety management. A list of possible scenarios was also provided to help the assessors to think about problems
that could arise following a disruption to the normal operations. The remaining key hazard contributory factors; namely hazardous substances/items are already covered in other guidance and therefore not to be repeated in the prototype methodology document.

A review of the existing methods and techniques suggests that rating schemes are by far the most widely used qualitative method for risk evaluation and it has the potential to fulfil all of the risk evaluation criteria set out in Section 5.3. The issue is how big the rating scale should be. 3-point scales appear to be most popular amongst the existing methods. Such a scheme is also recommended by the regulator (i.e. the HSE) for workplace risk assessment. However, it was concerned that this may be too crude for crowd safety risks. The key criteria are that the rating scale should be sufficient to cover the full spectrum of eventualities and enable clear and meaningful distinctions to be made between different levels of likelihood or severity. Considerations were therefore given to establish how likelihood can be categorised and, for severity, what the possible outcomes are if people get harmed. In the event, a 4-point rating scale for likelihood and a 5-point scale for severity were used. In order to minimise bias due to the “leniency” effect and the “halo” effect, a description of likelihood or severity was assigned to each anchor point. No figures were used in the rating to avoid them being mistakenly perceived as real numbers and turned the method into a “semi-quantified” approach. Similar to other qualitative methods elsewhere, a risk matrix system was developed to bring together the likelihood rating and severity rating to give an overall risk level.

The methodology was presented in the form of a guidance document and is shown in Appendix D.
CHAPTER 8
EVALUATION OF THE PROTOTYPE CROWD SAFETY RISK ASSESSMENT METHODOLOGY DOCUMENT

Following the production of the prototype crowd safety risk assessment methodology document, a series of tests were carried out to appraise it. The appraisal programme contains two key elements: (i) evaluation to determine what improvements can be made to the prototype methodology and the document in which it is presented, and (ii) verification of the methodology to prove that it inspires a better crowd safety risk assessment. Figure 8.1 gives an overview of the appraisal programme.

Figure 8.1: An Overview of the Appraisal Programme

Prototype Public Safety Risk Assessment Guide

Usability Test

Revise Text

Combined Validity and Usability Test

Produce Draft Assessment Guide

Comparison Between New and Existing Methodology

Fine Tune Assessment Guide

End
The appraisal programme consists of the following: a usability test; a combined validity and usability test and a comparison between the new and existing methodologies. The first two tests formed the evaluation part of the appraisal programme. The methodology document was revised after each test. The final document was then subjected to the third and final test for verification. This chapter concentrates on the evaluation of the prototype methodology document. In particular, Section 8.1 discusses the constraints associated with the appraisal. Section 8.2 looks at the design of the evaluation programme, Sections 8.3 and 8.4 describe the usability test and the combined validity and usability test respectively and presents their findings. The verification part of the appraisal programme will be covered later on in Chapter 9.

8.1 Methodological Constraints

The evaluation of the prototype methodology can serve two purposes: to identify scope for further improvement and to minimise the effect of any variables that are irrelevant to the research question in hand. In this case, it is the user interface issue (i.e. how the methodology is presented). The interest of this research project is on how useful the methodology is rather than how user-friendly the methodology document is. But, the two issues are often intertwined and need to be separated for the verification. Also, the user interface aspects of the methodology must be of a high quality for it to be found useful in practice.

Ideally, the evaluation should involve a representative sample of the end-users, i.e. the crowd safety assessors, in user trials and obtain their feedback afterwards. However, the feasibility of this method depends upon two factors: (i) the availability of assessors as trial subjects, and (ii) the resources available for the evaluation. The former was proven to be the decisive factor in the case of this research. Getting enough assessors to give a representative sample of all venue types is always difficult, if not impossible. And for those who were willing to take part, many were unable to devote the time required for a full-scale user trial. Another consideration is that it is necessary to reserve assessors for the verification process. Using assessors who were already exposed to the “noise” (of the user-interface issues) in the evaluation could bias their judgement on the usefulness
of the proposed methodology during the verification. This further reduced the number of suitable subjects for the evaluation. Because of these reasons, crowd safety assessors were in short supply and had effectively become the most valuable commodity in the context of the appraisal. How to make the best use of them to cover not only the evaluation but also the verification parts of the appraisal programme becomes a key logistic concern.

Given the circumstances, an alternative approach has to be found so that the limited number of assessors available to the author is used most effectively. It also needs to accommodate those assessors who are unable to take part in the full user trials. The use of novice subjects, such as university students, was considered. However, this is unlikely to yield satisfactory results because the methodology document is intended for “expert users”; i.e. assessors who are already familiar with their venues and the sort of crowd safety problems that could arise there. It is not intended as a “knowledge provider” for novices. As such, those who take part in the evaluation must have some understanding of what is being assessed. Otherwise, the use of novice subjects would put in doubt the validity of the evaluation findings. The importance of having subjects who reflect the user population has been stressed by many authors (e.g. McClelland, 1995).

In the event, it was decided that the solution should be to design an evaluation programme which contains two tests: a usability test followed by a combined validity and usability test. The aim of the usability test is to examine the user interface aspect of the methodology document so that the necessary improvements can be made before subjecting it to full user trials. The rational behind this is to use human factors experts, who are not in short supply, to screen out as many usability problems as possible. This is so that in the combined validity and usability test, the crowd safety assessors can focus primarily on the technical aspect of the methodology and not being distracted too much by any major presentational problems.

In order to get round the problem of assessors not being able to spare the time required for a full user trial, it was decided that the combined validity and usability test should contain two separate parts carried out in parallel: i.e. user trials for those who can devote
the time and a questionnaire survey for those who cannot. The advantage of a questionnaire survey is that those who take part do not have to set aside a specific chunk of time for the user trial. Instead, they can comment on the methodology at their own pace on their own time. Although a questionnaire survey is not the most ideal evaluation method, the author felt that it is a worthwhile trade-off to make in order to include the viewpoints of those who would otherwise be unable to take part. In this respect, the quality of the evaluation can only be enhanced by including the survey. The assessors recruited for the user trials and the questionnaire survey were from the authors’ personal contacts and contacts from the HSE.

8.2 Designing an Evaluation Programme

Sanders and McCormick (1987) pointed out that evaluation should be carried out under conditions representative of those where the product is to be used and with subjects representative of the users. With this in mind, the ideal evaluation method for the prototype methodology document would be a user trial. This should involve actual crowd safety assessors to try out the methodology document and use it to carry out trial assessment on their own venues. Observations, “talk-through”, debriefing/discussions, follow-up interviews, questionnaires and analysis of risk assessment records are some of the methods that can be employed during and after the trial to collect information about the prototype (e.g. its usability, difficulties, advantages, disadvantages, assessors’ preferences, etc.). In practice, however, the feasibility of carrying out a significantly large number of user trials was undermined by the constraints identified in Section 8.1.

An alternative approach has to be found whereby a sufficient evaluation can be carried out on a less than ideal number of user trials. There are two aspects of the prototype methodology document: the methodology itself and how it is presented. One way of overcoming the problem is to evaluate them separately. It was therefore decided that the prototype methodology document should be tested for its usability first so that its presentational/user interface could be improved before subjecting it to the full scale user trials involving crowd safety assessors and actual venues. The rational for this decision is, again, explained in the previous section.
8.2.1 Usability Test

Guidance and checklists (e.g. Hartley, 1985; Department of Trade and Industry, 1989; Plain English Campaign, 1993) are available to help authors to make their texts more user friendly. They can be applied here to check the usability of the prototype methodology document. But in addition, it was also important to put the document to the test by independent specialists. The heuristic evaluation technique (Nielsen and Molich, 1990) was therefore selected for this purpose.

Originally designed to evaluate user interface of computer-based systems, heuristic evaluation is an established and a simple technique. It involves the use of evaluators to judge adequacy of a design prototype; they do so based on a set of usability principles (the heuristics). Despite its simplicity, it can be highly capable providing sufficient evaluators are used. Also, it is believed to be one of the most cost-effective evaluation techniques (Nielsen, 1992; Lansdale and Ormerod, 1995). It compares favourably with other techniques such as checklists and walkthrough approaches and can be at least as effective as user trials (McClelland, 1995). Apart from cost effectiveness, a major advantage to this particular research project is that it does not require the involvement of crowd safety assessors. Instead, human factors/usability specialists were used in the evaluation.

Some modifications were made to the original technique so that it becomes more appropriate to the evaluation of a paper-based document. They include converting the list of heuristics and adding a glossary of the heuristics. Section 8.3 will look at the modified technique in detail. Based on their findings, the prototype was revised.

When applied to this particular research project, the heuristic evaluation has one possible drawback. Whilst the evaluators should be able to pick up most of the usability problems, they would do so in a largely human factors or usability viewpoint. Usability problems that are likely to emerge only when actually applying the methodology and those associated with convention within public venue sectors may not be identified under this method. The revised document was therefore subjected to the combined
validity and usability test where both the validity of the methodology and its usability were evaluated by actual assessors.

8.2.2 Combined Validity and Usability Test

In this test, actual assessors were used to try out and comment on the revised methodology document. It aims to find out how workable (i.e. validity) and how “user-friendly” (i.e. usability) the methodology was. In order to maximise the number of assessors involved in the evaluation, it was decided that this test should consist of two separate parts carried out in parallel: a set of user trials and a questionnaire survey where assessors were simply asked to study the methodology document and comment on it by filling in a questionnaire. Although questionnaire survey was not the best evaluation method, it was a worthwhile trade-off to make in order to include the viewpoints of those who were unable to take part in the user trials.

8.3 The Usability Test

In this test, a total of six human factors specialists were employed as evaluators to evaluate the user friendliness of the prototype methodology document, using the heuristic evaluation method. They were:

- Joanna Foulkes Human factors consultant of several years experience
- Julie Goodfield Human factors consultant of several years experience
- Magdalen Page Managing Director, ICE Ergonomics
- Margaret Ryan Human factors consultant of several years experience
- Mike Joy Management and training consultant of several years experience.
- Dr Andrew Shepherd Senior Lecturer, Dept. of Human Sciences, Loughborough University

Each specialist was sent a copy of the document and an instruction sheet. The instruction sheet contained the following:
information about the research, methodology document and who the intended users are;

- instructions on what to do; and

- the heuristic list and glossary, shown later on in Tables 8.1 and 8.2 respectively.

The evaluators were asked to read the methodology document, apply the heuristics provided on the list to evaluate the document and report as precisely as possible, and in their own words, any non-compliance to the heuristics and other usability problems they had identified. They were also asked to be specific about where the problems were found and suggest remedial measures.

8.3.1 The Modified Heuristic Evaluation Method

Because the heuristic evaluation method was originally intended for evaluating user interface of computer-based systems, modification was made to make it more suitable for the evaluation of text. The key feature of the heuristic evaluation method is the keyword prompters called “heuristics” (i.e. usability principles). Nielsen and Molich (1990) have proposed the following heuristics which can be applied when evaluating the interface:

- Simple and natural language.
- Speak the user’s language.
- Minimise user memory load.
- Be consistent.
- Provide feedback.
- Provide clearly marked exits.
- Provide shortcuts.
- Good error messages.
- Prevent errors.

Molich and Nielsen also give a full glossary of the heuristics in the same paper. Some of them are user interface specific and are not applicable to text evaluation. On the other
A modification to the heuristic list is therefore necessary before it can be utilised in this test. Firstly, three of the original heuristics were removed from the list, they are "provide feedback", "provide clearly marked exits" and "good error messages". This is because these heuristics address the kind of interactive features which are irrelevant to paper-based interface (i.e. text). The remaining heuristics concern the presentation of information which are relevant to both computer-based user interfaces and paper-based interfaces. They have therefore been kept on the list.

The next step was to add to the list usability principles that are appropriate to the evaluation of text. Hartley (1995) pointed out that readers come to text for many reasons and they might wish to read in detail, skim, search and look back/ahead. Wright (1981) also recommended that the text should be well structured to allow readers to jump about, to look for specific information and to consult it only when they have a query. Similarly, in our context, assessors might use the guide in a number of ways. Initially they might want to find out more about risk assessment and how it can be applied to crowd safety. They might then use it more extensively to assess their venues. Some might also use it to find out how they can improve their existing assessment or to identify ways of tackling any problems they have experienced (e.g. how to assess behaviour, how to estimate the risks of a rare event). Once they become familiar with the methodology, the readers might refer to the document for specific information or a quick consultation. To enable users who might use the document for different purposes to find their way around easily and to locate specific information quickly (i.e. to "allow quick search and easy navigation") is an important usability principle and should therefore be included in the new heuristics list.

Usability issues are identified and checklists for evaluating text are provided in different literature sources (e.g. Broadbent, 1977; Wright, 1981; Hartley, 1985; Pintrich et al, 1986 and Department of Trade and Industry, 1989). Many of them are rule-based. They cover a variety of usability topics, ranging from information organisation to typographic considerations. For our purpose, only those that are not in the original heuristic list were looked at. They can be summarised as follows:
- Provide accurate and comprehensive information.
- Provide appropriate information - should take into account users’ capability and limitations in physical, cognitive and psychological domains. Should also identify the problems users might encounter when applying the information and suggest appropriate solutions.
- Avoid ambiguity - provide understandable and clear information.
- Provide well structured information - so that the users who use the document in different ways can navigate easily. This includes signposting, cross referencing, etc.
- Provide visible and legible text - typographical considerations such as appropriate text size, spacing, line length, margins, etc.
- Give suitable illustrations - use illustrative materials (e.g. pictures, examples) to help clarify the message, they should be placed appropriately and clearly distinguishable from the main text.

The first two of the above concern both the usability and the validity of the methodology document and cannot be adequately evaluated without actually applying it. They were therefore assessed later in the user trial part of the combined validity and usability test. The third principle is essentially the same as “allow quick search and easy navigation” mentioned previously. This and the remaining four principles were added to the list. Table 8.1 shows the revised list of heuristics used in this test. A glossary of the heuristics is provided in Table 8.2. It is partly based on that given by Molich and Nielsen (1990).

<table>
<thead>
<tr>
<th>Table 8.1: Heuristics Used in the Usability Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple and natural language</td>
</tr>
<tr>
<td>Speak the user's language</td>
</tr>
<tr>
<td>Minimise the user's memory load</td>
</tr>
<tr>
<td>Be consistent</td>
</tr>
<tr>
<td>Allow quick search and easy navigation</td>
</tr>
<tr>
<td>Avoid ambiguity</td>
</tr>
<tr>
<td>Provide shortcuts</td>
</tr>
<tr>
<td>Prevent errors</td>
</tr>
<tr>
<td>Provide visible and legible text</td>
</tr>
<tr>
<td>Give suitable illustrations</td>
</tr>
</tbody>
</table>
Table 8.2: A Glossary of the Heuristics Used in the Usability Test

<table>
<thead>
<tr>
<th>Heuristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple and natural language</td>
<td>Text should not contain irrelevant or rarely needed information. Break up long sentences and untangle complex sentences. All information should appear in a natural and logical order.</td>
</tr>
<tr>
<td>Speak the user's language</td>
<td>Use language which is appropriate for the intended users. The information should be given clearly in words, phrases and concepts familiar to the users.</td>
</tr>
<tr>
<td>Minimise the user's memory load</td>
<td>The users' short-term memory is limited. They should not have to remember affiliated information from one part of the text to another. Essential information should be visible or easily retrievable whenever appropriate. Complicated information should be simplified.</td>
</tr>
<tr>
<td>Be consistent</td>
<td>Should maintain consistency of the organisation of information, the viewpoint, the wording, and the style and format. Users should not have to wonder whether different words or situations mean the same thing.</td>
</tr>
<tr>
<td>Allow quick search &amp; easy navigation</td>
<td>Should cater for the different needs of the users and allow them to read in detail, to skim, to search, to look for a specific piece of information and to consult it only when they have a query. They should be able to locate the information they want and find their way around easily.</td>
</tr>
<tr>
<td>Avoid ambiguity</td>
<td>Information should be presented in a clear and precise manner. Avoid wording which could be interpreted in a number of ways.</td>
</tr>
<tr>
<td>Provide shortcuts</td>
<td>Detailed information which is helpful to users who are unfamiliar with the subject matter is often too cumbersome to the expert users. The text should allow the latter to skip the &quot;unnecessary&quot; information.</td>
</tr>
<tr>
<td>Prevent errors</td>
<td>Avoid using text and illustrative materials which could lead to a misunderstanding of the information.</td>
</tr>
<tr>
<td>Provide visible &amp; legible text</td>
<td>Typographical considerations such as text size, spacing, line length, margins, etc.</td>
</tr>
<tr>
<td>Give suitable illustrations</td>
<td>Use illustrations (e.g. pictures, tables, graphs, examples, etc.) to help clarify the message. Illustrative materials should be placed appropriately and should be clearly distinguishable from the main text.</td>
</tr>
</tbody>
</table>

Having developed a heuristic list, the next phase was to determine who would be the evaluators and how many were required. An evaluator can be categorised according to his degree of expertise into one of three categories. They are (i) novice, (ii) "regular specialists" who understand the usability issues involved and (iii) "double specialists" who have expertise in usability issues in general and are familiar with the specific context in which the design is to be used. Nielsen and Molich (1990) suggested that for regular specialists, between three and five evaluators would be needed to identify a
reasonably high proportion (74% - 87%) of the usability problems. For double specialists, three of them would find around 90% of the problems. A similar target can also be achieved when using six regular specialists. On that basis, it was decided that six regular specialists should be invited to act as evaluators. All of them are human factors specialists with an understanding of the usability issues involved. Most of them also have experience in designing or evaluating text.

8.3.2 The Results

The usability test generated some valuable findings and, thus, enabled the author to improve the usability of the guide before engaging actual assessors in the next part of the evaluation. Table 8.3 below summarises the main findings of the test. They are presented in terms of the heuristics given in Table 8.1.

<table>
<thead>
<tr>
<th>HEURISTICS</th>
<th>COMMENTS FROM EVALUATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple and natural language</td>
<td>• Most evaluators think that the language used is very readable and is in plain English. But one evaluator believes that it assumes too high a level of literacy - it may be appropriate to experts dedicated to this sort of thing. People who are not familiar with risk assessment would skip reading it after the first few paragraphs.</td>
</tr>
</tbody>
</table>
| Speak the user's language              | • There are a few terms which would benefit from defining (e.g. "undertaking", "engineering devices" and "pinch point").  

  • The paragraph numbers do not serve the user's navigation. Assessment steps should be numbered. If paragraph numbers are needed, they should be small and unobstructive. |
| Minimise the user's memory load        | • The use of pronouns at times adds to the user's memory load.  

  • The use of words such as "the former" and "the latter" to refer to a point listed earlier in the text could add to the user's memory load. |
| Be consistent                          | • The "area" used in the risk assessment examples could be standardised, e.g., "forecourt" has been used in most examples. But the areas used in examples 4 and 6 are the "sector 1" and the "yellow zone". This may make users wonder why they are chosen.  

  • The assessment stages should be numbered to correspond to the numbers in Figure 1. |
| Avoid ambiguity                         | • The title BACKGROUND is ambiguous and could be specific. Consider using PURPOSE.  

  • The instruction to "break down the venue..." (para. 32) may be ambiguous, since it may not be necessary to do this. Consider saying instead "Make sure you are working with areas that you can handle: break the venue into more manageable areas if necessary." |
<table>
<thead>
<tr>
<th>HEURISTICS</th>
<th>COMMENTS FROM EVALUATORS</th>
</tr>
</thead>
</table>
| Allow quick search & easy navigation | • Placing the paragraph numbers in a margin may facilitate navigation.  
• The contents page may benefit from a “list of insets” to improve way finding.  
• Could be useful to “colour code” each risk assessment step.                                                                                                                                                                           |
| Allow quick search & easy navigation (cont.) | • The document would benefit from some additional text (e.g. in paragraphs 26 &/or 27) which describes how the methodology takes the reader through the risk assessment procedure, i.e. use of examples, insets, steps, etc. - To include a section on “How to use this document”.  
• Whilst the document is well written, it is still a hard process to suddenly pick up. It might be useful to give some advice to the reader, e.g. along the lines of: flick through the document and get a feel for what’s involved; think of a venue you know and read the document with this in mind; keep referring to the flow chart and check the overall stage of assessment you are “currently doing”; don’t feel overwhelmed, it becomes much easier with practice.  
• A concise introduction setting out the purpose of the document would be clearer, to include: scope; glossary; what is risk assessment; who does it.  
• The definitions (pages 1 & 2) should be laid out more clearly, probably with the specific term as a hanging indent and bold, with a short paragraph of definition, followed by a short paragraph of supplementary notes.  
• No signposts to help, no hierarchical structure. Providing paragraph heads, overviews etc. would help.                                                                                                                                                                |
| Provide shortcuts                   | • Some paragraphs (e.g. paras. 16-25) could be introduced by their keywords (in bold) followed by the explanation. There is a lot to read here and much could be simplified.                                                                                                                                  |
| Prevent errors                     | None of the comments received concern this issue.                                                                                                                                                                                                                                                   |
| Provide visible and legible text   | • The headings “Step 1: Identify hazards”, etc. could benefit from being made more obvious and more distinguishable from the sub-headings.  
• The contents page could benefit from being in a larger font.  
• The assessment process sections (especially the headings) require greater emphasis within the style of the document to improve quick search and easy navigation.                                                                                     |
| Give suitable illustrations        | • All insets are shaded in 10% grey. A darker shade would be needed so that they stand out better from the main text.  
• The insets would achieve greater effect if they were indented from the main body of the text.  
• The reader would benefit from the inclusion of a “reference” section detailing the publications referred to within the text. This may be particularly relevant as the text refers to the legal requirements imposed upon the venue owner.                                                                                      |
In addition to Table 8.3, there are also minor comments concerning specific paragraphs and text (i.e. typographical errors, wordings). Based on these findings, the methodology document was revised. But because of a lack of proper printing facilities, comments on some aspects of the document design (e.g. colour coding for different assessment steps) cannot be implemented in the revised document. It has to be noted that because of the project timescale and delayed response from some evaluators, the author had to start revising when only four sets of comments were received. As such, some of the above findings were not implemented in this revision. Since then, the remaining two sets were received and considered together with the findings of the combined test. The revised methodology document (i.e. the second draft) is shown in Appendix E.

8.4 Combined Validity and Usability Test

Actual assessors from various public venues took part in this test to conduct a full evaluation on the revised methodology document. This test aimed to examine the validity of the methodology and to identify any remaining usability problems. The validity of the methodology depends on two things: firstly, whether the methodology complies with the risk assessment principles set out in the relevant Approved Code of Practice and guidance document by the HSC/HSE (e.g. HSC, 1992; HSE 1994) and,
secondly, whether it is suitable and sufficient for the assessment of crowd safety risks in public venues. The former was verified through expert judgement; i.e. the revised methodology document was sent to the HSE for comments and approval. Therefore the test concentrated on the latter and on usability. As discussed in Sections 8.1 and 8.2.2, they were evaluated through user trials and a questionnaire survey, described in Sections 8.4.1 and 8.4.2 respectively.

8.4.1 User Trials

The subjects

Actual assessors whose work duties include assessing crowd safety were invited to take part in the user trials. They were asked to assess crowd safety risks using the revised methodology document. In order to ensure that the subjects are representative of the user population, they should ideally come from public venues of all types and sizes. If this were to be satisfied, ten assessors would be needed (i.e. 5 venue types x 2 venue sizes (large/small)). However, the financial and time constraints of the project and a shortage of assessors mentioned in Section 8.1 made this impossible to achieve in practice. In the event, assessors from five different public venues/bodies took part in the user trials. They included the police, one transport venue, two theme parks and one event organiser. Although this is not impeccable, it represents the best possible effort to select subjects who broadly resemble the user population. The names of the venues and organisations participated in the this part of the appraisal programme are given as follows:

- Alton Towers.
- Camelot Theme Park.
- Event Management.
- Metropolitan Police Service.
- Tyne and Wear Metro.
The trials

The author visited each venue/organisation separately to conduct the user trial. Before each visit, the subject was given a briefing note and a copy of the revised methodology document. He was asked to study the document briefly prior to the trial. This is to minimise any "learning effect" that could take place due to subjects still trying to familiarise themselves with the document.

In the trials, subjects were asked to carry out a trial risk assessment on a small part of their venues using the methodology document. Depending upon their existing practice, they could conduct the trial assessment either on their own or as a team.

The venues used for the trials

Although using the same (real or fictional) public venue for every trial would ensure consistency and allow better control over the trials, it was decided that the subjects should be allowed to assess their own venues for several reasons. Firstly, a good understanding of the venue being assessed and its operations is essential to the risk assessment, the use of a venue unfamiliar to the subjects would at worst render them unable to do the assessment or, at best, could lead to an significant increase in the time and effort required to do the trial. Secondly, this is so that the subjects can get something out of the trial too; i.e. the findings generated in the risk trial assessment would be of relevance to them. This should help to attract more assessors to participate and make the subject more involved in the trials. Thirdly, this would provide an opportunity for the author to look at how adaptable the methodology is to different venue types. Finally, as all venues are different in their layouts, natures of operation, visitors, etc., it is impossible in practice to select or create a venue that is "typical" and representative of all venue types.

As such, the subject's own venue was used in each user trial. In order to ensure that the trial can be completed within a reasonable duration of time, each subject was asked to select in advance an area of his venue on which he wished to carry out the trial risk assessment.
The measures

Information about the validity and usability of the revised methodology document was obtained by means of the following methods: direct observation, talk-through and questionnaire/discussions at the end of each user trial.

A direct observation was made in each trial to look for any inadequacy in the methodology and any difficulty in applying it. Where deemed necessary, the assessor was also asked to talk through or explain some of the activities either when they took place or afterwards. In addition, this test would benefit from obtaining information directly from the subjects themselves. Hence, they were invited to comment on the guide after the trial. In order to ensure that comments were given in a structured manner and yet to allow free response from the subjects, a questionnaire consisting of a series of open ended questions was used. It covers all risk assessment stages (e.g. identify hazards, etc.). Comments were invited on the methodology and its presentation, any problems experienced at each stage, things which the assessors particularly liked or disliked and any improvement that could be made. The briefing notes and the questionnaire used in this test are included in Appendix F.

Another means to gather information is by analysing the outputs of the subjects; in this case, the risk assessment records. This method was not taken up because proper analyses of the records require a good understanding of the venues being assessed, which the author did not possess.

8.4.2 Questionnaire Survey

In an effort to obtain comments from a wider audience, a questionnaire survey was also carried out in parallel to the user trials. It targeted assessors and other relevant people who were unable to take part in the trials. Assessors from nine venues were invited to take part. They include one transport venue, two sports venues, two shopping/exhibition
venues, one fairground, one show/entertainment venue, one enforcing authority and one local authority.

Each participant was sent by post a copy of the revised methodology document and a questionnaire. The questionnaire used here is also shown in Appendix F and was very similar to that used in the user trials. Again, open ended questions were used to allow free response. The survey participants were asked to study the document and give their comments and suggestions by answering the questions in the questionnaire. A stamped addressed envelope was also enclosed for returning their findings. The names of the venues and organisations participated in the questionnaire survey are given as follows:

- Cheltenham Racecourse (i.e. The Steeplechase Co. (Cheltenham) Ltd.).
- The Football Licensing Authority.
- King’s Cross Thames Link.
- Leeds United Football Club.
- Loughborough Market and Fair.
- The MetroCentre.
- The National Exhibition Centre (NEC Ltd.).
- Stall Moss Theatre Ltd.
- City of Westminster.

8.4.3 Results of the User Trials

This was a fruitful exercise which generated valuable feedback on both the methodology itself and its presentation. The information generated here and from the questionnaire provided a good basis for a further revision of the methodology document.

In general, the document was well received and the methodology worked well. However, a number of problems were identified. In particular, the trials highlighted a key methodology issue which the author had been trying to address earlier; namely, the degree of sophistication. It has already been established earlier in Section 5.3 that the methodology should be simple enough for people whose experience in risk assessment
may be not much more than the “5-Steps” approach (i.e. HSE, 1994; HSE, 1998). But at the same time, it also needs to be sufficiently sophisticated to enable assessors to account for and assess the often complex crowd safety hazards. Whilst this is fine in principle, it is still necessary to establish where exactly this balance should lie. The degree of rigidity of the methodology was another issue highlighted. The benefits and pitfalls of a highly structured method such as HAZOP and human error analysis techniques were discussed in Section 6.1. There appears to be no hard and fast rules for their application. Also, these issues need to be addressed separately for each assessment step, a sophisticated and highly structured method may be workable for some steps but not others. The user trials therefore provide an opportunity to find out where the balance should be drawn.

The part of the methodology with which subjects had the most difficulty was hazard identification. In order to find out what caused the difficulties, in-depth discussions were held with the subjects at the end of the trials. The results of the discussions suggested that over-sophistication was the most probable cause that led to confusion and misuse. In particular, the idea of using combinations of keywords to identify hazards seemed to be the main source of the problem. As already discussed in Section 7.3.1, the idea was similar to the HAZOP II technique (e.g. Kletz, 1984; Charsley, 1995), which has been successfully applied to evaluate evacuations (Gould & Au, 1995; Gould, 1996). But in crowd safety, it was found that whilst this was more acceptable to the few assessors who have had some knowledge of the more complex risk assessments (e.g. the safety manager of a rail operator where QRA is used to assess some other areas of its operation), it was a much alien idea to the majority. Therefore, they were unable to apply the method correctly, unless substantial additional training is provided.

Another possible reason for the problem is that the suggested method was still too structured and is therefore unsuitable for crowd safety where things cannot be well defined - a point already discussed in Section 6.1. Both groups of assessors believed that the prototype method should be replaced by something simpler. Suggestions given by subjects included the use of just a single set of keywords or a “question and answer” type approach.
Another part of the crowd safety risk assessment methodology where most development had been made is risk evaluation. As in hazard identification, the method suggested in the document is more complex than that given in many other guidance documents in the public domain (e.g. British Safety Council, 1993; HSE, 1994; HSE, 1998). But in this case, all subjects found it very useful and easy to use. However, one subject, whilst acknowledging its value, pointed out that he would prefer to use the existing “high/medium/low risk” approach (e.g. HSE, 1994) on the basis that his assessors were more familiar with it.

The trials also set out to investigate the usability of the methodology document. Despite the changes made to the document following the usability test, several usability comments were received following the trials. This reinforced the point made earlier in this chapter that some usability issues are identifiable only by actual assessors after trying it out on a realistic setting.

The general view was that the document, especially the earlier assessment steps, was too “heavy” to read. One subject pointed out that despite his extensive safety and risk assessment background, he had to read the document twice before he could appreciate the information it contained. A similar remark was also made by one of the reviewers in the questionnaire survey. The “heaviness” of the document could be due to the over-sophisticated hazard identification method. The danger is that the heavy reading could put people off reading the entire document altogether.

A similar concern was also raised by an evaluator in the usability test. He believed that it was due to the language which assumes too high a level of literacy. This is in conflict with other evaluators who believed that the language was generally readable and in plain English. This was investigated further through in-depth discussions with the subjects. These discussions suggested that the main reason was the over-sophisticated hazard identification method. Bearing in mind the background and experience of most assessors, the proposed method is vastly incompatible with their perceptions of how the hazard identification should function. A second reason concerned the continuous use of text in the guide. One subject suggested that this could be improved by introducing
diagrams and colours to break up the text and make the guide look more interesting. Unfortunately, this could not be implemented due to limited publishing facilities.

The following lists the key findings of the user trials. They are presented in terms of the different risk assessment steps and presentation issues.

**Overall approach**

- It had been established through observations and discussions that people have different preferences in the order of doing things. Whilst some preferred to firstly identify all hazards then identify the causes and consequences of each one of them and so on, others would like to deal with one hazard at a time (i.e. identify the hazard, then its causes and consequence, etc. before moving on to the next hazard). It should be pointed out in the methodology document that either preference is valid.

- If the assessment is to be carried out by a team of assessors, a good chairperson is very important. This was in evidence in two of the trials where they started off without a chairperson. As the trials progressed, the chairmanship was resumed and the assessment became more organised, effective and comprehensive. This point should be emphasised in the methodology document.

**Identify hazards**

- The keywords were found to be effective in general. It prompted thinking and also prompted some assessors to ask themselves questions which they had not thought of in the past.

- Some assessors had identified a variety of hazards from a single keyword. Whilst this is encouraging, some of the hazards could be identified again from a different keyword - this could also happen in the HAZOP technique. This might cause confusion amongst some assessors as to what to do with these hazards. Guidance to address this issue has already been given but it is necessary to ensure that it is given in the appropriate part of the methodology document.
Most assessors had difficulty in understanding how the hazard identification keywords are meant to be used. In particular, they found the concept of applying combinations of keywords very confusing. However, once it was explained, many reported that they are useful and thought provoking. Nevertheless, they would prefer this part of the methodology document to be simpler and less confusing. A few suggestions were given, including the use of a series of questions, a single set of keywords or a combination of both.

A glossary of keywords was available at the back of the document but this was not always used. Although this was not a problem in most cases, occasionally keywords were applied in a different way from intended (e.g. “place”). Despite this, however, they still served to prompt hazard identification but, in the view of the authors, their effectiveness was reduced. Also, it was reported by one assessor that some of the keywords did not fit in with his specific context. A review of the keywords would therefore be required to ensure that their meanings are immediately obvious to most assessors (e.g. to replace “place” by “open space”).

Some assessors tended to stick with the keywords provided, which are general in nature, rather than to describe in their own words the specific hazards they had identified from them. This problem could be reduced by emphasising that they are just prompts and by including some brief guidance on the record form advising assessors to describe the specific safety problems they have identified in their venues.

The hazard identification method should also address interfaces between two areas.

There was some doubt as to whether safety management issues should be regarded as hazards, control measures or causes.

Evaluate risks

The risk rating scheme worked extremely well in all user trials. The assessors reported that they liked the scheme and found it very useful.

Likelihood categories were defined in terms of whether the hazard had happened before and how likely this could happen in the future. It was designed to encourage assessors to consider the past history of the venue. However, two problems had
been identified. First of all, there should be a distinction between hazards that have happened only once or twice and those that have happened several times in the past. It is reasonable to give a higher likelihood rating to the latter (e.g. the former should be given a “possible” whilst the latter could be a “likely”). Secondly, for a new venue or where there have been significant changes recently, a hazard that has never happened before would have little/no bearing as to how likely it is to happen. Some modifications will therefore be required on the likelihood definitions.

Decide further actions

- One assessor pointed out that when identifying what actions are required, they should be realistic actions rather than a wish list. This point needs to be included in the document.
- Another assessor believed that if no actions were to be taken, it is important to mention the reason(s) for this.

Record findings

- It was suggested that in addition to the existing form, a follow-up form should also be provided so that the venues could use this to make sure that actions are followed-up.
- It was suggested by one assessor that there should be a separate column for “who might be harmed”. Another assessor suggested that there should be a column for allocating responsibilities (i.e. an “Action By” column).

Presentation issues

- Most assessors believed that the document is about the right size.
- Many assessors found the document too “heavy” to read. One assessor pointed out that he had to read it a second time before he began to understand and appreciate the method. Another reported that he had difficulties in applying the methodology document at first and that he believed it would take time to digest.
Most assessors found the risk assessment flow diagram (i.e. Figure 1 of the
document) and the examples useful. This, again, coincides with comments from a
number of evaluators in the previous test.

The mixture of the main texts (which consist of the guidance) and the insets (which
consist of a step-by-step guide) could at times be confusing to the users. The use of
a colour for the insets could help to reduce this problem. Alternatively, the author
would have to consider physically separating the main guidance from the step-by-
step guide.

It was suggested that as many assessors could carry out their assessment using only
the assessment record form (and use the rest of the document for reference only), it
may be beneficial to put some brief guidance on the form itself. This would be
similar to the form provided in the "5 Steps to Risk Assessment" leaflet (HSE,
1994).

It could be helpful to include in the "intention of the guide" a list of venue types for
which this document is intended. It could make the readers feel that the
methodology document is relevant to their venue.

Include pictures, drawings, diagrams, etc. in the methodology document. This
would break up the text, make it more interesting to read, less formal and less
boring.

Subjects were found flipping through the pages to look at the keywords and the risk
rating scheme. This can be improved by including a set of "pull-out" keywords and
risk rating scheme at the back of the methodology document.

8.4.4 Results of the Questionnaire Survey

The response rate to the questionnaire survey was disappointing. Questionnaires were
sent out to nine venues/organisations, but only four sets of comments were received.
They were from a sports venue, a transport venue, a local authority and an enforcing
authority. As a result, the findings of the survey were not as comprehensive as those
from the trials. However, given the timescale of the project, the author had to proceed
with the revision of the methodology document.
The feedback received, although limited, was encouraging. In general, the methodology document was found to be, in the words of the reviewers, comprehensive, informative, helpful, easy to follow and workable. It provided a logical approach to risk assessment and would be useful especially at a time when risk assessment is a topical issue. However, it could be rather time consuming to follow throughout the exercise but this was considered by some as necessary if a safety culture were to be developed. One reviewer arranged for his staff to assess a number of premises using the document and reported that a comprehensive assessment was obtained which produced an assessment true to the known risks of the trial premises.

The information obtained from the survey was less critical of the methodology than that generated from the trials. Much of the comments received focused on specific points and paragraphs in the document. With regard to the methodology issues, the main criticisms were that it could be quite time consuming to do and was difficult to understand at first reading. These responses are broadly in line with some of the problems identified earlier. It is worth noting that many of the problems identified in the user trials were from observations on how the participating assessors applied the methodology. In the questionnaire survey, however, the author was not present when the review took place and was therefore unable to establish whether the methodology was applied correctly - in two of the user trials, the assessment started off smoothly when the assessors identified hazards by going through each keyword separately rather than applying suitable combinations of keywords. The incorrect use of the methodology (especially the hazard identification part of the assessment) may help to explain the much better review from the survey. It is also not possible to establish the extent to which the “being polite” factor might have affected some of the comments.

The following lists the main findings of the questionnaire survey. Again, they are presented in terms of the different risk assessment steps and presentation issues.

Identify hazards

- “Audience profile” is missing from the hazard keyword list. This is important especially for multi-purpose venues where the audience can be entirely different.
The addition of this keyword may assist in making management aware of the need to research the profile of an artist/group and if necessary review their assessment for any particular event.

- There is a need to examine hazards under normal operational circumstances as well as minor upsets and major emergencies. This need should be emphasised.
- There is a need to brief employees on hazards at regular intervals.
- To carry out venue inspections and to observe crowds (i.e. paragraph 32) is more than useful but it is essential if a thorough understanding of performance is required.

**Identify causes and consequences**

- One reviewer found that this part of the document was harder to understand but the problem was not specified.

**Estimate risks**

- One reviewer believed that assessors would need some hazard ranking training in order to estimate risk and to prioritise actions. However, the findings of the user trials above appear to suggest otherwise.
- The methodology document refers to a trivial risk as being one which is remote or does not cause real harm (i.e. paragraph 56). It was suggested by one reviewer that there are circumstances where both these requisites would have to be met for the risk to be determined as trivial. Particularly with large crowds, the risk of harm may be significant even though the likelihood is remote.

It is worth pointing out that during the development of the method, the author had carefully considered this issue and decided against giving a higher risk rating to a hazard purely on the basis that it could cause more harm. This is because HSC (1991) has already set out that risk should reflect both the likelihood of harm and its severity, and there have been no suggestions either by the HSC/HSE nor by other creditable sources that any preference should be given to either risk property. This is also in evidence in practice in the high hazard industries where a lot of thought has
been given to issues concerning risks and risk assessment. Here, the risk of a hazard is calculated through a straightforward multiplication between its probability or frequency (i.e. the likelihood) and the costs of the consequence (i.e. the severity). Under this formula, if the probability/frequency is extremely low, the risk would effectively be trivial regardless of the costs. The same principle has also been adopted in Defence Standard 00-56/1 (MoD, 1991) for the classification of risk concerning computer and programmable electronic system elements of defence equipment.

Decide and prioritise further actions

- In controlling the risk, consideration should be given to the provision of contingency plans which are fully understood and practised by staff.

Record findings

- The record sheet given in the methodology document is straightforward to use.

Review and revise assessment

- It was pointed out that the need for a re-assessment when changes occur is imperative. This should apply not only to structural changes but also to changes in management procedures and outside influences.

Others

- There may be a need to further emphasise the point that as with many other safety areas the need for appropriate competency is essential.
- Whilst acknowledging the point about the duty of the venue owner (i.e. paragraph 16), one reviewer added that consideration should also be given to the appointment of one single person to act as co-ordinator who is of sufficient experience to understand safety issues and able to evaluate all issues raised. He pointed out that in
football, the relevant authority has pressed for the appointment of safety officers to fulfil this task.

*Presentation issues*

- In general, the guide is easy to follow and should not be difficult to understand provided it is used by a competent and experienced person. As risk assessment becomes more understood and sophisticated, it could act as a reference with continuing referral.

- The guide is comprehensive and provides a general overview to all crowd circumstances. There are however more specific documents for particular venue types, e.g. the Green Guide and the Pop Concert Guide, which will need to be read in conjunction for specific cases.

- Given that the subject of crowd safety risk assessment is not fully understood, the guide has been constructed using as much information as is available and as such, provides the best available form to the subject.

- Most of the methods were hard to understand at the first read - as a trained accident investigator and a hazard ranker, he had to read the guide twice to get a grip with it. But if the assessors can understand the method described, the risk assessment method will not be difficult to apply.

8.4.5 Further Changes to the Methodology Document

Based on the results of the user trials and the questionnaire survey, a number of changes were made to the methodology document and the third draft document was produced. The most significant changes include:

1. Keywords used in hazard identification were revised. The over-sophisticated approach of using combinations of keywords was replaced by a much simpler
approach using only a single set of keywords. The new set consists of a mix of previous and new keywords.

2. The definitions of the anchor points used for risk evaluation have been revised to reflect the future likelihood of something happening. This is to avoid confusion being created by mixing past experience and prediction of the future in the same definition. It also makes the definitions more appropriate for brand new venues and venues that have not had much operating time to generate sufficient experience and reliable information on past incidents.

3. Instead of estimating the likelihood of a hazard occurring, readers are now required to estimate how likely it is to occur and cause harm to people. This is because in public venues, there are many hazards that, most of the time, do not lead to any real harm. For example, obstruction to movement and cross flows occurs very often in a busy venue. Whilst they have the potential to cause harm, that potential is realised only in some circumstances. The observations of the user trials found that some assessors took it quite literally when asked to estimate how likely a hazard is to occur. This could result in grossly overestimating some risks and thus putting other hazards which actually pose a higher risk lower down in the priority list.

4. In addition to the sample risk assessment record form, a “follow-up” form is also given in the third draft document. This can be used by venue owners to monitor the actions decided in the risk assessment.

The following gives a full list of the key changes made to the second draft. The third draft is presented in Appendix G.

**Identify hazards**

- The previous keyword approach had been replaced by a much simpler approach which consists of only a single set of “hazard keywords”. To achieve this, there was a need to strike a balance between ensuring the keywords provided sufficient coverage of hazards arising from different factors (e.g. venue design, behaviour, etc.)
and restricting the set to a reasonable size. An approach with too many keywords would be time consuming to use and could put some people off adopting it. In extreme cases, the keywords could become highly specific and the set could turn into something of a checklist. This would, of course, restrict thought and thus work against the intention of the technique.

In the event, the simplified approach has a total of sixteen keywords. Whilst keeping some of the previous keywords (e.g. “dangerous behaviour”), others had to be replaced because of the above consideration. The new keywords describe problems that could arise rather than how they could come about (e.g. to replace previous keywords such as “insufficient: capacity”, “uneven distribution”, etc. with “crowding/congesting”).

- The new keywords have been worded in such a way that the meanings are immediately obvious to most people.

- The readers have been advised to describe the hazards they identify in their own words. This has been included as part of a step-by-step example of hazard identification (i.e. Inset 1).

- Advice about what to do if the same hazard is identified from different keywords has been included.

- Readers are also advised to consider the five main hazard contributory factors, i.e. venue design, visitors’ behaviour, crowd safety management, hazardous substances or items and interfaces between different areas.

- The need for assessors to examine hazards under normal operational circumstances as well as minor upsets and major emergencies has been addressed.
**Evaluate risks**

- Likelihood categories are now defined in terms of how likely something is to happen in the future. Reference to whether it occurred in the past has been removed. However, a paragraph has been added to point out that past history could give some indication about the future likelihood. A distinction between hazards that have happened only once or twice and those that have already occurred a few times has also been made in the paragraph. This should make the likelihood definitions suitable for venues who have a wealth of past data as well as those where there is little or no past history.

- Instead of estimating the likelihood of a hazard occurring, readers are now required to estimate the likelihood in terms of how likely it is to occur and cause harm to people. This is because in public venues, there are many hazards which, most of the time, do not lead to any real harm. For example, obstruction to movement and cross flows occurs very often in a busy venue. Whilst they have the potential to cause harm, that potential is realised only in some (relatively rare) circumstances. The observations of the user trials found that some assessors took it quite literally when asked to estimate how likely a hazard is to occur. This could result in grossly overestimating some risks and thus putting other hazards which actually pose a higher risk lower down in the priority list.

**Decide further actions**

- It has been pointed out that the actions identified should be realistic, not a wish list.

**Record findings**

- As many people would use only the record form to prompt them what to do next during the assessment, a brief guide has been added to the form. It also reminds people to think about whether any visitors are particularly vulnerable to certain hazards.
- A follow-up form has been included in the Appendix of the document so that the venue owners can use it to keep track of the actions (e.g., who by, deadline, progress of actions, etc.).

Review and revise assessment

- It has been stated that readers should review their assessment when there is a significant change. This includes structural changes, changes in management procedures and outside influences.

Usability issues

- The “Introduction” sections were simplified and shortened. Changes were also made to the language so that it assumes a lower level of literacy.

- The size of the main text was increased in order to make it more legible and to break up the continuous texts over several pages.

- Several second level headings were added to the text to allow easy navigation.

- A brief overview of the risk assessment method was included.

- If the assessment is to be carried out by a team, a competent chairperson is vital. This point has been emphasised in the document.

- Some people prefer to identify all hazards first before evaluating the risks whilst others prefer to assess one hazard first before moving to the next hazard. It has been pointed out in the document that either approach is acceptable.

- A list of venue types for which the guide is intended has been included.
It has been pointed out that the document was intended for public venues in general and that specific guidance is available for certain venue types (e.g. the Green Guide, the Pop Concert guide). Readers may need to refer to those documents for specific advice as well.

8.5 Conclusions

The prototype crowd safety risk assessment methodology document in Chapter 7 was evaluated for its validity and its usability. Given that this is a practical document to provide guidance, advice and support to help assessors in their assessment of crowd safety risks, the ideal evaluation method would therefore be user trials carried out under realistic conditions with actual assessors as subjects. But because of a shortage of assessors, an alternative approach had to be found. After much careful consideration, an evaluation programme was designed. It consists of two key elements: a usability test and a combined validity and usability test. The latter, in turn, was made up of user trials and a questionnaire survey. This was to maximise the number of assessors involved in the evaluation and include the viewpoints of those who were unable to take part in the user trials.

The usability test concentrated on the user-interface aspect of the methodology document. The idea was to get rid of as many significant usability problems as possible through this test before subjecting the document to tests involving actual assessors. Although the author can use guidance, checklists, etc. to evaluate texts, it is essential that the document should be evaluated by an independent person. In the event, six human factors specialists were employed as evaluators and the heuristic evaluation method was used. Some modification was made to the method in order to make it more suitable for the evaluation of text. The results of the usability test are summarised in Table 8.3. The prototype document was revised to produce a second draft methodology document, shown in Appendix E.

The revised methodology document was then subjected to the combined validity and usability test. Assessors from five public venues and organisations took part in the user trials part of the test. This was not ideal but it represented the best possible effort to find
subjects who broadly resembled the user population. In each trial, the subject(s) was asked to carry out a trial risk assessment on a part of his venue. Evaluation was done by means of direct observation, talk-through (when deemed necessary) and questionnaires and informal discussions afterwards. The user trial was found to be a very fruitful exercise. The results of the user trials suggested that the part of the methodology with which subjects had most difficulty was hazard identification. It is believed that this is because the method suggested was over-sophisticated. The use of combinations of keywords is an alien idea to most assessors and what they were used to do. A substantial amount of additional training on how to apply the method would be needed in order for it to be effective. But given the large user population, this is impractical. The risk evaluation method suggested in the revised document was also more complicated than that given in many other guidance documents. However, in this case, the subjects found it very useful and easy to use. This is probably because the suggested method uses rating schemes, which are already familiar to the assessors.

Overall, the methodology document was found to be too "heavy" to read. This was largely because of the over-sophisticated hazard identification method. But it was also suggested that the language used in the document assumed too high a level of literacy.

The response rate of the questionnaire survey was disappointing. Out of the nine venues who agreed to take part, only four sets of comments were received. They were less critical to the methodology than the trial findings. Many comments concern specific points and paragraphs in the document. The main criticisms were that the methodology could be time consuming to apply and the document was difficult to understand at first reading. This is in line with the findings of the user trials.

Following the user trials and the questionnaire survey, the second draft methodology document was revised once again to produce the third draft document. This is shown in Appendix G of this thesis. The methodology document was then ready to be verified.
CHAPTER 9
VERIFICATION OF THE CROWD SAFETY RISK ASSESSMENT METHODOLOGY

This chapter looks at the final part of the appraisal programme in Figure 8.1. The aim is to verify the crowd safety risk assessment methodology presented in the third draft document by showing that it compares favourably with published guidance currently available to crowd safety assessors. Also, it is to show that the use of risk assessment in general can improve on crowd safety assessment. The merit of the methodology can be verified by comparing the performance of the subjects doing the same assessment using different methods. Ideally, this ought to be done through empirical tests using a representative sample of the end user population (i.e. actual public venue assessors) as subjects. However, this cannot be achieved due to a number of constraints. Section 9.1 looks at these constraints. Instead, the verification was done in two parts: a set of controlled experiments using novice subjects and a small number of user trials to gauge the opinions of actual assessors. The former allows comparisons to be made between the performance of subjects using different methods to be made in an objective manner. Therefore, it forms the main part of the verification. In the latter, a questionnaire was used to obtain the subjective judgement of a small sample of the end user population. The questionnaire is shown in Appendix H of this thesis.

Section 9.2 looks at the issues involved in the design of the experiment, including the selection of a suitable published risk assessment method against which the third draft crowd safety risk assessment methodology was compared. Section 9.3 describes the experiments and the results are presented in Section 9.4. The design of the user trials and the results are discussed in Sections 9.5 and 9.6 respectively.

9.1 Methodological Constraints

Ideally, the verification should be done by carrying out an empirical test to compare the performance of subjects using different methodologies. But as in the evaluation programme, the verification programme is also impeded by the lack of actual
assessors, limited resources and, more importantly, from an experimental design point of view, the need to get rid of other irrelevant variables or "noises" that could also affect subject performance.

Again, as in the case of the evaluation programme, the verification test should involve a representative sample of the crowd safety assessor population and, because the proposed methodology is intended for a wide range of public venues, it should also cover as many different venue types as possible. But above all, it is vital for the validity of the test that the different methodologies the subjects were asked to use should be the only variable affecting performance. Other factors that could also affect performance must be kept constant. User interface is one such variable that should have already been minimised during evaluation. For the other variables, as the task analysis in Chapter 5 shows, knowledge and experience of the subjects on crowd safety and the type of venue being assessed are important "performance shaping" factors affecting hazard identification in particular and, perhaps to a lesser extent, risk evaluation. How familiar the subjects are with the risk assessment methods used in the test will also have a significant bearing on their performance. To what extent age and gender might affect performance is unclear. But they can be taken care of by ensuring an equal distribution of gender and age groups between experimental groups who try out different methodologies.

Ensuring the subjects have a similar knowledge and experience, however, is more of a problem if actual assessors are to be used. Not only that assessors from different venues will have varying levels of knowledge and experience, what they know about crowd safety will also vary and tend to be venue specific - i.e. only relevant to their types of venue operations. As the case studies in Chapter 3 demonstrate, the situation in one venue could be very different to that in another. This kind of knowledge and experience is not easily transferable. As such, the learning curve will be very steep for some subjects and much less for others; depending upon how similar the venue being assessed is to the one they know. The validity of the verification test would be in doubt if performance were to be measured at a point where some or all of the subjects are still at their learning curves.
Given the above, it seems that many tests would have to be carried out on each different venue type and each experimental group should contain subjects with a similar variation of backgrounds and levels of experience. A substantial amount of training will also be needed to help the subjects to get over the learning curve. This would be impossible to set up because of the following reasons:

- **Costs** - The costs involved in financing the tests may include travel expenses for the author and the subjects, room hire, meals and training costs. Given the number of tests that need to be carried out to cover all venue types and the number of subjects involved, it is likely to be huge and well beyond the means of the project budget.

- **Time** - Crowd safety assessors are often heavily involved in operational matters too. Past experience suggests that they are very busy and difficult to get hold of. Therefore, it would take many months (or more) to set up and carry out such a large number of tests. Bearing in mind that there were only two years full funding available for the entire research project, the time needed for the empirical tests is too high in relation to the project timescale.

- **Effort** - The participating assessors will require to be trained and to take part in a number of tests. The workload of most assessors would prohibit them from devoting such effort. It is also unlikely that many public venues are willing to devote the amount of human resources the test demands.

- **Shortage of assessors** - The problems concerning a serious shortage of assessors as subjects have already been discussed in the previous section.

An alternative is to carry out the test on the same venue using assessors from the same (or very similar) background and with similar experience as subjects. But this too is deemed as unpractical (and not practicable) due to the shortage of assessors. Therefore, in order to ensure the validity of the verification, it was decided that the test should be done through controlled experiments using novices as subjects instead.
In addition to the experiments, it is also beneficial to carry out field trials to gauge the opinion of the end users and to find out whether they think the proposed methodology is better than the methods they currently use. This provides a supplementary source of information to the experience findings. Therefore, a set of user trials was also carried out to obtain subjective judgements from the actual assessors. It is worth noting that because only a small number of trials were possible due to a lack of assessors, their results can only provide secondary proof to verify the crowd safety risk assessment methodology. The experiments remain the main part of the verification programme.

9.2 Designing the Experiments

In designing the experiments, there are four important issues need to be addressed. They are (i) what other method(s) should be used to compare against the crowd safety risk assessment methodology, (ii) what performance indicator(s) to measure, (iii) who the subjects should be in the experiments, and (iv) which venue(s) should be used. The last two issues are interrelated and were therefore addressed together in Section 9.2.3.

9.2.1 Selection of Other Assessment Methods

The literature review in Section 2.6 and the venue survey in Section 4.2 have revealed that many assessment methods had been used by different venues. Clearly, testing each of these methods one by one against the crowd safety risk assessment methodology, though desirable, is unrealistic in practice. What is therefore required is to select an assessment method(s) that is representative of other existing methods.

As mentioned at the beginning of this chapter, the aim of the verification is to compare between conventional crowd safety assessments, risk assessment and a risk assessment that are specifically designed for crowd safety. Conventional assessments are generally unstructured and experience-based. There is no particular guidance for this type of assessments. Risk assessment generally refers to methods that are in line with the risk assessment principles highlighted in Section 2.2. The MHSWR ACoP
(HSC, 1992) provides the formal guidance for this type of assessments. The methodology that is most closely associated with it is the “5-Steps to Risk Assessment” method suggested by the HSE (1994). Although the exact methods used by different venues vary, the survey has found that they are based on the same basic principles and methodology. Many venues have made modifications to the basic methodology for their own operations; e.g. different emphasis given to different hazard types by different venues. Because of their differences, what is suitable for one venue may not be appropriate to another. Therefore, to compare the crowd safety risk assessment methodology against each of the different methods in use was deemed inappropriate. It would also be too resource intensive, time consuming and hence impracticable to do given the relatively large number of such methods. Hence, it was decided that the “5-Step” method should be used in the experiments to represent risk assessment in general. Another reason for selecting the “5-Step” method is that it is a recognised method from an authoritative source. It forms the basis of many other risk assessment guidance documents readily available to assessors; e.g. general health and safety (British Safety Council, 1993), fire safety (Home Office & Scottish Office, 1997), fairgrounds and amusement parks (HSE, 1997) and outdoor events (NOEA: 1993).

The comparison between some of the individual methodologies adopted by different venues and the crowd safety risk assessment methodology was made subjectively in the user trials instead.

9.2.2 Measuring Performance

Performance can be measured in terms of the time taken to complete a given task(s) (i.e. speed) and/or in terms of the quality or quantity of the task outputs (e.g. accuracy, consistency, number of items produced, etc.). For the experiments, however, the author believes that the time required to complete the risk assessment is not a good indicator of how useful the methodology is for the following three reasons:
It is not the intention of the methodology to enable a quicker assessment. Instead, it is to help assessors to carry out a risk assessment that is more appropriate to the crowd safety context.

Given the large numbers of people who could be harmed, it is important that crowd safety risk assessment should be sufficiently thorough. A methodology that is more thorough could be preferable even though it takes longer to complete.

There has been growing concerns over crowd safety following the Hillsborough Disaster. Despite the shortcomings in safety improvements discussed in Section 2.3.5, more and more venue owners, managers and assessors begin to give crowd safety a higher priority. The prosecutions following the Hillsborough Disaster also serve to illustrate how serious it could be for the organisation, the agency and the individuals involved if things go wrong. As such, exactly how long it takes to do the risk assessment is no longer the prime concern providing it is not excessively time consuming. Instead, what is of more interest to many is to have a methodology that is useful and appropriate to their operations and their needs.

Therefore, it was decided that the verification should focus on the outputs of the test (i.e. the risk assessment findings) instead. The parts of the methodology where significant development was made were hazard identification and risk evaluation. Although there was also development made to other parts of the assessment (e.g. crowd safety risk assessment record forms), it was relatively minor and the main features of those parts remained very similar to many of the existing methods and largely echoed what has already been given in the existing guidance. Therefore, the verification of the crowd safety risk assessment methodology was carried out through measuring the outputs of the subjects in hazard identification and risk evaluation.

In both hazard identification and in risk evaluation, it was impossible to measure the accuracy of the outputs due to a lack of recognised criteria. Hence, the performance indicators used in the experiments were the number of hazards identified and the consistency of the estimated risks.
9.2.3 Selection of Subjects and Venues

Section 9.1 has already explained why novice subjects have to be used. The question that still needs to be addressed here is whether anyone who are novices to public venue operations and risk assessment methods are suitable as subjects or whether it is more beneficial to recruit people who have certain background knowledge and/or a certain quality. The case studies in Chapter 3 show that many crowd safety problems are associated with visitor activities and how they interact with the venue. As such, it is believed those who have some background knowledge about people and behaviour are more suitable subjects for testing the methodologies. On that basis, undergraduate students from Department of Human Sciences, Loughborough University were used. An added advantage of using them as subjects was that they can be recruited on mass (i.e. the whole class).

The task analysis in Chapter 5 shows that a good knowledge of the venue being assessed is vital for the success of the crowd safety risk assessment task. Furthermore, the revised methodology as well as other methods were all intended for people who know the venues they assess. It was therefore decided that a venue that was familiar to all of them should be used. On this basis, the multi-purpose Loughborough Student Union Building was selected for the experiment.

9.3 Experiments to Verify the Methodology

The focuses of the verification were on the hazard identification and risk evaluation parts of the methodology where significant development had been made. Two experiments were conducted. Experiment 1 examined the validity of the hazard identification method. Subjects were asked to identify the hazards that could arise in the Loughborough Student Union Building using different methods. Experiment 2 looked at the reliability of the methodology. This is particularly relevant to risk evaluation where it is done qualitatively. In this experiment, subjects were given a set of hazards that can be found in the Student Union Building and were asked to estimate their risks, again using different methods. The subjects had to repeat the same task a few weeks later to see how consistent their findings were. A secondary purpose in
both experiments was to establish whether there is any significant improvement in performance if the assessment is done by team effort rather than by individual assessors on their own.

Experiment 1

For the purpose of the experiment, the subjects were asked to focus their hazard identification on areas within the Student Union Building only. In order to ensure that subjects were familiar with the building, a briefing was given immediately prior to the experiment to give the subjects some background information about the venue and its operations.

In the experiment, subjects were asked to identify any hazards that could arise in the building. A plan of the building was provided for the exercise. They were then randomly allocated to one of the following four experimental groups; each group was given different methods to use:

- **Group A** – simulating the conventional crowd safety assessments, there was no structure to the assessment and the subjects in this group received no guidance.
- **Group B** - each subject was given a copy of the “5 Steps to Risk Assessment” booklet by the HSE. It contains the risk assessment principles upon which most of the existing health and safety risk assessment methods are based.
- **Group C** - subjects using the relevant parts of the revised methodology.
- **Group D** - same as Group C except subjects were randomly grouped into small teams of three and were asked to carry out hazard identification by team effort.

Subjects' performance was measured in terms of the numbers of hazards they had identified. A comparison between Groups A to C enabled the author to establish whether the methods used for the assessment would lead to any significant differences in performance.
The hazard identification method in the crowd safety risk assessment methodology is based on the HAZOP technique that is designed to facilitate assessments by a team of assessors. Because of this, the methodology itself also recommends that assessments should be carried out through team effort where possible. Therefore, a comparison between the performance of Groups C and D would provide an indication on whether significant improvements could be gained if the assessment was carried out by team effort.

**Experiment 2**

Subjects who took part in Experiment 1 also participated in Experiment 2. The aim was to see if the use of different methodologies has any effects on how reliable they are in evaluating risks. It was measured in terms of consistency between individuals within each experimental group and consistency over times. The subjects were re-grouped into one of the following three groups:

- **Group B** - subjects using the “5 Steps to Risk Assessment” leaflet produced by the HSE.
- **Group C** - subjects using the new crowd safety risk assessment methodology.
- **Group D** - subjects working in teams of three using the new methodology.

Group A was abolished because the conventional assessments do not have any formal risk evaluation procedures. Also, it would be impossible to estimate risk levels without any guidance in the first place. Thus, subjects originally in Group A were re-allocated to the above groups to increase the sample size of each group.

The experiment was carried out in two parts. The purpose of Part 1 was to examine consistency within each group. This was measured by comparing the output of the individual subjects/teams within each group. In this part of the experiment, subjects were each given a list of 15 hazards that could be present in a show/concert held in the Student Union Building. They were asked to estimate the risk associated with each hazard using the risk rating schemes given in different methods. This was held on the
penultimate week prior to the University Easter vacation. Part 2 was to look at consistency over times. This was done by comparing the outputs generated here against those produced in Part 1. Subjects were invited back on week 2 after the vacation for this part. They were allocated to the same groups as before and were asked to do the same risk evaluation tasks on the same set of hazards.

Groups B and C were compared to see whether the outputs generated using the methodology are more reliable than those from using the “5-Steps” risk assessment approach. Similarly, the outputs of Groups C and D were compared to see whether assessment by team effort led to better reliability.

9.4 Results of the Experiments

9.4.1 Experiment 1 - Hazard Identification

A group of 43 undergraduate Human Sciences students were recruited as subjects. As described in the previous chapter, they were divided into four groups. The subjects in the first three groups (i.e. Groups A to C) worked individually whilst those in the last group (i.e. Group D) worked in teams of three. In total, there were 29 individuals or teams in the four groups - eight in Group A and seven in each of the other groups. For identification purposes, the outputs of each individual subject/team were given a code (i.e. A-1 to A-8, B-1 to B-7, etc.). To enable a valid comparison to be made, each experimental group should have an equal number of samples (i.e. seven). Therefore, one set of outputs was removed randomly from Group A before the results were analysed.

The numbers of hazards identified by the seven subjects/teams in each group are listed in Table 9.1. The group mean scores are given at the bottom of the table.
Table 9.1: The Numbers of Hazards Identified by Subjects in Each Group

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>8.71</td>
<td>9.43</td>
<td>14.29</td>
<td>16.00</td>
</tr>
<tr>
<td>Std Dev</td>
<td>2.63</td>
<td>4.24</td>
<td>5.79</td>
<td>5.60</td>
</tr>
</tbody>
</table>

Comparison between new and existing methods

The effect of different hazard identification methods on subjects' performance can be examined by comparing how many hazards were identified by subjects in Groups A, B and C. Table 9.1 shows that there was a considerable amount of variation in each of the three groups (and Group D). The standard deviations range from just over 30% of the mean score in Group A to 45% in Group B. In Group C, the standard deviation is around 41% of the mean score. The large standard deviations could be due to two reasons. Firstly, all subjects are new to both crowd safety and risk assessment. The “double” learning curve involved may magnify the differences in individuals’ ability and consequently serve to exacerbate the variation in each experimental group. This may also explain the considerably smaller standard deviation in Group A where no assessment methods were given.

Secondly, in order to get together a sufficiently large number of students for the experiment, an arrangement was made to use an entire class of second year students as subjects. This did not only enable the author to test all subjects at the same time but also made the test more manageable given that subjects had to come back after the same duration of time for the second part of Experiment 2. The down side, however, could be that the level of motivation of the subjects recruited in this way may vary more than if the more traditional recruitment method of advertising for volunteers has
been used. The variation in motivation may in turn lead to a larger variation in performance.

**Results**

The mean scores in Table 9.1 show that subjects who used the “5-Steps” approach managed to identify more hazards than subjects in the “conventional assessment” group (i.e. Group A), suggesting that some improvements could be gained even just by using the general risk assessment. At the same time, there was a marked difference in performance between subjects who used the methodology (i.e. Group C) and the other two groups. On average, subjects in Group A and B identified 8.71 and 9.43 hazards respectively. But subjects in Group C who used the methodology scored a mean of 14.29 hazards. The subject who had achieved the highest score in the experiment also came from this group. This result suggests two things: (i) that the methodology does not only help its users to identify more hazards but also the improvement in hazard identification is substantial; and (ii) that the hazard identification method given in the “5-Steps” approach is much less effective. The latter helps to confirm what was said in the previous chapters that existing guidance is insufficient when applied to the crowd safety context.

A One-way Analysis of Variance (ANOVA test) was carried out to establish whether the result is significant. Details of the ANOVA test is shown in Figure 9.1 below. It shows that there is less than a 5% chance that the differences in mean scores are due to something else other than the different methods used in the experiment (i.e. p < 0.05). It can therefore be concluded that as far as hazard identification is concerned, the methodology is far superior than the existing “5-Steps” approach and the conventional assessments.
**EXPT. 1 One-way Analysis of Variance (ANOVA test) - Groups A to C**

**H₀**: Different risk assessment methods used by the subjects have no systematic effect on their performance.

**H₁**: The performance of subjects is affected by the assessment methods used in the direction suggested by the mean scores.

**Data Table:**

<table>
<thead>
<tr>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>18</td>
<td>14</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>13</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

$$\sum = 61$$

$$\text{Mean} = 8.71$$

$$\frac{\sum}{N} = 227$$

$$\sum X = 2933$$

$$n_A = 7$$

$$n_B = 7$$

$$n_C = 7$$

$$N = 21$$

$$k = 3$$

$$T = \frac{(\sum X)^2}{N} = 2453.76$$

$$B = \frac{\sum [(\sum X_j)^2/n_j]} = 2582.43$$

**Source Table:**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>ms</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>2</td>
<td>128.67</td>
<td>64.33</td>
<td>3.30</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Within</td>
<td>18</td>
<td>350.57</td>
<td>19.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>479.24</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Therefore, reject H₀.**

Another way to analyse the results of Experiment 1 is by means of frequency distribution, i.e. the number of subjects in each group who managed to identify so many hazards. From Table 9.1, the number of hazards identified by subjects in the three groups ranges from 5 to 25. Table 9.2 shows the distribution of scores over this range, it is represented in graphical form in Figure 9.2.
Table 9.2: Distribution of Scores in Experiment 1

<table>
<thead>
<tr>
<th>No. of Hazards</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 or less</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>6 - 10</td>
<td>5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>11 - 15</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>16 - 20</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>21 or more</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 9.2: Graph showing the Distribution of Scores in Groups A to C

Table 9.2 shows that more subjects in Group C identified a higher number of hazards than the other groups. At the lower half of the range, only two of the seven subjects in this group scored ten or less whereas the figures in Groups A and B are six and five respectively. The majority of the scores in Groups A and B are between six and ten hazards whilst the mode in Group C falls in the next range, i.e. between 11 and 15.

The graph in Figure 9.2 shows a similar story. The score distribution curves for Groups A and B both bias towards the left of the graph (i.e. the lower end of the range). They both peak at the “6 - 10 hazards” range although the Group B curve is
better spread across the range. The curve for Group C, on the other hand, is more towards the centre of the graph and with a higher frequency than the other two groups at the top half of the range. This indicates a better performance overall by subjects in this group. The analysis of the frequent distribution serves to confirm the conclusion drawn earlier from analysing the mean scores.

Comparison between individual and team approaches

A second analysis was carried out on Groups C and D to establish whether subjects who worked together in small teams performed better in hazard identification. In terms of the mean scores, the results in Table 9.1 show only a slightly better improvement for those working in small teams. But the frequency distribution shown in Figure 9.3 appears to tell a different story. The curve for Group D biases more towards the top end of the range, suggesting a better performance. An ANOVA test was therefore carried out on the data to see whether it is significant. This is shown in Figure 9.4.

Figure 9.3: Graph Showing the Distribution of Scores in Groups C and D
Figure 9.4: One-way ANOVA Test on the Data from Groups C and D

EXPT. 1 One-way Analysis of Variance (ANOVA test) - Groups C and D

Ho: No difference in the number of hazards identified between subjects who work on their own and those who work as small teams.
H1: Subjects who work as small teams identify more hazards than those who work on their own.

Data Table:

<table>
<thead>
<tr>
<th>Group C</th>
<th>Group D</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>14</td>
<td>20</td>
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<tr>
<td>18</td>
<td>13</td>
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<tr>
<td>9</td>
<td>5</td>
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<tr>
<td>25</td>
<td>15</td>
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<tr>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>8</td>
<td>20</td>
</tr>
</tbody>
</table>

$\sum x = 100$  
$\sum x = 112$

Mean 14.29 16.00

$\sum x^2 = 3610$

$n_c = 7$

$n_D = 7$

$N = 14$

$k = 2$

$T = (\sum x)^2/N = 3210.29$

$B = \sum [x_i^2/n_i] = 3220.57$

Source Table:

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>ms</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1</td>
<td>10.29</td>
<td>10.29</td>
<td>0.32</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Within</td>
<td>12</td>
<td>389.43</td>
<td>32.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>399.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

T-test using the build-in function in Microsoft Excel:

$p = 0.29$

$p > 0.05$, therefore cannot reject Ho.

It shows that the differences in scores between Groups C and D are insignificant. There is a more than 5% chance that the null hypothesis for the test could be true and the evidence is simply insufficient to support the conclusion that the differences seen in Table 9.1 are due to the “team work” factor.
The result from this part of Experiment 1 is inconclusive. The ANOVA test suggests that there is a chance that the “team work” approach may not give a significantly improved performance in hazard identification under experimental conditions and when the methodology is used. But this does not necessarily mean that the team approach is of little or no value. What is worth noting is that in the experiment, the assessment teams were formed by people from the same background - i.e. all team members are Human Sciences students who are novices to public venue operations. This is necessary in order to ensure that all independent valuables (e.g. the level of knowledge on crowd safety) are kept constant across the experimental groups. As such, the experiment cannot reproduce one of the key benefits of the team approach; namely to bring together people from different backgrounds (e.g. venue designers, operation manager, safety specialist, front line staff, etc.) and different viewpoints. This particular benefit is important and well recognised and it is a prominent feature in established techniques such as HAZOP.

9.4.2 Experiment 2 - Risk Evaluation

As mentioned in Section 9.3, Experiment 2 was carried out in two parts. Part 1 was to test the consistency between subjects within the same experimental groups. Part 2, which took place a few weeks later, was to generate a second set of data on the same tasks. Findings in Part 2 were then compared with those of Part 1 to test the consistency of the subjects’ findings over a period of time. The same class of Year 2 students was used. However, several of them dropped out of this experiment because they had to leave after Experiment 1 or took part in Part 1 but failed to return for Part 2. In addition, three subjects failed to follow exactly the risk rating scheme given to them (e.g. allocate a “high/medium” rating instead of just a high or medium or low rating). In the event, there were six sets of estimates in each group. Furthermore, one subject did not give an estimate on Hazard 9 in the second part of the experiment. Instead of excluding the entire set and thus reducing the sample size in each group for that particular hazard to five, it was decided that all estimates on Hazard 9 should be disregarded. Again, a unique code was given to each subject/team for identification purposes.
The two risk evaluation methods being tested have different numbers of anchor points. In Group B where the “5-Steps” approach was used, subjects were asked to estimate risks in terms of high, medium or low (i.e. 3 anchor points). In Groups C and D, subjects were asked to estimate risks in terms of likelihood and severity. Risks are then categorised into five levels using the matrix provided. Therefore, the findings of the different groups cannot be compared directly. In order to overcome this problem, each set of hazards were ranked in accordance with the risk ratings allocated by the subject. The risk rating allocated by each subject/team of subjects and the equivalent ranking can be found in Appendix I.

Consistency within a group

Kendall Coefficient of Concordance, W, was used to calculate consistency between subjects in each group in both parts of the experiment. The Chi-Square method was then used to establish if the results are significant. Detailed calculations for Groups B, C and D are given in Appendix I-1, I-2 and I-3 respectively. Their results are summarised in Table 9.3 below.

<table>
<thead>
<tr>
<th></th>
<th>Group B</th>
<th></th>
<th>Group C</th>
<th></th>
<th>Group D</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Concordance</td>
<td>W = 0.347</td>
<td>Significance</td>
<td></td>
<td>W = 0.386</td>
<td>Significance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p = 0.012</td>
<td></td>
<td></td>
<td>p = 0.005</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All concordance coefficients are significant (i.e. p < 0.05). The results suggest that none of these groups were very consistent (Note: W = 1 for a perfect match between subjects). But subjects in Group C who used the methodology were more consistent between themselves than those using the “5-Steps” approach (Group B). It also shows that the team approach adopted in Group D led to a further, more obvious increase in concordance.
**Consistency over time**

The calculations to determine the level of consistency over time are also shown in Appendix I. In order to enable a comparison to be made between the findings of each group in Parts 1 and 2 of the experiment, the sums of ranking (i.e. \( R_j \)) established in the Kendall coefficient calculations were used. The 14 hazards were then re-ranked according to \( R_j \) to give the verdict of each group as a whole. Spearman Rank Correlation Coefficient (i.e. \( r_s \)) was used to establish the correlation coefficient between the group ranking in Part 1 and that in Part 2. The results of the analyses are summarised in Table 9.4 below.

<table>
<thead>
<tr>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Correlation</strong></td>
<td><strong>Significance</strong></td>
<td><strong>Correlation</strong></td>
</tr>
<tr>
<td>( r_s = 0.81 )</td>
<td>( p&lt;0.0005 )</td>
<td>( r_s = 0.53 )</td>
</tr>
</tbody>
</table>

The correlation coefficients in Table 9.4 are all significant (i.e. \( p < 0.05 \)). The result shows that subjects in Group B generally produced more consistent findings over time than those in Groups C and D. It also shows that Group D produced more consistent estimates than Group C.

On the surface, this appears to suggest that the “5-Steps” approach is a more reliable method, in terms of consistency over time, than the crowd safety risk assessment methodology. But there is another possibility; namely that subjects from all experimental groups changed their minds when they re-evaluated the hazards in Part 2 but the methodology, which has a more sophisticated rating scheme and a bigger rating scale, is more sensitive to the changes. This notion is probable given the subjects’ lack of knowledge on crowd safety. In other words, they were dealing with concepts with which they were unfamiliar. Cole (1990) suggests that this could have two possible effects on the results of the experiment. Firstly, instead of assessing the overall situation, subjects were more likely to make their assessment based on memory of specific episodes (e.g. what happened when they were there last time). Naturally, different subjects would have remembered different episodes (or, to put it
another way, different segments of the overall situation) and could result in differences in the perception of risk. This helps to explain the generally low concordance across all groups (Table 9.3). The team approach adopted in Group D may have enabled the memories of different episodes to be pulled together to give a more global picture for the evaluation. This may explain why Group D achieved higher concordance and was more consistent over time than Group C. It follows that actual assessors, who have a much better knowledge and understanding of the overall situation, should produce more reliable risk estimates than the novice subjects used in this experiment.

Secondly, the experiment could have alerted the subjects to crowd safety issues that were new to them. As such, when re-visiting the venue after Part 1 of the experiment (e.g. for the end of term disco), they would have noticed new things (consciously or sub-consciously) that they failed to notice previously. As a result of the new knowledge acquired, their risk perception would have changed when they came back for the second part of the experiment.

In theory, the above should have an equal effect on all three experimental groups. But the author believes that the methodology is inherently more vulnerable to these factors because:

(i) The risk evaluation method given in the methodology is considerably more sensitive and is therefore much more receptive to different opinions and changes of mind. The “5-Steps to Risk Assessment” approach has three different levels of risk to choose from, whereas the risk evaluation method has five possible outcomes from a total of 20 possible combinations of likelihood and severity. Therefore, a change of prediction is more likely to be reflected in the final risk rating under the new methodology. In this respect, the result in Table 9.4 has actually highlighted a key benefit of the methodology, i.e. it is more capable of picking up any changes in the circumstances identified by the assessors that could have a safety implication.
(ii) The risk evaluation method in the methodology is also more complex than that
given in the “5-Steps” approach. Subjects in Group C and D therefore could
have encountered a steeper learning curve than subjects in Group B. Whilst
Group B might have already been familiar with its method by Part 2 of the
experiment, the subjects in Groups C and D may still need more time for the
learning curve to settle down.

(iii) Inevitably, the risk estimates given in Part 2 were influenced by the subjects
remembering what answers they gave previously. It is therefore not surprising
that subjects who used a method which is more straight forward and consists of
only three possibilities were likely to give more consistent answers than those
who used a method that has five risk levels and 20 possible combinations of
likelihood and severity.

9.5 User Trials to Obtain Assessors’ Judgement

This is the part of the verification programme where actual assessors were used and
where direct comparisons were made between the crowd safety risk assessment
methodology and some of the methodologies that were in use at the time. The aim is
to obtain subjective opinions from them on how the methodology compared with the
other methodologies.

The trials carried out here were essentially the same in design as those in the
combined usability and validity test described in Section 8.3 - i.e. subjects were asked
to try out the crowd safety risk assessment on selected parts of their own venues.
However, a different questionnaire was used. The new questionnaire, shown in
Appendix H, invited the participants to comment on each part of the methodology, to
judge how useful it was and to compare it with the methodologies they were using in
their organisations. Two 5-point rating scales were used in the questionnaire for the
judgement and the comparison.

A key benefit of this approach is that it was conducted in realistic settings. The
participants were allowed to carry out the trial assessment in a manner that is
consistent with their usual practice and on a venue with which they are familiar. This approach also allowed the methodology to be tested for different venue types and operations.

The venues used in the trials

Subjects were asked to carry out the trial assessment on their own venues or one with which they were familiar. As in the case of the combined validity and usability test, the reasons were: (i) the needs for the subjects to have sufficient knowledge on the venue being assessed, (ii) the needs to make the trials as acceptable and attractive as possible to those who may take part, and (iii) the impossibility to find or create a “typical” venue.

The first reason is particularly important as it could affect the validity of the comparison. A risk assessment methodology is only here to help the assessor to make the most of his knowledge and to ensure that his assessment is systematic. It does not, for example, tell him what hazards could arise in his venue. Therefore, unless he knows about the venue being assessed, its operation and the kinds of problems that could arise, it would be difficult, if not impossible, for him to make a suitable and sufficient risk assessment regardless of the method used. In other words, if the same venue was to be used for all trials, how much the participants know about the venue rather than which method was used could become the dominant performance shaping factors.

The subjects

Actual assessors were invited to take part in the trials. Again, the availability of subjects and the financial and the time constraints of this research project mean that only a small number of trials were possible. In the event, assessors from five venues/organisations were invited to try out the methodology. They include two transport venues, a sports ground, a police force and a pop concert venue. A list of the venues/organisations who took part is given below.
The trials

A separate user trial was held for each venue/organisation. All subjects were given a copy of the revised methodology document (i.e. the third draft) prior to the trials. They were advised to study the document in advance in order to reduce any “learning effect” that could take place in the trial. On the day of the trial, the subjects were asked to conduct a trial crowd safety risk assessment on parts of their own venues. Afterwards, they were invited to comment on the methodology and to compare it against their existing methodologies by completing the questionnaire in Appendix H. In order to minimise any bias that might be introduced by the presence of the author, it was left with the participants for them to fill in and send back later on.

9.6 Results of the User Trials

Four questionnaires were received from the five venues/bodies who took part in the trials. The reason why the remaining venue failed to return its questionnaire is unclear. Furthermore, the entire page 2 of one of the questionnaires received was left uncompleted. As such, judgement on Steps 2 and 3 of the methodology (i.e. “identify causes and consequences” and “decide whether existing precautions are adequate”) is missing from this particular questionnaire.

The judgement of the participating assessors is summarised in Tables 9.5 and 9.6. Table 9.5 shows the verdicts of the assessors on how useful each part of the methodology is and Table 9.6 shows their judgement on how it compares with their existing risk assessment methods. It has to be noted that because of the small sample
size, the results should be treated merely as a snap shot of the opinions of some assessors. Also because different venues have used different methods to assess crowd safety, the comparisons shown in Table 9.6 are between the new methodology and a pool of existing methods rather than a single method as in the case of the experiment. Despite the small sample size, this part of the verification has produced some rather encouraging results. All participating assessors found the methodology and the vast majority of its contents to be useful or very useful. Most of them also found the methodology either better or much better than the risk assessment methods that were already in use in their venues.

Table 9.5: Opinions of Assessors on the Usefulness of the Methodology

<table>
<thead>
<tr>
<th>Activity</th>
<th>Very Useful</th>
<th>Useful</th>
<th>Fairly Useful</th>
<th>Not very Useful</th>
<th>Useless</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify hazards</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Identify causes &amp; consequences *</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Decide if existing precautions are adequate *</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Evaluate risks</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Decide further actions</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Record findings</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Review and revise assessment</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td><strong>2</strong></td>
<td><strong>2</strong></td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

* only 3 sets of opinions have been obtained

Table 9.6: Judgement on How the Methodology Compares with Existing Methods

<table>
<thead>
<tr>
<th>Activity</th>
<th>Much Better</th>
<th>Better</th>
<th>About the Same</th>
<th>Worse</th>
<th>Much Worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify hazards</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Identify causes &amp; consequences *</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Decide if existing precautions are adequate *</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Evaluate risks</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Decide further actions</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Record findings</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Review and revise assessment</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td><strong>1</strong></td>
<td><strong>2</strong></td>
<td><strong>1</strong></td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

* Only 3 sets of opinions have been obtained
In terms of how useful the methodology is, “hazard identification”, “risk evaluation” and “record findings” are the top three sections that received the best rating. In all cases, 75% or more of the participating assessors gave them the top rating (i.e. very useful). As stated in Section 9.2.2, hazard identification and risk evaluation were where significant development was made. In the case of “record findings”, a risk assessment record form and a follow-up form were also developed to help the users to carry out and record their assessment more systematically. This compares well with other sections of the methodology where the development made there was relatively minor. The number of assessors who gave the top rating to these sections ranges from zero for the “review and revise assessment” section to two (out of three) for the “decide if existing precautions are adequate” section.

In terms of how good the methodology is in comparison to the existing methods, only the “risk evaluation” section has achieved the top rating (i.e. much better). 50% of the assessors who took part said it was much better than their existing methods and a further 25% said it was better. The hazard identification method and the “record findings” section were also highly rated. Three out of four assessors judged that they were better. However, it is somewhat disappointing that their rating was not significantly better than the other parts of the methodology. A possible reason for the assessors not giving the hazard identification method a better rating is that some of the hazard keywords may not be directly relevant to their specific applications, since they are intended for a wide variety of public venues. The use of loosely defined keywords could also be a reason for the method not achieving a better rating. Unlike the risk evaluation method which is based on the same “risk rating scale scheme” principles as the existing methods, the keyword approach is a new and quite different concept to what the assessors are used to. It is therefore possible that the learning curve involved during the user trials could have made the keyword approach appear less beneficial and less attractive to them at the time.

Both the hazard identification and the risk evaluation methods have received good comments. In the case of hazard identification, all four participating assessors commented in the questionnaire that they found the keywords useful. But two of them
did highlight a potential danger that some people might follow the keywords too rigidly and effectively turn them into a checklist. It was therefore suggested that the methodology document should stress that these keywords were not a checklist. Similarly in risk evaluation, two suggestions were made with regard to the risk rating scheme. Firstly, it was suggested that level “E” instead of “-” could be used to represent trivial risk. Secondly, a fifth category should be added to the existing four likelihood categories. Some consideration has already been given to the size of the likelihood rating scale in Section 7.3.4. It was decided that although a fifth likelihood category may be desirable, a trade-off had to be made here to enable the rating scheme to fit in with the ALARP principle at the following stage of the assessment.

Other parts of the methodology have also received good ratings. In particular, all four assessors praised in their comments Table 5 of the methodology document, where the ALARP principle is adopted to provide a basis for decisions on what actions are required.

Although the sample size is too small for the user trial results to be statistically significant, the subjective judgement obtained here nevertheless provides extra evidence to support the view that the methodology is more superior to and more suitable for crowd safety risk assessment than the existing methods.

9.7 Conclusions

The verification of the crowd safety risk assessment methodology was conducted by means of two controlled experiments and a set of user trials to gauge the subjective judgements of a small sample of actual assessors. In the experiments, although the methodology was only compared to one existing risk assessment method; i.e., the “5-Steps to Risk Assessment” approach by the HSE, the HSE approach forms the basis of most of the existing methods used by and the guidance available to the assessors. It is therefore reasonably representative of the current best practice in terms of crowd safety risk assessment. The user trials, on the other hand, allowed direct comparisons to be made against several risk assessment methods currently in use by different venues.
The first of the two experiments (i.e. Experiment 1) shows that on average, subjects who used the methodology had managed to score significantly higher than those who used the “5-Steps” method and those doing conventional assessment. An ANOVA test carried out on the data shows that this finding is statistically significant, demonstrating that the crowd safety risk assessment methodology has led to improved performance in hazard identification. Subjects using the general risk assessment method were also found to perform better than those doing the conventional assessment. A second analysis carried out on the distribution of scores confirms the finding. Frequency distribution shows that more subjects in the group using the methodology identified a larger number of hazards than the other groups, again suggesting that the methodology compares well against the “5-Steps” method and the conventional assessment as far as hazard identification is concerned. However, it has to be said that although all three methods of assessment rely on assessors’ knowledge and experience, it can be argued that the conventional assessment may rely more heavily on knowledge and experience, on the basis that there was no guidance or any other form of assistance provided. As a counter-argument, however, the guidance given in the “5-Steps” method is only very general in nature. There was no specific advice given to the subjects on what hazards to look for. For this reason, it is argued that there is no obvious evidence to suggest that the lack of knowledge and experience affected the subject group doing conventional assessment significantly more than the group using general risk assessment.

The experiment results are in line with the findings of the user trials. In terms of how useful the methodology is, the hazard identification method received the top rating from all participating. Nevertheless, it has to be noted that because of the small sample size, the user trial findings can only be regarded as providing an insight into what the actual assessors think of the methodology. In terms of how good the methodology is compared to a number of existing methods, three out of four assessors judged that it is better than the methods they were using at the time. However, it is somewhat disappointing that the judgement given to this part of the methodology is not much better than those given to other parts where less development was involved. A possible reason for this is that assessors were unfamiliar with the keyword approach.
adopted in the methodology and the learning curve involved could have made it appear less beneficial and less attractive.

Experiment 1 also gave an opportunity to find out whether there are any significant benefits in doing hazard identification through team work. The performance of two experimental groups, one worked individually (Group C) and the other worked in teams of three (Group D), was compared. The result is inconclusive. The frequency distribution graph in Figure 9.3 shows that apart from one team in Group D which scored particularly badly, the curves for both groups resemble a normal distribution. The curve for Group C peaks at the “11-15 hazards” range whereas the Group D curve has a steeper gradient and peaks at the “16-20” range. In terms of the mean scores, the raw data appears to show that Group D had achieved a higher score than Group C. However, the difference is marginal and furthermore it is found to be insignificant in a subsequent ANOVA test. The reason for the experiment failing to show any significant improvements when subjects were working in teams could be because, under the experimental condition, the assessment teams were formed by members with the same background. This does not simulate a key benefit of the other techniques that also involve team working, e.g. HAZOP; namely, the benefits of bringing together people with different backgrounds and viewpoints.

Experiment 2 was conducted in two parts to test consistency within each experimental group as well as consistency over time. In Part 1, where consistency within group was tested, no groups managed to achieve a high concordance. But in comparison, Group D, where subjects worked in small teams of three, achieved a considerably higher level of consistency than Group C, where subjects were working on their own using the methodology. Group C is, in turn, slightly better than Group B where the “5-Steps” method was used. This indicates that the methodology has led to more reliable outputs in terms of concordance, but the level of reliability can improve further if a team approach is adopted.

In Part 2 of the second experiment, the correlation coefficients in Table 9.4 show that subjects in Group B gave more consistent findings over time than their counterparts in Groups C and D. Between Groups C and D, subjects in Group D were found to be
more consistent over time than those in Group C. It is believed that a learning effect that may have taken place in the few weeks between Parts 1 and 2 of the experiment could have affected the results. Another factor that needs to be taken into account when examining the results is that the methodology has a rating scheme with bigger rating scales and a higher number of possible outcomes than the “5-Steps” approach (i.e. Risks A to E as opposed to H/M/L risks). It is therefore more sensitive to any change of mind or change of perception by the subjects. By the same token, however, it can equally be argued that the methodology is also more receptive to changes in the circumstances and other factors that could affect safety. It is therefore more capable of reflecting through the evaluation any resultant changes in risks.

The risk evaluation method has also received much praise from the assessors who took part in the user trials. Three out of four of them found the method very useful and two of them thought that it was much better than their existing methods.

Overall, the verification programme has shown that the crowd safety risk assessment methodology compares favourably with the “5-Steps” approach and with the existing methods used by some venues. In the experiments, those who used the methodology are found to perform better in hazard identification and also achieve a higher level of concordance in risk evaluation. In the user trials, most participants have considered the methodology better than the risk assessment methods they were using at the time for crowd safety assessment. However, consistency over time is a potential shortfall of the methodology. The experiments have shown that subjects using the “5-Steps” approach appear to produce more consistent risk estimates over time than those using the methodology. What is uncertain is that to what extent this is an inherent problem caused by bigger risk rating scales and more potential outcomes in the methodology, or if this was because the methodology is more receptive to either changes in risks or in the perception of risks by the subjects.
CHAPTER 10
CONCLUSIONS AND DISCUSSIONS

10.1 Summary of Research

The conventional methods of assessing crowd safety in public venues tend to be rather ad hoc, highly subjective and rely heavily on the personal experience of the assessors. This has resulted in crowd safety management and planning being reactive rather than proactive in dealing with problems; i.e. they are restrictive to dealing with known past problems and lacking foresight to prevent new problems from arising. Also, decision making and priority setting tend to be based on personal judgements rather than objective assessments of the situation. This approach to crowd safety assessment is considered unsatisfactory as significant problems could be missed out and it does not provide a sufficiently rational basis for decision making and planning.

It is believed that the pitfalls with the conventional methods can be improved through risk assessment. Risk assessment is a systematic activity that enables people to examine their undertakings and establish how risks could arise and their impacts on those who may be affected in a structured and more rational manner. Essentially, it is a tool that helps people to make informed decisions on how to manage risks. Risk assessment is well established, particularly in the area of workplace health and safety, and has become an essential part of safety management and planning. It has been employed in a range of applications, ranging from the high hazard industries, such as nuclear plants, to more conventional places of work, such as factory shop floors and offices. Its benefits are well known and well recognised. There is scope for also applying risk assessment to non-work environments; the literature review in Chapter 2 has highlighted some of the work carried out in these areas.

A key requirement in risk assessment is that, to remain valid, it needs to be appropriate to the nature of the work and the nature and extent of the hazards. To this end, a review of the existing risk assessment guidance and methods available to assessors in public venues has revealed that they are inadequate in satisfying this requirement. Therefore, the aim of this thesis is to investigate and explore how risk
assessment can be applied to crowd safety and to provide more support for decision making in crowd safety planning and risk management. Through the development of a suitable risk assessment, this thesis demonstrates that risk assessment can be applied to crowd safety to improve the current situation.

It is important to recognise that whilst the risk assessment principles are the same, the ways in which they can best be applied to a particular context vary. Even in the work environments, differences in the nature of work and the nature and extent of hazards mean that different risk assessment methods are used in different places of work. For example, quantified risk assessment may be appropriate to the high hazard but not in the manufacturing industry. Even within the same industry, the different nature of work calls for different risk assessment methods. The railway industry, for example, utilises both quantified and qualitative risk assessment methods for different aspects of their operations.

The differences between public venue environments and workplace environments are even more profound and fundamental. For example, “human factors” are important in both types of environments, but the workplace is a much more controlled environment than public venues in terms of activities and behaviour. The works and the processes of work shape activities and behaviour in the workplace. There are clearly defined tasks, procedures and practice, which help to govern what people do. People are much freer to do as they wish in public venues, and their activities are more wide-ranging and not as definable. The presence of large crowds also poses a unique set of hazards that are not normally encountered in the workplace; e.g. overcrowding. These differences can have a very significant impact on the risk assessment methodology. Therefore, the first issue this thesis needed to address was the nature of “work” and the nature and extent of hazards in public venue environments. It is essential to establish an understanding of the issues before a suitable method(s) can be found to assess them.
Information Gathering and Background Research

There are a number of constraints that restrict the methods that can be used to conduct the research. Firstly, crowd safety is a new area for research with plenty of experience but very little published research knowledge. Secondly, it is a complex problem with many interrelating and interacting factors affecting the outcomes, as illustrated in the two case studies in Chapter 3. Also, these factors tend to vary from venue to venue and in different circumstances. Thirdly, for reasons given in Section 1.4, the means to test and validate crowd safety are restricted. Because of these constraints, the research method adopted in this thesis is different, in a number of ways, from the methodology one would normally expect for an empirical research project. One key difference is how data and information are gathered. In order to establish the nature of work and the nature and extent of hazards in public venues, much reliance has to be placed on front line experience. A lack of published information means that literature review alone is not a suitable means of researching the subject. Instead, case studies and a venue survey were carried out, in Chapters 3 and 4 respectively. They provided the main sources of information and compensated the lack of literature information in the public domain.

The case studies have highlighted some of the crowd safety issues that could arise in a major public venue. They showed that, in general, there are two types of safety hazards. The first type is the general health and safety hazards, which are often associated with physical features and items. These hazards are by no means unique to public venues as they can also be found in the workplace as well as in many other places; although in a large crowd, the extent of these hazards can be significantly higher. But the main distinction between the workplace and public venues in terms of the nature of hazards is in the second type of hazards; namely, those associated with the presence of large crowds. These hazards are usually related to the “human factors” such as interactions between individuals in a large crowd, the interactions between people and the venue, and behaviour. The subsequent venue survey has found that it is these human factors that gave the assessors the most concerns and posed the most problems in terms of risk assessment. In fact, only one out of the eight public venues that used risk assessment was able to give some considerations to the
activities of the visitors. This finding has highlighted an important inadequacy in the existing methods for risk assessment when applied to assess crowd safety.

In terms of risk evaluation, the survey found unanimously that every assessor uses the rating method. This finding is in line with that of the literature review, in Section 2.4, which shows that rating is the only method used or suggested for qualitative risk assessments. Quantified methods are unsuitable, as there is not the data available for this kind of assessment. The other possible risk evaluation method is ranking. This too is considered unsuitable because it does not give any indication of how much risk a particular hazard poses.

However, beyond the consensus that rating is the most suitable method for evaluation, there is a great deal of variation amongst the assessors in exactly how risk rating is carried out. The rating methods currently in use range from a single three-point rating scale for the overall risk to risk rating regimes that explicitly take into account the key considerations such as likelihood and severity. What constitutes a suitable risk rating method for crowd safety remains an outstanding issue. In addition, for risk rating is essentially a process of passing judgements on risks, the validity and reliability of the judgements is also a key issue. Another issue highlighted in the survey is how to deal with high-magnitude low-probability events, such as a freak accident or disaster. The question is whether there are any justifications for treating the likelihood of an event a more dominant factor than its severity or vice versa in risk evaluation. The final issue is one that is of a more practical nature, namely the misinterpretation of the meaning of risk by some assessors. This could be because everyday use of the word risk tends to equate it with chance or likelihood. Misinterpretation was in evidence amongst the assessors who took part in the venue survey.

A key benefit of gathering direct information through case studies and venue survey is that it provides the opportunity to get a full picture of the operations involved and raw information that enables in-depth investigations and analyses to be carried out. It also enables researchers to develop a different line of enquiry to further explore those issues that are not thought of in advance but are deemed relevant at the time. However, the potential pitfall is that the information is venue specific and focuses on
the experience of a few. There is a danger that it may not sufficiently reflect the situations in other public venues. To reduce this danger, care was taken in the survey so that a variety of different public venues were selected for this exercise.

In addition to the nature of work and the nature and extent of hazards in public venue operations, another important line of investigation concerns the tasks of the assessors. This is to ensure that not only the risk assessment is suitable to the kind of hazards that can be found in public venues for mass gatherings but it addresses the needs of the assessors who undertake it as well. Hence, attention of the research has also been given to the assessors and their risk assessment tasks. Part of the survey was devoted to identify the practical issues facing the assessors. These issues have to be taken into account if a workable solution is to be found to improve the management and planning of crowd safety. The issues highlighted in the survey are summarised in Table 4.3. What is of particular interest amongst the findings is the issue of time constraints; i.e. the amount of time an assessor can devote to risk assessment is often limited, especially if he also has operational duties to perform. It can be argued that, in the long run, whilst it may be desirable in theory to carry out a detailed risk assessment based on quantified data, it may still not be practicable to do so if the time constraints remain. This prompts a wider question of what is an appropriate method of risk assessment for crowd safety or, more precisely, how simple or sophisticated it should be. What is clear from the literature is that risk assessment has to be appropriate to the nature and extent of the hazards. But beyond that, there are no fixed rules or guidance. Hence, a review was also carried out of the risk assessments elsewhere to look at how this and other issues identified so far have been addressed. This is further discussed below.

To investigate the task of assessing crowd safety risks, and in particular, the question of what would enable the assessors to successfully accomplish their tasks, established task analysis techniques were deployed in Chapter 5 as a research tool. By examining the task in this way, it was possible to identify where and what assistance or support are required to enable the assessors to conduct a suitable and sufficient assessment of crowd safety risks. A systematic examination of the task also gave a different angle to the research, thus enabling the identification of further issues of relevance and
questions not highlighted in the case studies or the survey. An example is the issue of validity and reliability in risk evaluation, which was identified only through task analysis. By pulling together the findings from the task analysis, the case studies and the survey, a specification was drawn up detailing what the requirements are in terms of addressing the various issues identified and the needs of the assessors. This was given in Section 5.3.

Administration of Risk Assessment Methods

The next phase of the research was to look at how various risk assessment issues and assessors’ needs can be addressed. A review of the risk assessments elsewhere was conducted and the findings are given in Section 2.4, as part of literature reviews. The implications of the findings to crowd safety risk assessment were discussed in Chapter 6. As previously mentioned, the aim of the review was to obtain information that may help to identify possible means of addressing the issues. The review looks at the risk assessment methods, techniques and tools used in or suggested for a variety of other applications. Even though nothing can be found that is directly applicable to crowd safety per se, much has been learnt from these assessments that can help to address the issues relevant to crowd safety.

Looking at the different risk assessments, what is noticeable is the variety of methods in existence. What is also noticeable is the huge difference in the level of assessment adopted for different contexts. At one end of the scale are the very sophisticated QRA methods involving the use of fault tree and event tree modelling. At the other end are the much simpler qualitative assessments, intended for workplaces such as offices and light industrial premises. It is argued that, as they are, neither of the two method types is suitable for crowd safety for the following reasons:

(i) Nature of work and hazard – Crowd safety hazards are much more complex than those in the ordinary workplace, although some hazards are similar in nature to each other. At the same time, they may have some similarity in complexity with the kinds of hazards in, for example, the nuclear industry, but are very different in nature.
(ii) Extent of risk – Past incident data shows that the results of failing to ensure crowd safety can range from a few casualties to hundreds of fatalities. Compared to the high hazard industry where QRA is used, crowd safety is more “low hazard”. Yet, it is much more “high hazard” than the common work environment.

(iii) Practicality – Even if QRA type methods were more desirable in principle, it is currently not a viable option due to resource and time constraints and the lack data to support such an assessment. Another issue that needs to be resolved before QRA is ever achievable is how to account for the activities in public venues, which are not very definable. There is a further discussion on this particular issue below.

Therefore, it is concluded that an appropriate level of risk assessment for crowd safety should lie between the two types of methods. It has to be more detailed and intensive than the simple risk assessments for the common workplaces, but there is no justifiable requirement, nor the means, for it to be as detailed and sophisticated as the QRA methods.

For hazard identification, of particular interest are the methods and tools for assessing complex systems or human activities. A common feature of these methods is the requirement to break down a complex engineering system or a set of complex human tasks into smaller elements. None of the existing methods for doing so (e.g. the uses of system flow diagrams and task analysis) are believed to be applicable to crowd safety because, as previously mentioned, human activities in public venues are much less definable than system components and work activities. Nevertheless, using the same principle, it is possible to break down a complex venue in terms of its make up. The concept of “functional areas” was identified for this purpose.

There are several established methods, techniques and tools for identifying hazards in complex systems and human activities; for example, HAZOP and brainstorming, the various human error analysis techniques, keywords, checklist, etc. All of them have different features and characteristics. Chapter 6 has highlighted the features of those methods that have the potential to encourage a systematic and proactive assessment and to resolve the difficulties in dealing with “human factors” and behaviour related
hazards. It has also ruled out those methods that are inappropriate to the nature of work and hazards in crowd safety. The outputs of the review were fed into Chapter 7 where features of the existing methods were incorporated into a prototype method for crowd safety hazard identification. Brainstorming, HAZOP and keyword approaches received particular interest as they possess the quality required for a comprehensive, systematic and proactive assessment of complex problems. A common element of these methods is the keyword prompters. Keywords for crowd safety hazards were, therefore, developed based on the case studies and survey findings. They are generic keywords covering crowd and behaviour related hazards as well as the more general health and safety type hazards that can be encountered in public venues.

In terms of risk evaluation, the review has found that rating is by far the most widely used qualitative risk evaluation method. But as previously discussed, the outstanding issue is the detailed design of the rating method. To this end, methods used in other contexts have provided little direction or guidance. What is clear, however, is that the “semi-quantified” type of methods was ruled out as they are mathematically flawed. The development of the risk evaluation method in Chapter 7, therefore, focused on the detailed design of a risk-rating regime. It was decided that the regime should consist of separate ratings for likelihood and severity and risk can be determined from the two ratings through a likelihood-severity matrix. In doing so, it allows a wide spectrum of risk types to be accounted for whilst limiting each rating scale to a sensible size; a large rating scale can be difficult to use and can have implications on the consistency of the findings. It also enables assessors to evaluate “extreme” events that are high-magnitude low-probability (and vice versa) without any artificial adjustments to make likelihood or severity a more dominating factor than the other. Such adjustments are hard to justify, as the research has not found any significant evidence to suggest that likelihood is more important than severity (or vice versa). Requiring the assessors to think about likelihood and severity separately will also help to reduce misconception. Another key feature of the method is the assignment of text description to each of the likelihood and severity ratings. This is to provide guidance to the assessors in order to introduce a more objective element to the evaluation and thus enhance the validity and reliability of their evaluations.
Evaluation and Verification

Having developed a prototype methodology for crowd safety risk assessment, it was necessary to evaluate it to identify scope for improvement. Ideally, the evaluation should involve a representative sample of the assessors. This is important because, firstly, the assessors are the intended users of the methodology and, secondly, they have the necessary experience to pinpoint any problems and inadequacy the prototype may have. However, as highlighted earlier in this chapter, the availability of assessors for the evaluation, and for the subsequent verification programme, is a key constraint of this research. To minimise the effect of this problem, the evaluation programme consists of the following components:

(i) A “pre-evaluation” usability test – As there were only limited assessors available for evaluating the prototype, it was important to maximise what they could contribute to the evaluation. To prevent assessors being distracted by “side issues” such as readability and the user-interface issues, this test is designed to iron out as many significant usability problems concerning the presentation of the methodology as possible. This was done using the heuristic evaluation method with human factors specialists employed as evaluators.

(ii) User trials – This is the main part of the evaluation whereby assessors were asked to try out the methodology in order to test its validity and usability. Observations, informal discussions and a questionnaire were the techniques used to exact findings from the trials.

(iii) Questionnaire survey – The user trials were time consuming to do and, hence, not every assessor involved in the evaluation was able to participate in the trials. The aim of the survey was to capture the views and comments of those assessors who were unable to take part in the trials and, thus, provided additional information for the evaluation.

The results of the evaluation indicated that the hazard identification method was oversophisticated and difficult to use for the assessors. The use of combinations of hazard keywords was an alien idea for most assessors and there was a mis-match between the assessors’ expectation and the proposed method. Hence, there was much difficulty in
applying the method. Although an alien idea does not necessarily render it a bad idea, subsequent review of the method has revealed that at least part of the difficulty arose from the fact that the prototype method still has the pre-requisite to define the character of venue and the activities. For example, to identify the hazard, it was still necessary to define, though at a more reduced level, what venue features and aspects of crowd activities are involved before considering what problems associated with these features and activities could arise (i.e. their “failure modes”). In principle, this means that hazard identification is better structured and more comprehensive. But the user trials suggested that even such a level of definition could still be a problem for many venues.

The methodology was revised accordingly after the evaluation. Amongst the changes made, the most important modification was the abandonment of the “combinations of keyword” approach for hazard identification. This was replaced by a HAZOP I type keyword approach, as it is more suitable for situations where things are really not very definable. It is also a simpler method and is easier and less time consuming to use.

The risk evaluation method, on the other hand, appeared to work very well although it is also more complex than the single rating methods used by the assessors. Relatively minor problems were identified concerning specific aspects of the proposed method. But, by and large, there were no fundamental changes to the original method.

The final draft of the risk assessment methodology for crowd safety was subjected to a verification programme. This was carried out by means of controlled experiments and user trials to compare the final draft with an established method representative of the existing methods used by many venues. As before, the unavailability of assessors was a major constraint to how verification can be conducted. There were also other related issues that needed to be considered. For example, the differences between public venues and, hence, the varying knowledge and experience of their assessors, make comparing like with like impossible to achieve. The time and effort that would be required of the participating assessors and the running costs also make it not viable to carry out empirical tests involving large numbers of assessors. Hence, undergraduate students were used instead as subjects in a set of controlled experiments. The benefits
are two-fold. Firstly, a sufficient number of subjects can be found for the experiments. Secondly, all subjects had a similar level of knowledge and experience, which enables comparisons to be made on equal terms in this respect. Nonetheless, it is recognised that inputs from the assessors are also important at this stage as they are the intended users and they hold the experience and the intimate knowledge about the venue and its operations necessary for a comprehensive assessment. Thus, a number of user trials were also carried out in parallel to the experiments in order to obtain the verdicts from the assessors.

Another research constraint is that there are no “correct answers” per se against which risk assessment findings by the subjects can be compared to determine how they well perform, as risk is about uncertainty and future happenings. Therefore, indirect methods of measuring performance were employed. In hazard identification, it was measured in terms of the number of hazards that one can identify. For risk evaluation, the focus was on establishing the validity and the reliability of the evaluations. More specifically, it measured the consistency between individuals’ evaluations of the same hazard and the consistency of the evaluations by the same individual on the same hazards at different times.

The findings of the user trials were very favourable to the methodology. All assessors involved regarded the proposed hazard identification and risk evaluation methods as either useful or very useful. Compared to the methods they were using at the time, the majority found the proposed methods either better or much better. Whilst the results gave some indications on how the assessors thought of the proposed methods, it has to be noted that they are merely subjective judgements from a small sample of assessors. More substantial evidence was required, and this was provided through the controlled experiments.

In terms of hazard identification, the results of the controlled experiments showed that subjects using the proposed method identified a larger number of hazards. The results are sufficiently significant to conclude that the use of the method can lead to improved performance in hazard identification. Also, by adopting a keyword approach that is so similar to the HAZOP I (structured brainstorming) approach, it would be interesting to
also see if it leads to further improvement if subjects worked in a small team, as in the case of a HAZOP study. However, the findings showed that team working did not appear to result in any significant improvements. Nevertheless, what is worth noting is that this result does not necessarily mean that there were no significant benefits to be gained with team working. One of the key requirements for a HAZOP type study is that the team should consist of people with different backgrounds, knowledge and concerns. This was not simulated in the experiments, as it was not possible to do so with the existing subject group.

In terms of risk evaluation, there were mixed findings. The results of the experiments have shown that subjects using the proposed method are more consistent with each other's evaluation findings, and this consistency between evaluation findings improved further when subjects worked in small teams. However, it has also found that subjects using the proposed method were less consistent over time; i.e. they produced different evaluations on the same hazards at different times. There are a number of factors that may help to explain this result. Firstly, the proposed method has larger rating scales and a higher number of risk levels. This means that there are more choices to choose from and, hence, more scope for giving a different answer. This factor could affect consistency between individuals as well as consistency over time. Secondly, because of the larger rating scales used in the proposed method and also because the proposed method is generally more complex, it is less likely that subjects would remember in the second part of the experiment what answers they gave previously. To what extent better reliability of the alternative method was achieved due to subjects remembering their previous answers is not entirely clear. The third factor is that subjects may have a change of mind between the first and second parts of the evaluation experiment. This is possible because of the “learning effect”; i.e. as crowd safety was new to all subjects in the first part of the experiments, subsequent visits to the student union building (i.e. the venue used for the experiments) could result in them learning about crowd safety in the building. Consequently, the learning effect could lead to changes in the perception and evaluation of the risks. It is possible that the lower level of consistency achieved in the proposed method is actually an indication that it was more sensitive to changes, either in risks or risk perception, and reflects such changes better in the findings.
Overall, the verification programme has shown conclusively that the methodology in the final draft can lead to improved performance in hazard identification. But it is less conclusive with regard to risk evaluation. Consistency of the evaluation findings over time is a concern. It is possible that the proposed method has actually led to a drop in consistency over time. But equally, it could be because the proposed method is more sensitive to changes in risks or risk perception and it is more difficult for the subjects to remember what answers were given in the first evaluation. If true, the former can be particularly beneficial as risk can change between different venues and from time to time. Further investigations are required into these factors.

10.2 Discussion and Conclusions

It is important to recognise that the research described in this thesis merely represents the first step towards achieving a systematic, comprehensive and objective method of assessing crowd safety risks to enable informed decision making. The direct product is an assessment methodology for examining the complex crowd safety issues that can arise in public venues. The key parts of the methodology are the hazard identification and risk evaluation methods. The methodology has proven to be more effective in the assessment of crowd safety in places of mass gathering, in the respect that people using it are likely to identify more hazards. It is clear that much benefit can be gained for making the assessment method more suitable and appropriate to the nature of work and hazards. The methodology has also proven to generate findings that are more valid, in the respect that people are more in agreement with each other’s evaluation of risks. However, it also appears that the methodology produces findings that are less reliable, in the respect that more people are likely to come up with a different risk evaluation at different times. But as discussed above, there is still some uncertainty as to exactly what the contributory factors to this are and the extent of their influence.

Apart from the direct achievements in the course of developing the methodology, the investigations into the nature and extent of hazards in public venues have also led to an improved understanding of the crowd safety risks and how they can be captured and accounted for in risk assessment. In particular, the hazard identification keywords
have provided the taxonomy of the kinds of crowd safety hazards that could arise in a public venue of mass gathering. It is believed that the research work has also served to cast a light on how risk assessment is possible in non-work related contexts where the hazards can be different and the activities are difficult to define.

Overall, the research work possesses the following characteristics that distinguishes it from other research studies in many respects:

- It is unique in its application. Although risk assessment is well established, there has been little attempt to apply it to the public environments where the activities involved are much more wide-ranging and less definable. This thesis has shown that the safety problems that could exist in such an environment can be complex and distinctively different from many other environments or contexts where risk assessments have been used. It follows that a different risk assessment is required to assess these problems. The thesis has described a way in which alternative risk assessment methods could be developed.

- It ventures into territories that have not received too much research attention in the past, i.e. crowd safety. Even though people have been managing large crowds for a long time, there have been very few research studies into the subject. The area of risk assessment is much better researched and more established but traditionally the focus has been on quantified methods. More recently there has been more attention devoted to quantitative methods. The lack of research, and the richness in practical experience has presented a unique challenge to the research methodology. This means that the research has to place a heavier reliance on information in the field to take advantage of the wealth of experience out there. This thesis has described an approach for researching into a subject area where there is plenty of experience but little research. It has also illustrated how an analytical tool such as task analysis may also be used as a research tool to form part of this information gathering process.

- As a part of the overall research methodology, it explicitly sets out to establish the practical considerations associated with the management and assessment of crowd safety (i.e. through a venue survey and, to a lesser extent, task analysis). The lack of research is only one reason for this. Fundamentally, rather than being an
empirical research, the research aimed to bridge the gap between the risk assessment principles and its application to produce a practical solution to a set of complex problems that could affect the safety of many. To this end, the thesis has combined the theory and past research on risk assessment with key considerations such as the legal requirements, the existing guidance and current practices, and the practical issues and constraints facing the assessors. In fact, it is worth noting that from the experience of this research, the inclusion of these practical considerations has enriched and enhanced the research.

- It involved the end users throughout the research. The research methodology has accommodated a significant amount of venue assessor involvement. Their inputs are not only vital at the information gathering stage, but they were also invaluable in the evaluation of the risk assessment methodology. In particular, where there could be alternative solutions to a problem, as in the case of hazard identification, it is often those who have the first hand experience who hold the key that helps to find the answer as to which is the more suitable solution overall. As a direct result of assessors’ inputs in the evaluation, the hazard identification method suggested in the prototype was revised. Unfortunately, the question of whether the prototype method or the revised HAZOP I type method produce better performance was not tested in the research. However, when comparing the user trials in the evaluation against the user trials in the verification (i.e. after the method was revised), there is qualitative evidence to suggest that the latter is probably more suitable overall at present when it is applied to real life situations by actual assessors. Nevertheless, in the long run, it will be most interesting to establish whether a more structured and sophisticated method, such as that suggested in the prototype, is more or less superior to the relatively simple method currently recommended for the type of hazards encountered in public venues.

As a ground laying research into an area that has received very little research attention in the past, this research has dealt with the topic of crowd safety risk assessment at a more general level. It has covered a wide range of issues but has not investigated all of these issues in great depth. It is hoped that the work completed in this thesis will pave the way for further research and improvements in crowd safety and crowd safety risk assessment in the future.
Furthermore, this research has focused largely on the “technical” aspects of risk management; i.e. the use of risk assessment as a means to assist managers to identify appropriate technical solutions for controlling crowd safety risks. The final draft of the methodology does not explicitly address the management factors such as management beliefs/mindset, costs, inter-organisational communication and culture. As previously highlighted in Section 2.3.5, relying on technical solutions alone may be insufficient to ensure safety. Some researchers (e.g. Elliott and Smith, 1993; Smith, 1995) have even suggested that over-reliance on technical solutions alone could lead to management complacency and serve as a barrier to learning. There is a further potential danger that over-reliance on technical solutions might lead to venue managers completely ignoring the issue of safety and leaving it to the technical experts (e.g. safety officers). When assessing the role of technical experts in risk management, some researchers have also argued that over-reliance on technical experts could become problematic if the issue is “trans-scientific” in nature or if it lies outside the accepted boundaries of knowledge and cannot be scientifically proven. At its most complex, this could become a social-political conflict (e.g. Calman & Smith, 2001). With this in mind, it is worth exploring further whether the use of risk assessment could be counter-productive.

The main focus of risk assessment is to identify potential problems, evaluate their risks and identify suitable means to control them. As the risk assessment methodology, as it stands, does not address management factors directly, it is possible that a manager could be lured towards searching for technical solutions rather than addressing the underlying shortfalls in their management system. The assessment methodology, which explicitly requires the identification of the causes of complex hazards, should help to encourage venue managers to identify the underlying causes and devise remedial measures to deal with the causes rather than just the symptoms. Nevertheless, it is acknowledged that the methodology may be insufficient in encouraging assessors to identify some of the management issues such as the social, historical and economic factors. Further work will be required in this area. Also, once the assessment is completed and the necessary changes are implemented, venue managers could have a false sense of security that the safety risks are under control.
and, so, relax their vigilance. It is possible that they may fail to consider, for example, whether the changes could give rise to new problems or whether the management system is adequate in facilitating the changes.

On the other hand, a systematic and comprehensive risk assessment would help to make venue managers more aware of the problems that could arise and the risks involved. In this respect, this could help to reduce management complacency and mindset. The hazard identification method developed in this research was designed to encourage lateral thinking, which would help managers to develop new perspectives, question their existing beliefs and improve management foresight. The risk evaluation method requires assessors to take a step back and evaluate in a more objective manner the risks in terms of the likelihood and the severity of harm. It follows that if the likelihood and severity are deemed to be high, then priority should be given to tackling the problem even in the absence of hard evidence of significant risk.

From past crises and disasters in crowd safety and other contexts, it appears that all too often evidence of significant risk only becomes apparent to the management in the wake of major disasters. As previously discussed in Section 1.4, fortunately in crowd safety, such disasters are relatively rare although the consequences can be very severe. Thus, the opportunities for learning from past disasters are very limited. Nevertheless, some evidence-based learning is still possible from past information such as incident/injury records, post event reports, customer complaints, de-briefings of front line staff, etc. For example, the analysis of accident records, match reports, etc. in the football industry by Elliott et al (1997) serves to show that evidence-based learning using past information is possible in some sectors. Worker participation in safety management is another possible source of information for risk assessment (Smith, 1996). Calman & Smith (2001) also argue that recognition should be given to other forms of knowledge, such as that held by the workers, users, consumers, local groups and those charged with implementing policy. They argue that uncertainties may be better understood by reference to this wider body of knowledge. The involvement of "lay" persons (as well as professionals) is particularly important with respect to issues that are not purely scientific (Irwin, 2001). Obviously, the extent of evidence-based
learning would very much depend upon the quantity and quality of the information each venue has collected. Learning from the experience of others can be another valuable source of information for risk assessment. Unfortunately, for many public venues, there is a general lack of data for evidence-based learning. For example, currently there appears to be no public forum whereby venue managers can exchange information and share experience. With limited evidence-based learning, there is a particular concern that assessors and managers might be less likely to identify new hazards that have a low likelihood of occurrence. As Reason (1998) pointed out, if people see nothing, they presume that nothing is happening, and that nothing will continue to happen. He concluded that in the absence of frequent bad events, the best way to induce and sustain a state of intelligent and respectful wariness is to gather the right kind of data. The problem of a lack of data and information is well illustrated when Medvedev, a leading Soviet nuclear engineer, explained why the Moscow-based Nuclear Safety Committee did not act to halt the electrical generation experiment, which led to the Chernobyl nuclear disaster in 1986.

*It was almost as if they had conspired not to intervene. Why? The fact was that there was a conspiracy of silence. Mishaps were never publicized; and as nobody knew about them, nobody could learn from them. For 35 years people did not notify each other about accidents at nuclear power stations, and nobody applied the experience of such accidents to their work. It was as if no accidents had taken place at all: everything was safe and reliable.* ("The Truth about Chernobyl" by G. Medvedev, 1991, New York, Basic)

Therefore, developing a system of information gathering, analyses and dissemination within an organisation and a public database of incidents and near misses are also very important for risk assessment.

### 10.3 Further Research

This final section of the thesis looks at some of the issues and areas that would benefit from further research and development.
The first issue that needs to be addressed is how to improve reliability in risk evaluation. The second related issue concerns the gathering of information about crowd safety to enable a more objective evaluation of the risks. The lack of researched knowledge on the risk factors and limited evidence based learning are some of the problems that need to be tackled in order to reduce the reliance on subjective judgements of the assessors and, hence, improve reliability. The third area that requires further investigation is how much a venue owner should do to tackle the risks. This issue has not been properly resolved in this research. The fourth issue is whether risk assessment is better if it is performed by an individual assessor or by team effort. These issues are all concerned with the tools and techniques of the methodology and its implementation. The final issue concerns the wider area of the organisational management aspects of risk management. This research has not directly addressed the organisational management factors, which could be an underlying cause to the incubation of crisis and disasters. Whether a risk assessment methodology that fails to explicitly address these management factors is counterproductive and, if so, how this can be resolved is an interesting area for further research. The remaining sections of this chapter will discuss all these issues further.

Improving Reliability in Risk Evaluation

One question immediately arising from the current research is the reliability of the risk evaluation method. As already discussed, the experimental results in Section 9.4 have shown that the subjects’ evaluations of risks under the proposed method appear to be less reliable over time. The thesis has highlighted a few possible reasons for this but it is not entirely clear to what extent these factors may have affected the outcomes of the experiment, and whether there were any other factors involved. For example, it would be interesting to establish the extent that the “learning effect”, as opposed to the relative complexity of the method, had on the experimental results. If learning effect is found to be a significant factor, then it is likely that reliability can be better maintained if the evaluation is undertaken by actual assessors, who have more experience and are more knowledgeable about the venues under assessment. Furthermore, it can be argued that the apparent lack of reliability shown in the experiment could be a sign that the method is more sensitive to changes in
circumstances. A method that is more sensitive to the learning curve and changes in risk perception can also be good for new venues and events where initially there is usually limited venue specific experience and knowledge. However, if the “learning effect” is not a significant factor, then it will be necessary to establish the true reason(s) for the drop in reliability and to identify the ways in which reliability could be improved. This may involve, for example, having to reduce the size (or the number) of the rating scales currently used in the proposed method. In which case, difficult decisions would have to be made to find the balance between reliability, validity and the ability to cover the full spectrum of eventualities and clearly distinguish different levels in terms of their likelihood and severity.

Understanding the Risk Factors and Evidence Based Learning

Making adjustments to the mechanism of the risk evaluation method will probably only deal with symptoms of the reliability problem. Another way of improving reliability is to tackle the underlying cause; namely, the subjective nature of the evaluation. Even though the proposed methodology promotes a more systematic and rational approach, risk evaluation is still essentially a matter of subjective judgements, expressed through ratings. It is believed that, in the long run, the way to further improve the validity and reliability of the evaluation is to make it a more objective process, whereby evaluations are based more on “hard information” or predictions about the crowds and the venues. Subjective judgements are more likely to be influenced strongly by personal perception as well as by factors that are not necessarily related to safety; e.g. commercial interest, political pressure, public opinions, the “hot” issues/concerns at the time, etc. Although in practice these factors are important considerations, it is more appropriate to deal with them later when deciding how the risks are to be managed, rather than to mingle them with the safety issues. Therefore, risk assessment ought to focus on safety alone. Only after the risks to safety are established can they be considered together with the other factors to facilitate decision making in planning and risk management.

For the purpose of this section, the term “hard information” refers to crowd and venue characteristics such as crowd size, density and movement; visitor type, behaviour and
activities; venue layout and features, etc. Such information is relatively easy to obtain in practice, normally through planning, intelligence gathering, operational experience, observations, CCTV footage/photographic images. Advances in computer modelling also make it possible to make predictions on such things as crowd distribution, areas of high-density and crowd dynamics (e.g. Hillier, 1996). Risk evaluation based on crowd and venue characteristics that are specific to the venue/event under assessment is likely to be much less subjective, and hence more reliable. However, the question that needs to be addressed is how these characteristics can be translated into risk, or how they can be used to provide an indication of the risk involved. Further research is required in this area.

One way of addressing this question could be to look at these characteristics in terms of how and to what extent they can affect crowd safety risks, or “risk factors”. For example, crowd density can be seen as a risk factor in that the higher the density, the higher the risk it is likely to pose. Similarly, the size of the crowd, visitor type, whether they are stationary or moving, the speed of movement, whether it is a single direction or multi-direction flow, venue characteristics, etc. are also factors that could have an effect on the overall risk (Au et al, 1993). By understanding the relationship between these factors and crowd safety risks, it would then be possible to use the information and prediction about the crowd and the venue in a more objective manner to evaluate what they could mean in terms of the risks they pose. A similar method of evaluation (i.e. using risk contributory factors) is used in the field of human reliability assessment (e.g. Williams, 1988). Currently, our understanding of this relationship is limited and is based on individuals’ experience rather than researched knowledge. To improve our understanding, much more research needs to be done on the dynamics and the behaviour of crowds and how they may contribute to risks. Just as in human error, the different crowd safety risk factors could interact with each other and there is still much to find out. We need to establish, for instance, why there appears to be less risk of people being seriously injured or killed by crushing on a metro train than in a pop concert even though the packing density on the train during peak hours can be higher. There are also many other examples of mass gathering, but not all of them turn into a disaster. Understanding what makes a crowded situation go wrong is an important part of this line of research.
Learning from past evidence could also help to improve risk assessment, both in terms of a more objective risk evaluation and improved hazard identification. However, as discussed previously in Section 10.2, the opportunities for evidence-based learning are currently very limited. There is a potential danger that people may not have enough experience to make the correct judgement when it comes to risks that have a high severity but a low likelihood of occurrence. More data and case studies of past incidents and near misses are, therefore, needed to be collected to facilitate better risk assessment.

The research work suggested above will not only be useful for risk evaluation, it will also better equip us to identify the suitable remedial measures to deal with the risks.

_Determining Appropriate Risk Management Measures_

Another area of risk assessment that needs looking into is decision-making for planning and risk management purposes. Having identified and evaluated the risks, the question is what should be done about the risks. There are two parts to this question. The first part concerns what remedial measures are required to tackle the hazards. This will vary depending on the causes and nature of hazards. The other part of this question is how much we need to do to manage the risk and, in particular, what the basis should be for making such a decision. This is an area that requires further examination. For the sake of completeness, the current methodology given in Appendix D has included a scheme for the interpretation of risk levels to determine the extent of actions required. This is also shown in Figure 7.3 of Section 7.3.5. The scheme was based on the principles of tolerability, acceptability and ALARP from the HSE (1992c) for the nuclear industry. Although the principles have become the convention in the safety field in general, their application to crowd safety has not been properly researched and is not verified in this thesis. Also, whilst the scheme is suitable for the nuclear and other similar industries where tolerability and acceptability criteria can be set in terms of the risk of a certain amount of exposure/dose received, it may not be appropriate for crowd safety. In the nuclear industry, the risk of someone receiving an excessive amount of exposure can be
determined more objectively through QRA and the criteria on what is an excessive amount can be set based on medical knowledge and evidence. But the same cannot be said for crowd safety. Under the current methodology, the basis for saying that a level A risk is intolerable and a level D risk is broadly acceptable, etc. is unsubstantiated and rather arbitrary. What the appropriate basis is for making risk management decisions in crowd safety needs to be looked at in more detail.

Risk management is a central topic of debate (e.g. Royal Society, 1992). Essentially, it is about putting together rational arguments making justifiable decisions on how much one ought to do to deal with the risks. There are many factors involved and numerous issues need to be taken into account when making risk management decisions. Apart from safety risks, other issues relevant to crowd safety may include social-political factors, such as public risk perception and public attitudes towards any trade-offs and inconvenience that may result from the risk reduction measures. For example, how much reduction in entertainment value are people prepared to accept for the sake of safety and how would people react to disruptions to road traffic if main roads are closed to improve safety at and near an event? The need for taking into consideration the social-political issues is highlighted by some of the criticisms on a purely risk-based approach to risk management decision making. For example, it is argued that such an approach is not sufficiently sensitive to public concerns and opinions (Kletz, 1988) and does not relate benefit clearly enough with tolerability (Royal Society, 1992). What the social-political issues are in crowd safety and how (and to what extent) they should be taken into consideration in risk management decision making could be an interesting area of research and debate particularly for social scientists.

Another possible area of research is the modification of the methodology for specific venue types. The current work is intended for public venues in general. However, as the case studies in Chapter 3 have demonstrated, every venue type is different in their nature of operations, visitor composition, visitor activities and so on. As such, hazards that are significant in one type of public venue may not be a problem in another, and the extent of the risk they pose could also vary from venue type to venue type. Therefore, it could be beneficial to use the current methodology as the basis for
developing more specific risk assessment for specific venue types to address the kinds of safety issues or problems they encounter.

*Risk Assessment by Individuals vs. Team Effort*

Whether a risk assessment performed through team effort is better than by individuals, (and why) is an interesting issue to explore further. This thesis has touched upon this issue through the experiments in Chapter 9. The results appear to show that the former is better when it comes to risk evaluation, but the results for hazard identification are inconclusive. A main difference between the experiments and how the team effort approach is intended to work is that all of the subjects in the experiments have a similar background in terms of crowd safety. Similar techniques involving team effort require that the team should include people from different backgrounds who have different roles to play in ensuring the safety of the overall system. Experience suggests that team effort should normally lead to improved performance. Whether this would equally apply to crowd safety is worth further investigation. A related question is whether the reliability and validity of risk evaluation can be further improved if the team consists of people from different backgrounds. From a practical viewpoint, there is also the question of whether or not there are sufficient benefits to make risk assessments by a team worthwhile, given that it can be more difficult to organise and costly to run. As a further development to the current methodology, it will therefore be interesting to look at these questions. From an implementation viewpoint, other questions that need addressing include who should be in the assessment team and what the optimum size of the team is. The assessment may not work as well if the team is too small. On the other hand, a team that consists of too many people will not only be costly to run, it could also be counter-productive.

*Organisational Management*

Smith (1999) has argued that many failures and crises emerge from the organisation's system of management (e.g. culture, core belief, ineffective communication, etc.) and
that the potential for failures is often built into the system by management practice, protocols and processes. Although the assessment methodology, which promotes lateral thinking, may help to prompt the assessors to take a step back to consider such issues during their assessments, it does not provide any specific help in enabling the identification of the underlying management issues that could lead to the incubation of crisis. The relationship between organisational management and incubation of crisis and the danger of relying on technical solutions alone has been the subject of various research projects. However, the questions are: (i) to what extent they are relevant to crowd safety; (ii) whether a “technical” risk assessment that does not directly address the management factors is still helpful or could it be counter-productive in some respects and give venue managers a false sense of security; and, (iii) how technical solutions can be addressed in conjunction with management issues or how management factors can be best captured in risk assessment so that they receive proper attention, as highlighted in Section 2.3.5. These are some of the outstanding issues that would require more thought.

Final Remarks

To conclude, the research work described in this thesis has taken the first step towards facilitating a more rational and justifiable decision making process for planning and risk management. There are still many issues that need following up and plenty of scope for further development, particularly in the subject of crowd safety. Although people have been practising it for many years, very little research has been done. One of the top priorities for future research should, therefore, be to improve our knowledge and understanding about crowds. Another priority is to establish the relationship between crowds and risks and how this relationship can be captured in risk assessment. Those issues discussed in this chapter are identified as a result of the current work for moving towards addressing these priorities. As this line of research progresses, more issues will be identified and more effort will be required before the ultimate goal of achieving an objective risk assessment, described earlier in this chapter, can be reached.
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Safety of Sport Ground Act 1975.


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APPENDIX A

Public Venue Interview Questionnaire
VENUE OWNER INTERVIEW QUESTIONNAIRE

A. Current Practice

1. What are your main operational/safety concerns (e.g. congestion/overcrowding, emergency evacuation, other aspects of safety, public disorder, crime, etc.)?

2. How did you arrive at the above?

3. What plans (and procedures) do you have in place to address your crowd safety concerns (e.g. congestion, emergency response, etc.)?

4. Please describe your safety assessment and planning process.

5. How is information (e.g. from existing guidance, discussions with others, comments from staff and visitors, past incidents, exercises, etc.) fed into your assessment and planning process?

6. What do you do to achieve the following (e.g. the approach adopted, any specific techniques or tools used, etc.):
   - to identify safety hazards
   - to determine whether or not they are significant. Also, what are the criteria, acceptable risk levels, etc.?
   - to determine whether existing measures and plans are sufficient
   - to identify any additional measures required (including modification of plans) and things that need to be improved
   - [For venues which require a licence to operate] to meet any safety related terms and conditions specified by the licensing authority. Also, what are they?

7. In your opinion, what are the benefits and pitfalls of the assessment method(s) mentioned above? (Also, have you considered doing the above in any other ways?)

B. Risk Assessment

Under the Management of Health and Safety at Work Regulations (MHSWR), employers are required to assess the risks to their employees and others who may be
affected by their undertakings. This also applies to public venues. The Health and Safety Executive (HSE) recommends that a risk assessment should:

- look for hazards
- decide who might be harmed and how
- evaluate the risks arising from the hazards and decide whether existing precautions are adequate or more should be done
- record your findings
- review your assessment from time to time and revise it if necessary.

8. From your experience, what are the constraints and problems associated with conducting crowd safety risk assessment in public venues such as yours?

9. How did you decide what is a suitable risk assessment to your specific venue(s)? Also, what do you think is a “suitable and sufficient” risk assessment for public venues which, on the one hand, can enable the assessors to address the sometimes complex crowd safety problems and, on the other hand, is simple and easy enough to use?

10. Given Q8 and Q9 above, to what areas do you think the crowd safety risk assessment methodology should pay more attention in order to best address your needs? (i.e. what support or assistance in the form of assessment techniques and guidance would you like to see?)

11. Do you have any other comments on crowd
APPENDIX B

Enforcing Authorities Interview Questionnaire
ENFORCING AUTHORITIES INTERVIEW
QUESTIONNAIRE

A. Current Practice

1. What are the main operational/safety concerns of the venues/events under your authority (e.g. congestion/overcrowding, emergency evacuation, other aspects of safety, public disorder, crime, etc.)?

2. How did they arrive at the above?

3. When dealing with a licence application (or renewal), what do you do to determine the terms and conditions which the applicant should meet?

4. How is information (e.g. from existing guidance, discussions with others, comments from staff and visitors, past incidents, exercises, etc.) fed into the above?

5. What plans (and procedures) do the venue owners/event organisers have in place to address their crowd safety concerns (i.e. congestion, emergency response, etc.)? Also, are they part of the terms and conditions?

6. In addition to meeting the terms and conditions set out by you, do the venue owners/event organisers also carry out some form of planning and safety/risk assessment? If NO, go to Q 9.

7. What are the planning and safety/risk assessment process(es) they usually adopt? In particular, what do they do to achieve the following (e.g. the approach adopted, any specific techniques or tools used, etc.):
   - to identify safety hazards
   - to determine whether or not they are significant. Also, what are the criteria, acceptable risk levels, etc.?
   - to determine whether existing measures and plans are sufficient
   - to identify any additional measures required (including modification of plans) and things that need to be improved.

8. In your opinion, what are the benefits and pitfalls of the assessment method(s) mentioned above? (Also, have they considered doing the above in any other ways?)
9. In your opinion, should they carry out additional planning and/or assessment? If so, what planning and safety/risk assessment process(es) would you prefer?

B. Risk Assessment

Under the Management of Health and Safety at Work Regulations (MHSWR), employers are required to assess the risks to their employees and others who may be affected by their undertakings. This also applies to public venues. The Health and Safety Executive (HSE) recommends that a risk assessment should:

- look for hazards
- decide who might be harmed and how
- evaluate the risks arising from the hazards and decide whether existing precautions are adequate or more should be done
- record your findings
- review your assessment from time to time and revise it if necessary.

10. From your experience, what are the constraints and problems associated with conducting crowd safety risk assessment in public venues such as those under your authority?

11. What do you think is a “suitable and sufficient” risk assessment for public venues which, on the one hand, can enable the assessors to address the sometimes complex crowd safety problems and, on the other hand, is simple and easy enough to use?

12. Given Q10 and Q11 above, to what areas do you think the crowd safety risk assessment methodology should pay more attention in order to best address the needs of the public venues? (i.e. what support or assistance in the form of assessment techniques and guidance would you like to see?)

13. Do you have any other comments on crowd safety risk assessment?
APPENDIX C

Analysis of the Tasks Involved in the Assessment of Crowd Safety Risks
APPENDIX C-1

Hierarchical Task Analysis (HTA)
CONDUCT A CROWD SAFETY RISK ASSESSMENT

Plan 0.0: 1.0 -> (2.0 & 3.0 in any order) -> 4.0 -> (5.0 regularly or if there are any significant changes or after any significant problems have been identified)

1.0 IDENTIFY HAZARDS

Plan 1.0: In any order

1.1 Identify Hazards Associated with Poor Venue Design

Plan 1.1: 1.1.1 -> (1.1.2 -> 1.1.3 -> repeat until the whole venue has been considered)

1.1.1 Consider each part of the venue
1.1.2 Identify undesirable design features (e.g. pinch points)
1.1.3 Identify hazards presented by each of the above design features

1.2 Identify Hazards Associated with Visitors' Activities/Behaviour

Plan 1.2: 1.2.1 -> (1.2.2 -> repeat for all activities)

1.2.1 Identify visitors' activities and likely undesirable behaviour
1.2.2 Identify hazards due to each activity/behaviour

1.3 Identify Hazards due to Inadequate Crowd Safety Management (e.g. staff errors, poor communication, etc.)

Plan 1.3: 1.3.1 -> (1.3.2 -> repeat for all inadequacies)

1.3.1 Identify areas of inadequacy
1.3.2 Identify hazards due to each inadequacy

1.4 Identify Hazards due to Disruptions to the Normal Operation

Plan 1.4: 1.4.1 -> (1.4.2 -> repeat for all scenarios)

1.4.1 Identify scenarios (e.g. equipment failures, cancellation of services, delays, adverse weather conditions, accidents, etc.)
1.4.2 Identify hazards that could arise under each scenario

2.0 DECIDE WHO MIGHT BE HARMED AND HOW

Plan 2.0: 2.1 -> 2.2

2.1 Identify Visitor Group(s) who might be Particularly Vulnerable
2.2 Consider How Visitors might be Harmed

3.0 EVALUATE RISKS

Plan 3.0: 3.1 (for all hazards) -> 3.2 -> 3.3

3.1 Estimate the Risk Associated with each Hazard

Plan 3.1: (3.1.1 & 3.1.2 in any order) -> 3.1.3 -> repeat for all hazards
3.1.1 Estimate likelihood of each hazard
- Take into account past experience
- Take into account any relevant historical data on accidents and near misses
- Consider relevant intelligence reports (if any)
- Consult relevant guidance and other sources of crowd safety knowledge
- Take into account any existing safety measures

3.1.2 Estimate severity of each hazard
- Consider the human costs
- Consider other costs and adverse consequences
- Take into account any existing measures and any other factors (e.g. the circumstances under which the hazard takes place) that could mitigate the harm

3.1.3 Estimate the risk posed by each hazard
- Estimate the risk level based on the estimated likelihood and severity of the hazard

3.2 Prioritise Risks

Plan 3.2: 3.2.1 -> 3.2.2

3.2.1 Determine acceptability of risks
Plan 3.2.1: 3.2.1.1, repeat for all identified hazards

3.2.2 Prioritise unacceptable risks
Plan 3.2.2.1 Compare all unacceptable risks to determine their relative importance

3.3 Identify Remedial Actions Required to Reduce Risks

Plan 3.3: 3.3.1 -> 3.3.2

3.3.1 Identify possible ways to reduce each unacceptable risk
Plan 3.3.1: (3.3.1.1 & 3.3.1.2 in any order) -> 3.3.1.2 -> 3.3.1.4 -> 3.3.1.5 -> repeat for all unacceptable risks

3.3.1.1 Consider the causes and consequences of hazard
3.3.1.2 Consider who might be harmed and how
3.3.1.2 Identify any ways to get rid of the hazard altogether
3.3.1.4 Identify any ways to reduce the risk
3.3.1.5 Identify any ways to control the harm or to protect those who are particularly vulnerable

3.3.2 Decide on the most suitable remedial actions to take
Plan 3.3.2: 3.3.2.1 -> 3.3.2.2

3.3.2.1 Analyse risk reduction options
consider how much risk the action of concern could help to reduce
consider how important these risks are
consider how effective each action could be in controlling these risks (e.g. eliminate the hazard altogether, reduce the risk or control its harm?)
consider whether it would create other problems elsewhere
consider what other trade-off or drawbacks there are (e.g. the cost of implementing the action, adverse effects on other aspects of operation, etc.)

3.3.2.2 Decide what actions to take (to achieve the best overall result)

4.0 RECORD FINDINGS

Plan 4.0: 4.1 -> 4.2

4.1 Show in the Record that a Proper Check was Made
Plan 4.1: 4.1.1 -> (4.1.2 where appropriate)
4.1.1 Record all significant information generated in the assessment, including significant hazards, the risks they pose and proposed remedial actions
4.1.2 Cross-reference to other documents or records for details

4.2 Show in the Record that Reasonable Precautions Have Been Taken to Ensure Crowd Safety
Plan 4.2: (4.2.1 & 4.2.2 in any order) -> (4.2.3 where appropriate) -> (4.2.4 where appropriate)
4.2.1 Record any measures that are already in place to control the risks
4.2.2 Record any actions to be taken to reduce the risks
4.2.3 Record reasons for not taking more action to control the risks
4.2.4 Cross-reference to other documents or records for details

5.0 REVIEW AND REVISE ASSESSMENT

Plan 5.0: 5.1 -> 5.2

5.1 Decide When to Review
5.2 Decide What needs to be Revised/Amended
5.3 Modify Assessment Accordingly
APPENDIX C-2

Tabular Task Analysis
**TABULAR ANALYSIS OF THE CROWD SAFETY RISK ASSESSMENT TASKS**

**TASK:** IDENTIFY HAZARDS

<table>
<thead>
<tr>
<th>Task no.</th>
<th>Sub-task description</th>
<th>Task requirements</th>
<th>Potential problems</th>
<th>Implications to crowd safety risk assessment methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Identify hazards associated with poor design</td>
<td></td>
<td></td>
<td>• A systematic and structured method of hazard identification.</td>
</tr>
<tr>
<td>1.1.1</td>
<td>Consider each part of the venue</td>
<td>Ensure that all parts of the venue are considered (procedural)</td>
<td>This could be difficult to achieve for large venues with complex layout</td>
<td>• Guidance on how to deal with large and complex venues. For example, divide venues into smaller, more manageable parts (e.g. functional areas) and assess each part in turn.</td>
</tr>
<tr>
<td>1.1.2 &amp;</td>
<td>Identify undesirable design features &amp; the hazards/harms that could arise</td>
<td>Ensure that all significant hazards are identified (procedural)</td>
<td>Too much emphasis on what happened in the past, need to be more proactive Experience-based approaches only focus on past experience &amp; hence not sufficiently comprehensive</td>
<td>• &quot;hazard prediction&quot; type method/one that encourages forethought is required (e.g. HAZOP).</td>
</tr>
<tr>
<td>1.1.3</td>
<td></td>
<td></td>
<td></td>
<td>• The hazard identification process must be systematic and structured.</td>
</tr>
<tr>
<td></td>
<td>Identify any problematic designs or designs that could cause problems (knowledge, experience &amp; info.)</td>
<td></td>
<td>Omissions; i.e. most hazards of this kind are relatively obvious but how the design may interact with visitors is less obvious Info. on near misses &amp; past problems do not always reach the assessors</td>
<td>• Hazard identification method needs to be though provoking.</td>
</tr>
<tr>
<td></td>
<td>Identify any non-compliance with regulations, standards &amp; guidelines (knowledge)</td>
<td></td>
<td>It is reasonable to assume that competent assessors are aware of the relevant regulations, standards, etc.</td>
<td>• Adequate information gathering, e.g. venue inspections, observations and monitoring, comments and complaints.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Method that encourages inputs from the front line staff.</td>
</tr>
<tr>
<td>Task no.</td>
<td>Sub-task description</td>
<td>Task requirements</td>
<td>Potential problems</td>
<td>Implications to crowd safety risk assessment methodology</td>
</tr>
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<td>---------</td>
<td>----------------------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>1.2</td>
<td>Identify hazards associated with visitor's activities &amp; behaviour</td>
<td>Ensure that all significant hazards are identified (procedural)</td>
<td>Omissions – this type of hazards are often difficult to account for Experience-based approaches only focus on recent experience &amp; hence, may not be sufficiently comprehensive</td>
<td>• Hazard id. method need to be though provoking. • Systematic hazard identification. • As all venues are different so there has to be some reliance on venue specific experience; hazard id. must take that into account.</td>
</tr>
<tr>
<td>1.2.1 &amp; 1.2.2</td>
<td>Identify undesirable activities/behaviour &amp; the hazards/harms that could arise</td>
<td>Identify any undesirable behaviour &amp; mass activities that could cause problems; assessors must know their visitors well to achieve this (knowledge, experience &amp; info.)</td>
<td>Assessors often find it difficult to account for crowd behaviour related problems (from case studies &amp; venue survey). Assessors may not have sufficient day-to-day/front line interactions with visitors. Info. on near misses, past problems, etc. may not reach the assessors</td>
<td>• Suggest observations • Involvement of front line staff. • Highlight the importance of information gathering; e.g. good incident reporting system, debriefing, staff &amp; customer comments, etc. • Hazard id. method need to be though provoking and provide prompts.</td>
</tr>
<tr>
<td>1.3</td>
<td>Identify hazards concerning crowd management</td>
<td>All significant inadequacies are identified (procedural)</td>
<td>Experience-based approaches only focus on past experience; hence not sufficiently comprehensive Inadequate feedback re: performance of existing SMS &amp; methods.</td>
<td>• A systematic method. • Prompts to encourage assessors to question their safety provisions. • Encourage involvement of front line staff where possible.</td>
</tr>
</tbody>
</table>
**TASK: IDENTIFY HAZARDS**

<table>
<thead>
<tr>
<th>Task no.</th>
<th>Sub-task description</th>
<th>Task requirements</th>
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<th>Implications to crowd safety risk assessment methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3.2</td>
<td>Identify hazards due to each inadequacy</td>
<td>Recognise significant inadequacies in their crowd management tactics (knowledge &amp; experience)</td>
<td>Inadequate feedback re: performance of crowd management tactics.</td>
<td>- Encourage the involvement of front line staff in hazard identification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recognise significant inadequacies in their safety management system (SMS) (knowledge &amp; experience)</td>
<td>Inadequate feedback re: performance of their SMS.</td>
<td>- Encourage the involvement of front line staff in hazard identification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Assessors with H&amp;S background should be reasonably familiar with SMS, those who have no H&amp;S training may not.</td>
<td>- Improve information gathering.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Cross reference to relevant guidance and documents on SMS.</td>
</tr>
<tr>
<td>1.4</td>
<td>Identify hazards due to disruptions to normal operation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4.1</td>
<td>Identify scenarios</td>
<td>Ensure that the assessment is comprehensive (procedural)</td>
<td>Assessors who are experienced with the venue concerned should have fairly good ideals, the problem is “mind set”.</td>
<td>- Possibly provide a checklist of possible scenarios</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Encourage assessors to think afresh</td>
</tr>
<tr>
<td>1.4.2</td>
<td>Identify hazards that could arise under each scenario</td>
<td>Aware of all significant problems that could arise in each scenario &amp; know how they could affect venue operations &amp; how visitors might respond (knowledge &amp; experience)</td>
<td>Some scenarios may need specialise knowledge/expertise (e.g. explosion)</td>
<td>- Part of risk assessment is to identify when specialists should be involved.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Omission</td>
<td>- Encourage the involvement of front line staff in hazard identification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- A systematic method.</td>
</tr>
</tbody>
</table>
**TASK:** DECIDE WHO MIGHT BE HARMED & HOW

<table>
<thead>
<tr>
<th>Task no.</th>
<th>Sub-task description</th>
<th>Task requirements</th>
<th>Potential problems</th>
<th>Implications to crowd safety risk assessment methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Identify the type of visitors who might be harmed by each identified hazard</td>
<td>Know the visitors well and aware of any special need &amp; any vulnerable visitor groups (knowledge)</td>
<td>Assessors who are experienced with the venue concerned should have fairly good ideals, the problem is &quot;mind set&quot;.</td>
<td>• General guidance on visitor groups who tend to be more vulnerable to most crowd safety hazards.</td>
</tr>
<tr>
<td>2.2</td>
<td>Consider how these visitors might be harmed</td>
<td>An understanding of what harms may arise in various circumstances (knowledge)</td>
<td>For physical hazards, it is normally quite straightforward to establish. But there is a general lack of understanding of human behaviour. Front line experience &amp; frequent interactions with visitors may help to improve understanding of what harms may arise in their specific venues</td>
<td>• Suggest observations • Recommend involvement of front line staff in the assessment process • Highlight the importance of information gathering: e.g. good incident reporting system, debriefing, staff &amp; customer comments, etc.</td>
</tr>
</tbody>
</table>
### TABULAR ANALYSIS OF THE CROWD SAFETY RISK ASSESSMENT TASKS

**Task: Evaluate Risks**

<table>
<thead>
<tr>
<th>Task no.</th>
<th>Sub-task description</th>
<th>Task requirements</th>
<th>Potential problems</th>
<th>Implications to crowd safety risk assessment methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Estimate risks</td>
<td>Make reliable estimates across all risks (procedural)</td>
<td>Uncertainty; i.e. no reliable statistics, data, etc. QRA type approaches are unsuitable Reliability &amp; validity are often the issues associate with subjective assessments Assessment by words contributes to inconsistency unless people all agree on the meanings Risk estimation scheme too crude or too sophisticated.</td>
<td>• Qualitative evaluation method • Appropriate numbers of likelihood and severity categories. • If words are used to describe different levels of likelihood and severity, they should be carefully chosen &amp; clearly defined.</td>
</tr>
<tr>
<td>3.1.1 &amp; 3.2</td>
<td>Estimate likelihood &amp; severity</td>
<td>Take into account precautions that are already in place (procedural)</td>
<td>Not done</td>
<td>• Explicitly require assessors to consider any existing precaution.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Take into account past experience and local knowledge (knowledge)</td>
<td>Assessors may not have sufficient day-to-day contact or front line interactions with the visitors Info. about near misses, past problems, etc. may not reach the assessors.</td>
<td>• Highlight the importance of information gathering • Suggest the involvement of front line staff in the assessment</td>
</tr>
<tr>
<td>3.1.3</td>
<td>Estimate the overall risks</td>
<td>Risk should reflect both likelihood &amp; severity of consequence (procedural)</td>
<td>Misconceptions.</td>
<td>• Explicitly require assessors to identify the consequences of hazards • Explicitly require assessors to consider both likelihood and severity.</td>
</tr>
<tr>
<td>3.2</td>
<td>Prioritise risks</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## TASK: EVALUATE RISKS

<table>
<thead>
<tr>
<th>Task no.</th>
<th>Sub-task description</th>
<th>Task requirements</th>
<th>Potential problems</th>
<th>Implications to crowd safety risk assessment methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2.1</td>
<td>Determine acceptability of risks</td>
<td>Ensure that the decisions are valid &amp; reliable (procedural)</td>
<td>Ad hoc decisions</td>
<td>• Risk-based decisions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unduly influenced by own experience, hot topic of the day, politics, etc.</td>
<td></td>
</tr>
<tr>
<td>3.2.2</td>
<td>Prioritise unacceptable risks</td>
<td>Ensure that the decisions are valid &amp; reliable (procedural)</td>
<td>Ad hoc decisions</td>
<td>• Guidance or criteria for prioritisation of risks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unduly influenced by own experience, hot topic of the day, politics, etc.</td>
<td></td>
</tr>
<tr>
<td>3.3.3</td>
<td>Identify remedial actions</td>
<td>Should be rational rather than gut feeling decisions; according to the HSE principle (1994), actions need to be taken, where practicable, to eliminate the hazards or, failing that, to minimise the extent of risk (procedural)</td>
<td>Best remedial actions not identified; i.e. only tackle the symptoms, not the cause of the problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Make sure that remedial measures will not cause significant problems elsewhere (knowledge &amp; experience)</td>
<td>Ad hoc decisions/rely on gut feelings.</td>
<td>• Require assessors to step back and think about what causes/contribute to the hazard in the first place</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unduly influenced by own experience, hot topic of the day, politics, etc.</td>
<td>• Need to identify the extent of risks (i.e. the consequences).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>As hazard identification</td>
<td></td>
</tr>
</tbody>
</table>
# TABULAR ANALYSIS OF THE CROWD SAFETY RISK ASSESSMENT TASKS

## TASK: RECORD FINDINGS

<table>
<thead>
<tr>
<th>Task no.</th>
<th>Sub-task description</th>
<th>Task requirements</th>
<th>Potential problems</th>
<th>Implications to crowd safety risk assessment methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td><strong>Show in the Record that a Proper Check has been Made</strong></td>
<td>Demonstrate that all significant hazards and the groups of visitors (if any) who might be at risk have been identified and considered. (Procedural)</td>
<td>Omissions</td>
<td>• Suggest a sample risk assessment record form whereby the assessor can list the hazards identified, who might be harmed, mitigating measures, the risks involved &amp; the actions taken/to be taken.</td>
</tr>
<tr>
<td>4.2</td>
<td><strong>Show in the Record that Reasonable Precautions have been Taken</strong></td>
<td>Record any corrective measures that are already in place, any further actions to be taken and, where appropriate, the reasons for not taking any action to control certain risks. (Procedural)</td>
<td>Omissions</td>
<td>• Suggest a sample risk assessment record form whereby the assessor can list the hazards identified, who might be harmed, mitigating measures, the risks involved &amp; the actions taken/to be taken.</td>
</tr>
</tbody>
</table>
## TABULAR ANALYSIS OF THE CROWD SAFETY RISK ASSESSMENT TASKS

### TASK: REVIEW & REVISE ASSESSMENT

<table>
<thead>
<tr>
<th>Task no.</th>
<th>Sub-task description</th>
<th>Task requirements</th>
<th>Potential problems</th>
<th>Implications to crowd safety risk assessment methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Decide When to Review</td>
<td>Make sure that risk assessment is always valid (see literature review on legal requirements and risk assessment principles in Sections 2.1 and 2.3). (Procedural)</td>
<td>Not done</td>
<td>• General guidance on when assessment needs to be reviewed and revised.</td>
</tr>
<tr>
<td>5.2</td>
<td>Decide Which Parts of the Assessment need to be Revised</td>
<td>Awareness of the changes since the last assessment. (knowledge &amp; experience)</td>
<td>Should not be too much of a problem for competent risk assessors.</td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>Modify Assessment Accordingly</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D

First Draft of the Crowd Safety Risk Assessment Methodology Document
(Document reformatted for this thesis)
ASSESSING CROWD SAFETY

A Guide to Assessing the Risks to Crowds in Public Venues

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Appendix B: Examples of the application of some venue feature keywords
Appendix C: Glossary of the venue hazard keywords
Appendix D: Glossary of the behavioural keywords
INTRODUCTION

BACKGROUND

1. Large crowds are a normal part of the operation of many public venues. From a commercial point of view large numbers of visitors may be desirable. But excessive crowding and poor safety provisions could lead at worst to injury or death and at the very least to frustration, dissatisfaction and reduced enjoyment.

2. The Health and Safety at Work, etc. Act 1974 (HSW Act) places a duty on the employer to ensure the health and safety of his employees (Section 2) and persons not in his employment who may be affected by his undertaking (Section 3). When applied to a public venue where the work activity involves the attendance of crowds, the employer has a duty to safeguard the health and safety of such crowds and to ensure that the risk to which they are exposed is as low as is reasonably practicable.

3. Under Regulation 3 of the Management of Health and Safety at Work Regulations 1992 (MHSWR), the employer is also required to make a suitable and sufficient assessment of the risks to the health and safety of his employees and others who might be affected. In the public venue context, this means the public venue owner should assess the risk his undertaking poses to employees and others, including the visiting crowds.

SCOPE

4. This guide is intended to help the public venue owner to assess the safety risks his undertaking poses to the visitors. It explains what a risk assessment is and gives practical advice and examples on how to carry out the assessment.

5. This guide is aimed at the assessment of risks to the safety of the visiting crowds. It should form a part of an overall health and safety risk assessment. In order to comply with Regulation 3 of the MHSWR, the public venue owner should also assess the health and safety risks to his employees and others who may be affected by his undertaking (e.g. contractors, tenants).

DEFINITIONS FOR THE PURPOSES OF THIS GUIDE

6. Crowd safety - the safety of members of the visiting crowds. It covers the safety of individual members as well as the crowd as a whole.
7. **Front line staff** - members of the staff who have direct contact with the visiting crowds and whose works involve interacting with, managing and/or monitoring them (e.g. stewards, ticket collectors at turnstiles, etc.).

8. **Hazard** - anything which has the potential to cause harm to members of the visiting crowds. This could be (a dangerous property of) an item or a substance, a condition, a situation or an activity.

9. **Public venue** - a place which opens to members of the public and where they assemble. It could be purpose built or otherwise, permanent or temporary, fixed or transient and indoor or outdoor. Examples of public venues include airports, railway stations, stadiums, shopping malls, exhibition halls, leisure parks, fairgrounds and sites that are used to hold one-off events (e.g. concerts, street festivals).

10. **Public venue owner** - a person or an organisation which owns the public venue and/or can legally seek to control the number of people entering the venue and the activities within it.

11. **Risk** - the likelihood that the harm from a hazard is realised and the extent of it (i.e. the number of people who might be exposed and the consequences for them). In the context of a risk assessment, risk should reflect both the likelihood that harm will occur and its severity.

**WHAT IS A RISK ASSESSMENT?**

12. Risk assessment is a systematic process which examines an undertaking and assesses the risks which could arise from it. In general, it involves identifying the hazards present and then evaluating the risks involved, taking into account whatever precautions are already being taken. The purpose of a risk assessment is to help the public venue owner to decide what additional actions need to be taken to eliminate the hazards or to reduce the risks. This will help him to comply with his duties under the HSW Act and other relevant health and safety law.

13. Many public venue owners already carry out some form of risk assessment on a day-to-day basis. During the course of their operations, they will monitor the situation, they will recognise problems as they develop and they will introduce corrective measures by either taking immediate action there and then or by implementing longer term solutions. The MHSWR however requires that public venue owners should undertake a systematic examination of their venues and that they should record significant findings from that risk assessment.

14. The *Management of Health and Safety at Work Approved Code of Practice* (ISBN 0-11-886330-4) sets out the principles of a risk assessment. In particular, a suitable and sufficient risk assessment should:
(a) identify all relevant hazards and address all significant risks;
(b) enable the employer to identify and prioritise the measures that need to be taken;
(c) be appropriate to the nature of the work and remain valid for a reasonable period of time;
(d) address what actually happens rather than what is supposed to happen. Actual practice may differ from the procedures and this is frequently a route whereby risks creep in unnoticed;
(e) ensure that all groups of employees and others who might be affected are considered;
(f) identify those groups who might be particularly at risk;
(g) take account of existing preventive or precautionary measures.

15. Risk assessment is not a stand-alone process. Instead, it forms a part of the planning to ensure the smooth running of the operation. Its findings could help the venue owner to make policies, to set performance standards and to allocate resources. It can also help the venue owner to decide what changes should be made to his venue, what crowd management measures to take, the appropriate staffing levels and the need for future development.

WHO SHOULD CARRY OUT THE ASSESSMENT?

16. It is the duty of the public venue owner to conduct a suitable and sufficient assessment of the health and safety risks his venue poses to the visiting crowds. He may appoint one or more of his own employees as assessors to assist him in carrying out this duty and/or may enlist help or support from outside the organisation (e.g. a consultant). However, this does not absolve him from this duty.

17. The public venue owner is also responsible for ensuring that a suitable and sufficient assessment has been carried out of the risks posed by other operations which take place in his venue. In a multi-occupancy situation where the activities of different occupants could affect each other and where there are safety issues which are of common concern, the risk assessment may need to cover the venue as a whole to be fully effective. This will require some degree of co-ordination and co-operation.

18. The assessor(s) appointed by the public venue owner should be competent. In general, the assessor(s) should have:

(a) a knowledge and understanding of the venue and its operation and the principles of risk assessment;
(b) the capacity to apply the above to public safety risk assessment which includes identifying the public safety problems and assessing the need for action;
an understanding of relevant current best practice;
(d) an awareness of the limitations of their own experience and knowledge; and
(e) a willingness and ability to supplement their existing experience and knowledge.

19. The public venue owner is solely responsible for ensuring that those he has appointed are competent and given adequate information and support (e.g. training, time and resources) to carry out their tasks.

20. A crowd safety risk assessment may be carried out by individual assessors on his own or by a team of assessors. In the view of the Health and Safety Executive (HSE), however, the latter is usually more desirable especially for large venues. This way, the assessment can benefit from the range of knowledge and experience which members of the assessment team can offer. It can also ensure that the risk assessment has taken into account different views and understanding.

21. The size of the assessment team could vary, depending on the complexity of the venue. As a rule of thumb, it should have enough people to answer the majority of the queries that could arise in the assessment without recourse to further expertise. However, the team should not be too large.

22. Therefore, for an existing public venue, the assessment team would normally consist of:

(a) the venue manager - he is responsible for the venue operation, understands the overall situation and is in the position to make most decisions; and
(b) appropriate members of the front line staff - they deal with the visiting crowds and therefore know what actually happens on the ground. They also have in-depth knowledge and experience of what problems could arise.

23. Where the risk assessment concerns a public venue which is at its design stage or a new extension to an existing venue, the assessment team would normally consist of people from the venue owner and the designer organisations. The former will be responsible for operating the venue and can contribute in the identification of operational problems posed by the design. The later has the technical expertise to make proposals on the feasibility and to comment on the costs of a design solution to a potential problem.

24. In addition, at some points in the assessment, it may be necessary to involve others from both within and outside the organisation whose expertise is needed or whose activities interact with the operation. It is up to the venue owner to decide how they should be involved (e.g. as a member of the assessment team, to participate in parts of the assessment or to co-ordinate and exchange information only when necessary). The following are examples of those who may be involved in the risk assessment:
(a) other departments within the organisation from which some of the front line staff come (e.g. catering);
(b) the emergency services;
(c) promoter or organiser of the event to be held in the venue;
(d) major tenants (e.g. in a shopping centre or a transport venue);
(e) operators of the transport systems used by many visitors;
(f) the local authority planning or environmental health department;
(g) specialists who can provide the necessary technical input to the assessment (e.g. where fireworks, laser or other special effects are used).

25. There are no fixed rules about how the assessment team should work. But experience from other sectors (e.g. the high hazard industries) suggests a structured brainstorming session could be useful. It can provide an environment in which team members can bring their knowledge and experience to bear. The venue owner needs to appoint a chairperson who is competent in risk assessment and in chairing such meetings. His role will be to control and guide the team through the assessment. Depending on the size of the venue and the complexity of the operation, most public venues should be able to complete the bulk of their assessment between one and a few half-day sessions once they are familiar with it.
A CROWD SAFETY RISK ASSESSMENT METHODOLOGY FOR PUBLIC VENUES

THE OVERALL RISK ASSESSMENT APPROACH

26. When carrying out a crowd safety risk assessment, you need to think about what hazards could arise and why, who might be harmed and how, whether the existing precautions are enough and, if not, what more should be done. The assessment should therefore consist of the following main steps:

Step 1: Identify hazards
Step 2: Identify causes, consequences and who might be harmed
Step 3: Decide whether existing precautions are adequate
Step 4: Evaluate risks
Step 5: Decide what further actions might be required

In addition, you should record all significant findings. There is a tabular form in Appendix A which you may find useful. From time to time, you should review and, if necessary, revise your risk assessment. Figure 1 gives an overview of the assessment process for quick reference.

27. If you own a number of similar venues (e.g. railway stations) or if your venue contains a number of similar features (e.g. rides in an amusement park), you might produce a basic “model” risk assessment reflecting the core hazards and risks associated with these venues or features. This may be applied by managers at each venue or supervisors at each feature, but only if they:

(a) satisfy themselves that the “model” assessment is broadly appropriate to their venues or facilities; and
(b) adapt the model to the detail of the actual situations in their venues or features, including any extension necessary to cover hazards and risks not referred to in the model.
1. Break down the venue into more manageable areas

2. Look afresh at what hazards the venue itself could pose

3. Think about what the visitors do and how they may behave

4. Assess your safety management system

5. Identify hazards associated with the use of substances or items which could cause harm

6. Look for possible disruptions to the normal or intended operation

7. For each hazard, decide what causes the problem

8. Think about who might be harmed and how

9. Identify the precautions already in place and consider how effective they are

10. Decide whether the precautions are enough

11. For each remaining hazard, estimate its likelihood and the severity of its consequences

12. Estimate the risk level

13. Identify what more could be done to reduce the risk further

14. If there is more than one set of possible solutions, decide which is the best option

Record Assessment Findings

Review and Revise Assessment

Figure 1: Crowd Safety Risk Assessment Process
STEP 1: IDENTIFY HAZARDS

28. The aim here is to systematically identify all significant hazards which could arise in your venue. You may already be aware of some hazards. But it is also important to identify hazards that are not immediately obvious - for example, a latent hazard or a new hazard which arises due to, say, the introduction of a new feature. Any hazards which are not identified here will not be addressed and thus leave a gap in the risk assessment.

29. Public safety hazards often arise from a combination of the following factors. You need to examine them, look for things that could go wrong and then decide what problems they could pose to public safety:

(a) the venue (e.g. a pinch point),
(b) the visitors (i.e. what they do and how they behave),
(c) poor safety management (e.g. insufficient staff training),
(d) the presence of hazardous substances or items (e.g. the use of a special effects), and
(e) a deviation to the normal or intended operation (e.g. delays or cancellation of a service or a fire).

30. Involve your front line staff. They might have noticed things which are not immediately obvious. Also, they might help to reveal what actually happens on the ground. At the very least, you should ask them what they think. However, it is much better to include them as part of the assessment team. For a major venue, you may need to carry out some form of brainstorming session (see paragraph 25). For a smaller venue, you can sit down with one or two experienced members of the front line staff and go through each part of your venue.

31. Apart from a brainstorming session, it is often useful to carry out a venue inspection and an observation. This allows you to look afresh at what could cause harm. Past incident records, written comments from the front line staff, customer complains, safety audit reports, notes made in debriefing sessions, post event reports and so on could also provide the information needed to identify hazards.

Break down the venue into more manageable areas

32. It may be difficult to assess the whole venue at once especially if the venue is large. Therefore, it is worth breaking it down into a number of smaller and more manageable areas first and then examine each area in turn. You can do so according to the main function for which each area is used (i.e. into functional areas) or based on the system already used to distinguish different parts of the venue (e.g. colour zones in a shopping centre).
For example: An airport terminal can be broken down into the following functional areas: access routes from a train station, from a bus station, from car park(s); forecourt; check-in area; concourse; passport control; departure lounge; gate rooms; etc.

A concert venue can be divided into the entrance/exit and concourse; the concert hall itself; bars and food outlets and the access routes linking these areas.

A theme park can be broken down into the forecourt; the concourse and different attraction or ride areas.

Look afresh at what hazards the venue itself could pose

33. Examine the overall layout of the venue to identify:

(a) if any popular areas, busy access routes, main attractions and popular facilities are situated too close together or intersect each other; and
(b) if there is a convergence of several access routes into a single area or route.

34. Examine the features in each area and find out what hazards they could pose. One way of doing this is to apply suitable combinations of the following venue feature keywords and venue hazard keywords. The former lists the types of feature you might find in each area. The latter describes how they may lead to a hazard.

<table>
<thead>
<tr>
<th>VENUE FEATURE KEYWORDS</th>
<th>VENUE HAZARD KEYWORDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>Insufficient: capacity</td>
</tr>
<tr>
<td>Access route</td>
<td>Insufficient: quantity</td>
</tr>
<tr>
<td>Entry/exit point</td>
<td>Insufficient: quality</td>
</tr>
<tr>
<td>Flooring/underfoot condition</td>
<td>Obstruction: access</td>
</tr>
<tr>
<td>Slope and stairway</td>
<td>Obstruction: from view</td>
</tr>
<tr>
<td>Step, kerb, ramp, etc.</td>
<td>Obstruction: line of sight</td>
</tr>
<tr>
<td>Bank and edge</td>
<td>Pinch point/funnelling effect</td>
</tr>
<tr>
<td>Wall, pillar, post, bollard, fence, etc.</td>
<td>Unguarded</td>
</tr>
<tr>
<td>Furniture/street furniture</td>
<td></td>
</tr>
<tr>
<td>Facilities</td>
<td></td>
</tr>
<tr>
<td>Information source</td>
<td></td>
</tr>
<tr>
<td>Maintenance or construction work</td>
<td></td>
</tr>
</tbody>
</table>

Inset 1 advises on how to use these keywords. Examples of the application of some of the venue feature keywords is shown in Appendix B. A glossary of the venue hazard keywords is given in Appendix C.
Inset 1: A step-by-step guide to the use of the venue feature keywords and the hazard keywords

(a) Select a relevant venue feature keyword; say, Place
(b) Select the hazard keywords which are applicable to the selected venue feature keyword; say, Insufficient: capacity
(c) Combine the venue feature keyword with each of the hazard keywords selected to identify how that particular venue feature may lead to public safety hazards

For example: If you are assessing the forecourt of an amusement park, the keywords Place - Insufficient: capacity could mean that it is not big enough to cope with the number of people waiting to be checked in, seeing people off, etc.

Flooring - Insufficient: quality could mean that the under floored condition is uneven, muddy, littered, etc.

(d) Some keywords may not be applicable to your venue. Therefore, do not be surprised if they do not generate an issue. Just ignore them and move on.
(e) Select the next relevant venue feature keyword and so on until all features in this area have been considered.

See Example 1

Example 1 (using the suggested assessment form shown in Appendix A):

| Hazards | Causes | Consequences | Exist?
|---------|--------|--------------|------
| Part of the crowd may spill onto the adjacent road and mingles with moving vehicles. | During peak hours, the number of people arriving exceeds the capacity of the forecourt. | | |

Area: Forecourt

35. These keywords are here only to prompt you, the assessors, and to structure the hazard identification process so that it is systematic. You do not have to apply them rigidly and don’t let them restrict your thought. Write down whatever you can think of from the keywords even though it may not seem to be the right place to do so. You may have also identified the immediate cause of a hazard here. Write it down as well (see Example 1). The aim here is to identify as many hazards as possible. Exactly where they are identified is not important.

For example In the theme park example above, you may think of other related problems elsewhere from the keywords Area - Insufficient: capacity, such as the arriving crowds spilling onto the adjacent road. Write this down as well if you think it poses a significant hazard.
36. These keywords are for public venues in general. They are not meant to be exhaustive. You can add your own keywords to the lists, remove those which you think are irrelevant and refine them to meet your needs.

Think about what the visitors do and how they may behave

37. The aim is to identify those activities and behaviours which could lead to a hazard. Think about what the area is used for, who your visitors are, the circumstances they may be in (e.g. in a hurry, in a lively mood) and so on. There is no need to account for all activities and behaviour, just look for those which could cause a problem. You can probably identify much of what the visitors do from experience and from past problems. But it can also be useful to observe the crowds and note down the things which concern you.

38. You may find the following venue feature keywords and behavioural keywords useful. The venue feature keywords are the same as those given in paragraph 34. The behaviour keywords describe the types of activity or behaviour which could cause harm.

<table>
<thead>
<tr>
<th>VENUE FEATURE KEYWORDS</th>
<th>BEHAVIOURAL KEYWORDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>Uneven distribution</td>
</tr>
<tr>
<td>Access route</td>
<td>High crowd density</td>
</tr>
<tr>
<td>Entry/exit point</td>
<td>Disruption to a stationary crowd</td>
</tr>
<tr>
<td>Flooring/underfoot condition</td>
<td>Rapid crowd flow</td>
</tr>
<tr>
<td>Slope and stairway</td>
<td>Cross flows</td>
</tr>
<tr>
<td>Step, kerb, ramp, etc.</td>
<td>Disruption or obstruction to a crowd flow</td>
</tr>
<tr>
<td>Bank and edge</td>
<td>Non-compliance</td>
</tr>
<tr>
<td>Wall, pillar, post, bollard, fence, etc.</td>
<td>Dangerous behaviour</td>
</tr>
<tr>
<td>Furniture/street furniture</td>
<td>Aggressive behaviour</td>
</tr>
<tr>
<td>Facilities</td>
<td>People with special needs</td>
</tr>
<tr>
<td>Information source</td>
<td></td>
</tr>
<tr>
<td>Maintenance or construction work</td>
<td></td>
</tr>
</tbody>
</table>

Inset 2 advises on how to use these keywords to identify activities and behaviour that could lead to a hazard. Appendix D gives a glossary of the behavioural keywords.
Inset 2: A step-by-step guide to the use of the venue feature keywords and behavioural keywords

(a) Select a relevant venue feature keyword; say, **Place**

(b) Select the behavioural keywords to describe the type of activity or behaviour which could take place there; say, **Uneven distribution**

(c) Combine the venue feature keyword with each of the behavioural keywords selected to decide what problems such activity or behaviour may cause.

   *For example:*  **Place - Uneven distribution** could mean that too many people choose to stay in the same area in, say, a large hall. This could lead to overcrowding.

   **Facilities - Disruption or obstruction to a crowd flow** could remind you of the situation where movement is blocked by people waiting for others nearby.

   *From Place - Disruption to a stationary crowd,* you could identify behaviour such as surging and people pushing their way through a packed crowd.

(d) Ignore those hazards which you have already identified earlier and move on. Also ignore keywords which do not apply to your situation.

   *For example:*  A path is obstructed by a stationary crowd in front of a nearby attraction. You may have already identified this earlier when examining the venue layout.

   You may have also thought of people entering a restricted area through a broken fence (i.e. **Fence - Non-compliance**) when you assessed this feature earlier

(e) Select the next behavioural keyword and so on until all features in this area have been considered.

See **Example 2**

**Example 2:**

**RECORD OF CROWD SAFETY RISK ASSESSMENT**

**Area:** Forecourt

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences</th>
<th>Existi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crowd movement is obstructed by people waiting for others nearby</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People try to cut through the crowd</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Assess your safety management system

39. Look afresh at your safety management system. The following issues are particularly relevant to ensuring public safety. First, identify any shortcomings in each issue. Then consider how they could affect your operation in each area.

<table>
<thead>
<tr>
<th>SAFETY MANAGEMENT ISSUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff roles and responsibilities</td>
</tr>
<tr>
<td>Command and communication</td>
</tr>
<tr>
<td>Co-operation and Co-ordination with other bodies</td>
</tr>
<tr>
<td>Monitoring of crowds</td>
</tr>
<tr>
<td>Staffing level</td>
</tr>
<tr>
<td>Staff selection and training</td>
</tr>
</tbody>
</table>

Inset 3 advises on how this can be done.

Inset 3: A step-by-step guide on how to assess your safety management system

(a) Select a relevant issue; say, command and communication.
(b) Decide what could go wrong; say, breakdown in communications. You may find a few shortcoming in each issue.
(c) For each shortcoming, ask yourself how it could affect your operation.

For example: As a result of a breakdown in communications, the arriving crowds are sent to the wrong entrance.

(d) Decide what hazards could arise.

For example: Severe congestion at that entrance and/or severe cross flows created by people turning back.

(e) Select the next issue and so on until all issues that are relevant to your operation in the area have been considered.

See Example 3

Example 3:

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences</th>
<th>Exist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe congestion and/or cross flows at entrance X</td>
<td>Breakdown in communications results in arriving crowd being incorrectly sent to this entrance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Identify hazards associated with substances and items which could cause harm

40. Your operation may involve the use (and storage) of substances and/or items which have the potential to cause harm to members of the public. If so, you need to identify the hazards and assess the risks created by them. First, identify what they are and where they are used and stored. The following are examples of the kinds of substances and items which could create hazards in a public venue:

(a) substances which are hazardous to health and are covered by the Control of Substances Hazardous to Health Regulations 1994 (COSHH) (e.g. substances that are toxic, corrosive or irritant; have maximum exposure limits or occupational exposure standards; have chronic or delayed effects; or biological agents)
(b) machinery (e.g. escalators, turnstiles, ticket machines, rides in a fairground or an amusement park, etc.)
(c) electric cables, generators, etc.
(d) fireworks, special effects in a place of entertainment or a show (e.g. laser), etc.
(e) open fire/naked flame (e.g. at a stall selling hot food)
(f) moving objects (e.g. vehicles, trolleys, etc.)

41. Then, decide what hazards each substance or item could pose to the visitors. Think about where and when it is used and how visitors may be exposed to it. Address what could actually happen rather than what is supposed to happen. Take into account any human errors by staff who handle the substance or operate and maintain the item. Also think about the visitors' behaviour (see Example 4). Manufacturers' instructions or datasheets and accident records can also help you to spot hazards and to put risks in their true perspective.

Example 4:

<table>
<thead>
<tr>
<th>Hazard Description</th>
<th>Cause</th>
<th>Consequence</th>
<th>Existing</th>
</tr>
</thead>
<tbody>
<tr>
<td>People pushed against unguarded mobile electric generators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People knock over hot food equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Look for potential disruption to the normal or intended operation

42. The aim is to consider how your venue operation could be disrupted and what new hazards could arise as a result. A major disruption such as a major fire would call for a complete change of the mode of operation (e.g. from normal operation to an evacuation) thus introducing new hazards. Even a relatively minor disruption such as a train delay or cancellation could exacerbate a problem or turn the trivial into a significant hazard.

43. First, identify the scenarios which could disrupt your operation. The following are some examples:

(a) accident (e.g. traffic accident outside or within the venue)
(b) closure of a part of the venue
(c) closure of a nearby or related venue (e.g. the closure of an adjacent train station)
(d) delay or cancellation of a service (e.g. flight delay)
(e) disruption to the arrival/departure profile (e.g. severe traffic congestion on a main approach road)
(f) emergency situation (e.g. a fire, bomb threat, structural collapse, toxic release, etc.)
(g) loss of utility (e.g. power cut)
(h) public disorder
(i) system or equipment failure (e.g. escalator stops, a jammed door or gate, etc.)
(j) weather (including a sudden change of weather and adverse weather condition such as too hot/cold, heavy rainfall/snowfall, high wind, etc.)

44. For a minor disruption which causes a slight deviation in parts of the venue, hazard identification could be relatively straightforward to do. Simply think about what effects each relevant scenario could have on the venue operation, on crowd movement, on people's behaviour and then identify the problems which could arise as a result (see Example 5).

Example 5:

<table>
<thead>
<tr>
<th>Area: Forecourt</th>
<th>RECORD OF CROWD SAFETY RISK ASSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazards</td>
<td>Causes</td>
</tr>
<tr>
<td>Congestion on access route to the escalators.</td>
<td>Escalator(s) fail.</td>
</tr>
<tr>
<td>A severe traffic problem and increase in the scale of last minute rush.</td>
<td>Road work on one of the main approach roads to the venue</td>
</tr>
</tbody>
</table>
45. A detailed assessment would be necessary in the case of a major disruption where the 
operation required to ensure safety is very different from the normal operation. The 
assessment would involve examining the venue itself, the visitors, the safety management 
system and the substances and items in the vicinity. Again, the venue feature keywords, 
the venue hazard keywords, the behavioural keywords and the safety management 
issues could help you to assess the first three of the above. Hazardous substances and 
items can be assessed by considering how they could react in the circumstance and what 
hazards this could introduce.

46. To write down what you have identified here, you may have to modify the assessment 
record form shown in Appendix A slightly to also indicate which scenario you are 
considering (see Example 6).

**Example 6:**

<table>
<thead>
<tr>
<th>Scenario: A major fire at the store room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area: the “yellow zone” inside the venue</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences</th>
<th>Existin</th>
</tr>
</thead>
</table>
| Assess route X blocked by the fire  
(i.e. from the keywords Access route - Obstruction: access) |                                             |                                                         |         |
| Gates A and B could become a pinch point in an evacuation  
(i.e. from the keywords Entry/exit point - Insufficient: capacity) |                                             |                                                         |         |
| People do not leave the venue when the fire alarm is activated. | People stop to find out what is going on or carry on with whatever they are doing. |                                                         |         |
| A certain chemical in the store room could release fumes | The heat                                        |                                                         |         |
| Electric cable could be damaged  | The fire or the heat                             |                                                         |         |

**STEP 2: IDENTIFY CAUSES, CONSEQUENCES AND WHO MIGHT BE HARMED**

47. The aim is to find out what causes the hazards or hazardous situations identified earlier, 
what danger they could pose and who might be affected. The identification of the cause(s) could 
help you to decide later on what actions need to be taken to get rid of the hazards. The 
identification of consequences and who might be harmed could help you to decide how to protect 
people against the harm and to estimate risks (see Example 7).
Example 7:

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences</th>
</tr>
</thead>
</table>
| Part of the crowd spills onto the adjacent road and mingles with moving vehicles. | During peak hours, the number of people arriving exceeds the capacity of the forecourt:  
  * not enough ticket counters  
  * only a minority of the visitors buy tickets in advance  
  * tickets are not processed quickly enough at the entrance | People, especially young children, could get knocked down by vehicles. |
| Crowd movement is obstructed by people waiting for others nearby.       | People waiting for friends, etc.                                       | Exacerbate the crowd congestion problem in the area.                        |
| People try to cut through the crowd.                                   | To get to the toilets which are often blocked by the main crowd flow   | Severe cross flows especially when wheelchair users try to make their way to the disabled persons toilet |
| People pushed against unguarded mobile electric generators              | crowding and cross flows in the area  
  * some generators protrude slightly onto the access route       | Burns. Toddlers and young children are particularly vulnerable due to their height |
| People knock over hot food equipment                                   | crowding and cross flows in the area  
  * people being pushed against the grills  
  * people try to push their way through the crowd | Severe burns to those in the immediate vicinity. Teenagers and young persons are particularly likely to be involved as they are more "lively" and tend to push each other around. |
| Congestion on access route to the escalators.                          | Escalator(s) fail  
  * No alternative access routes or people not aware of their existence | Crowding problem which could affect the immediate area and possibly beyond |
| A severe traffic problem and increase in the scale of last minute rush. | Road work on one of the main approach roads to the venue  
  * No alternative routes or people not aware of their existence | Crushing at the entrance/turnstiles |

For each hazard, decide what causes the problem

48. Find out what causes a hazard. You may have already found the immediate causes earlier on in STEP 1. But don’t stop there - there could well be other (underlying) causes that are equally important. It is worth bearing in mind that a hazard often arises due to a combination of reasons. Some of them may not be obvious. It could, for example, arise from the overall layout of the venue rather than the features you were assessing. It could be because of another problem elsewhere in the venue or what happens in another place. It is also possible that the problem is caused by a part of your operation which seems not directly linked to crowd management (e.g. how tickets are sold).
For example: Access to and from the venue could be affected by the crowds leaving a nearby football match.

In the previous example of crowd congestion in a forecourt, this could be caused by one or more of the following reasons: the forecourt is simply too small, the venue becomes more popular than originally designed for, not enough ticket counters, only a minority of the visitors buy tickets in advance, tickets are not processed quickly enough at the entrance and so on.

49. If the hazard is caused by people’s behaviour, it is important to consider what makes them behave in such a way. You will not be able to find a satisfactory solution to the problem if you simply dismiss this as the fault of the individuals concerned!

50. If a hazard is due to a poor safety management system, you may have to look beyond those issues listed in paragraph 39. Think about the more “global” safety management issues (e.g. policy, safety culture, etc.) and ask yourself whether you have done enough. You can find out more about safety management systems in HSE leaflet IND(G) 132L and the HSE publication entitled Successful Health and Safety Management (HS(G)65).

Think about who may be harmed and how

51. When identifying the consequences and who might be harmed, also think about how many people may be affected (i.e. whether it would harm a few individuals or most people in the vicinity) and whether any visitor groups are particularly vulnerable. Such visitor groups may include disabled persons, young children and elderly people who are often more likely to be harmed or are likely to suffer more when harmed.

STEP 3: DECIDE WHETHER EXISTING PRECAUTIONS ARE ADEQUATE

Identify the precautions already in place and consider how effective they are

52. Some hazards may already be controlled in some way, whether by deliberate measures (e.g. by venue design, engineered devices, crowd management measures or operational procedures) or by the circumstances in which they are found. The aim is therefore to identify them and decide whether they are enough or whether more should be done.

53. Think about how effective the existing precautions are. Again, you need to look at how they actually work, not how they are supposed to work. Also consider how your precautions may fail or become less effective. You could get caught out if you automatically assume that they would always work as intended!
For example: The circumstances could change as a result of an incident elsewhere. Venue features and engineered devices could suffer from vandalism, wear and tear, component failures, etc.

Crowd management measures and procedures could be hampered by equipment failures, human errors, breakdown in communications, confusion in role and responsibility and so on.

Decide whether the precautions are enough

54. In order to find out whether the existing precautions are enough, you will need to carry out a preliminary risk evaluation. As a general guide, if after the existing precautions the remaining risk becomes trivial or if is no more than exists in a similar everyday situation, you can say that it is adequately controlled and no further actions will be needed. You can therefore ignore the hazard and exclude it from the rest of the risk assessment. Otherwise, the hazard is still significant and you need to evaluate it in detail (see STEP 4). As explained in Inset 4, a trivial risk is one which is extremely remote (i.e. it has never happened before and there are no reasons whatsoever to suggest that it will ever happen) or one which does not cause any real harm (i.e. no more than inconvenience to the visitors, discomfort, frustration and so on). When deciding how the risk compares with that in an everyday situation, you should compare like with like. You cannot ignore a hazard on the grounds that its risk compares favourably with that involved in, say, a dangerous sport!

For example: In a street event, the pavement kerb often poses a tripping hazard. But, you could ignore it on the grounds that the risk is no more than that arising from walking along the high street on a normal Saturday afternoon.

If the crowd density is much higher than that on the normal high street, so will be the risk. The above argument is therefore no longer valid and this hazard should be evaluated further.

STEP 4: EVALUATE RISKS

For each remaining hazard, estimate its likelihood and the severity of its consequences

55. The aim is to decide for each significant hazard how much risk is involved after the existing precautions have been taken. The findings will enable you to establish how significant the hazards are and thus to prioritise any remedial actions required to control them. The evaluation of risk usually involves the following steps:

(a) decide how likely the hazard is to be realised (i.e. estimate the likelihood);
(b) decide how serious the harm is should the hazard be realised (i.e. estimate the severity), and
(c) establish the level of risk based on the above.

56. When estimating likelihood, it is important that you consider how likely the hazard is to occur and to cause harm, not just how likely it is to occur. This is because not all hazards cause harm all the time; the potential for a hazard to cause harm is realised only under some circumstances. In a risk assessment, we are only interested in the likelihood of someone being harmed.

For example: Cross flows and obstructions do not normally give rise to a significant problem unless they take place in a busy area.

57. When estimating severity, you need to take into account the circumstances under which the hazard takes place.

For example: If people climb up to a height, the seriousness of the injury, should they fall, will depend on how high they manage to climb. Also, more people would be injured if this behaviour takes place where there is a packed crowd underneath.

The severity (and the likelihood) of people mingling with moving vehicles will depend on whether it takes place on a busy main road with fast moving traffic or on a quiet side road where the vehicles move slowly.

Establish the risk level

58. As a general guide, Inset 4 gives a step-by-step description on how to evaluate risk. At the very least, you need to be able to decide whether the risks are intolerable, should be kept as low as reasonably practicable or are broadly acceptable. Providing this can be achieved, you can modify the likelihood categories, the severity categories and the number of risk levels given below to meet your specific needs.
Inset 4: A step-by-step guide to risk evaluation

(a) To estimate likelihood, select a Likelihood Category (LC) from Figure 2 which can best describe how likely the hazard is to be realised.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likely</td>
<td>A similar problem has happened before (either here or elsewhere) AND there are no reasons to think that it will not happen in the foreseeable future.</td>
</tr>
<tr>
<td>Possible</td>
<td>Never happened before BUT there are reasons to suggest that it could happen.</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Never happened before BUT could occur under exceptional circumstances.</td>
</tr>
<tr>
<td>Very Unlikely</td>
<td>Never happened before AND there are no reasons to suggest that it will.</td>
</tr>
</tbody>
</table>

Figure 2: Likelihood Categories

(b) To estimate severity, select a Severity Category (SC) from Figure 3 which can best describe how serious the consequence will be should the hazard be realised.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic</td>
<td>Multiple deaths/life threatening injuries.</td>
</tr>
<tr>
<td>Major</td>
<td>A single death/life threatening injury OR multiple injuries requiring hospitalisation.</td>
</tr>
<tr>
<td>Significant</td>
<td>A single injury which requires hospitalisation OR multiple injuries requiring first-aid treatment.</td>
</tr>
<tr>
<td>Minor</td>
<td>A single injury which may require some first-aid treatment; visitors feel anxious and are concerned about their safety.</td>
</tr>
<tr>
<td>Negligible</td>
<td>No real harm; no more than inconvenience, discomfort, frustration, etc.</td>
</tr>
</tbody>
</table>

Figure 3: Severity Categories

(c) From the selected likelihood category and severity category, you can establish the risk level of the hazard from the matrix given in Figure 4. The interpretation of the risk levels is laid down in Figure 5.

<table>
<thead>
<tr>
<th></th>
<th>Likely</th>
<th>Possible</th>
<th>Unlikely</th>
<th>Very Unlikely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>-</td>
</tr>
<tr>
<td>Major</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>-</td>
</tr>
<tr>
<td>Significant</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>-</td>
</tr>
<tr>
<td>Minor</td>
<td>C</td>
<td>D</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Negligible</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 4: A Risk Classification Matrix
Inset 4: A step-by-step guide to risk evaluation (cont.)

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Intolerable risk. Immediate action(s) must be taken to eliminate the hazard or to eliminate its source, regardless of the cost.</td>
</tr>
<tr>
<td>B</td>
<td>Should not be tolerated unless risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained.</td>
</tr>
<tr>
<td>C</td>
<td>Should not be tolerated unless the cost of risk reduction exceeds the improvement gained.</td>
</tr>
<tr>
<td>D</td>
<td>Broadly acceptable risk. But risk reduction should still be made if an inexpensive measure can be found.</td>
</tr>
<tr>
<td>-</td>
<td>Trivial risk. No further actions required.</td>
</tr>
</tbody>
</table>

Figure 5: Interpretation of Risk Levels

Example 8:

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Existing Precautions</th>
<th>LC</th>
<th>SC</th>
<th>Risk</th>
<th>Action</th>
</tr>
</thead>
</table>
| Part of the crowd spills onto the adjacent road and mingles with moving vehicles | • the road is normally quiet with only a few vehicles at any one time  
• vehicles are slow moving                                                | P   | Si  | C    |        |
| Crowd movement is obstructed by people waiting for others nearby        |                                                            | U   | Mi  | -    |        |
| People try to cut through the crowd                                     |                                                            | P   | Si  | C    |        |
| People pushed against unguarded mobile electric generators              |                                                            | L   | Si  | B    |        |
| People knock over hot food equipment                                    |                                                            | L   | Ma  | A    |        |
| Congestion on access route to the escalators                            | Procedures to divert crowd flows have been tried and tested many times in the past | U   | Mi  | D    |        |
| A severe traffic problem and increase in the scale of last minute rush. | • arrangements with the police and a motoring organisation to receive information on any major road works well in advance.  
• well established procedures to warn coach parties of the road works | P   | Ma  | B    |        |
STEP 5: DECIDE WHAT FURTHER ACTIONS MIGHT BE REQUIRED

Decide what more should be done to reduce the risk further

59. Identify what more should be done to eliminate each remaining hazard or to reduce the risk. Ask yourself:

(a) whether you have done all the things that the law says you have got to do; and
(b) whether generally accepted standards are in place.

The law also says that you must do what is reasonably practicable to keep the venue safe. Therefore, your real aim is to make the risks as small as possible by adding to your precautions if necessary. Table 3 suggests the appropriate courses of action for each risk level. Priority should be given to hazards which pose the higher risks.

60. First, consider what else can be done to get rid of the hazard altogether. This can usually be achieved by removing the source of the hazard or by tackling its causes. If this is not “reasonably practicable” to do (see Table 3), then think about how to control the risk (i.e. to make it less likely to occur or to cause harm, to reduce its severity and/or to protect people against harm). Guidance and good practices by other venues could help you to identify the remedial actions required.

If there is more than one set of possible solutions, decide which is the best option

61. If there are several possible actions, you may have to examine them in more detail to decide which of them to take. In general, you need to think about the level of risk posed, how effective the actions would be in controlling the risk, whether they could give rise to a problem elsewhere, how soon they can be put in place and whether the hazard needs to be addressed urgently or whether it is better to wait for a more permanent solution. You can of course take into consideration the cost-benefit factors such as the costs of taking those actions and how they may affect things like visitors’ enjoyment and the attractiveness of the venue.

62. Keep a record of what you have decided. If you believe that no actions are needed, it is useful to write down the reasons. It is also good practice to write down who is to carry out each action (see Example 9).
### Example 9

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Precautions</th>
<th>LC</th>
<th>SC</th>
<th>Risk</th>
<th>Actions</th>
</tr>
</thead>
</table>
| Part of the crowd spills onto the adjacent road and mingles with moving vehicles. | It is normally quite a few vehicles at time they are slow moving.            | P  | Si | C    | • open more ticket counters during peak periods  
• find ways to encourage advance purchase  
• review procedures on processing tickets  
**actions on:** Sales Manager                                                                                                                                                                      |
| Crowd movement is obstructed by people waiting for others nearby        |                                                                             |    |    |      | The above actions should help to reduce this problem. Therefore no further actions.                                                                                                                     |
| People try to cut through the crowd                                      |                                                                             |    |    |      | Could relocate the toilets but the cost of doing so outweighs the improvement gained. No actions.                                                                                                        |
| People pushed against unguarded mobile electric generators                |                                                                             | L  | Si | C    | • the generators should be guarded  
• ensure that generators are in line  
• closely monitor crowd flows and control access into this area when necessary  
**actions on:** Operation Manager and Duty Supervisors                  |
| People knock over hot food equipment                                     |                                                                             | L  | Ma | B    | • carry out inspection to ensure that all such grills are adequately guarded  
• relocate traders to another part of the venue  
• closely monitor crowd flows and control access into this area when necessary  
• stewards should discourage such "lively" behaviour in this area  
**actions on:** Operation Manager and Duty Supervisors                  |
| Congestion on access route to the escalators                             |                                                                             | U  | Mi | D    | No inexpensive action identified to reduce risk.                                                                                                                                                         |
| A severe traffic problem and increasing the scale of last minute rush   |                                                                             | P  | Ma | C    | • publicise and advise visitors to set off early  
• increase staff level and put in extra crowd control measures  
• consider delaying the start of the event if the situation significantly deteriorates  
**actions on:** Operation Manager and Duty Supervisors                  |
RECORD ASSESSMENT FINDINGS

63. If your undertaking has five or more employees, you are required by law to record the significant findings of your assessment. You should be able to show, through the record, that you have undertaken a suitable and sufficient assessment and that you have done what is reasonably practicable to reduce the risks. Significant findings usually include:

(a) the significant hazards identified in the assessment;
(b) the existing precautions in place;
(c) the remaining risks, including any groups of visitors who are especially at risk;
(d) the conclusions of the assessment, including the actions you have identified to further reduce the risks.

The record could be documented in writing or by other means (e.g. electronically) so long as it is retrievable for use by management or for examination.

64. Some hazards may have already been addressed elsewhere. For example, if hazardous substances are used, your COSHH assessment should have addressed the risks. Also, some of the existing precautions may have already been described in other documents (e.g. procedures). There is no need to repeat this information in the record, you can simply refer to where it can be found.

65. Keep the record for future reference or use. It helps to show that you have done what the law requires and can therefore help you if an inspector questions your precautions or if you become involved in any legal action (e.g. for civil liability). It also can also remind you to keep an eye on particular matters. Appendix A shows the tabular public safety risk assessment record form used throughout this guide. You may find it useful. Alternatively, you can develop your own form or record your assessment in another format if it suits you better.

REVIEW AND REVISE ASSESSMENT

66. Risk assessment is not a once-and-for-all activity. From time to time you need to review your assessment and revise it if necessary. A review can take place regularly (e.g. annually) or if there are developments which suggest that your assessment may no longer be valid, such as:

(a) a significant change to your operation, to your venue, in visitor composition or in the circumstances (e.g. the introduction of new hazards due to activities elsewhere, renewed terrorist threats);
(b) the detection of a significant problem; and
(c) the occurrence of a major incident or a potentially serious near miss.

67. If your operation concerns the staging of a regular event, ideally you need to start your review shortly after the event has finished. This is so that any problems and incidents which took place in the event are still fresh in people’s minds. In any case, the timing of the review should be such that you have enough time before the next event to implement the new actions identified in the assessment.
APPENDIX A
CROWD SAFETY RISK ASSESSMENT RECORD FORM
APPENDIX B
EXAMPLES OF THE APPLICATION OF SOME VENUE FEATURE
KEYWORDS
<table>
<thead>
<tr>
<th>KEYWORDS</th>
<th>EXAMPLES OF APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>viewing areas, a hall, rooms, an open space where people gather</td>
</tr>
<tr>
<td>Access route</td>
<td>designated/undesignated paths, corridors, junctions, turnings</td>
</tr>
<tr>
<td>Entry/exit point</td>
<td>including doors, gates, turnstiles</td>
</tr>
<tr>
<td>Furniture/street furniture</td>
<td>lamp posts, benches, plants/trees, decor, fountains, monuments</td>
</tr>
<tr>
<td>Facilities</td>
<td>toilets, food and drink outlets, stalls, litter bins, check-in desk, ticket machines</td>
</tr>
<tr>
<td>Information source</td>
<td>information display boards/monitor screens, public address systems, enquiry desks, signs, notices</td>
</tr>
</tbody>
</table>
APPENDIX C
GLOSSARY OF THE VENUE HAZARD KEYWORDS
## Glossary of Venue Hazard Keywords

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient: capacity</td>
<td>insufficient space to cater for the crowds, crowd movement and other needs such as emergency access (e.g. area too small, access route too narrow, not enough space in front for people to queue)</td>
</tr>
<tr>
<td>Insufficient: quantity</td>
<td>the quantity of the feature in the venue is not enough to meet the demand (e.g. no or not enough access paths, lack of toilet facilities, too few signs)</td>
</tr>
<tr>
<td>Insufficient: quality</td>
<td>the feature is or becomes unusable or unsafe to use (e.g. uneven/slippy flooring, steep slope, broken fences, insecure structure, feature consists of protruding objects which could give rise to a cut or a tripping hazard, ambiguous signs)</td>
</tr>
<tr>
<td>Obstruction: access</td>
<td>access to and from an area is blocked or significantly restricted (e.g. by an object or by other people)</td>
</tr>
<tr>
<td>Obstruction: from view</td>
<td>the feature is blocked and cannot be seen from a distance (e.g. people are unable to see a turning, a staircase or a ramp beforehand, an information display board is hidden behind an object or a gathering crowd or its text is too small to read from a distance)</td>
</tr>
<tr>
<td>Obstruction: line of sight</td>
<td>the view of spectators is blocked by an object or by other people (e.g. by a pillar)</td>
</tr>
<tr>
<td>Pinch point/funnelling</td>
<td>a narrow stretch or point which could hold up access or cause the crowd flows to taper</td>
</tr>
<tr>
<td>Unguarded</td>
<td>no or insufficient prevention of access to dangerous parts of an object or an area (e.g. exposed sharp edges, an unprotected pot-hole or where members of the public can wander into a dangerous part of a work site)</td>
</tr>
</tbody>
</table>
APPENDIX D
GLOSSARY OF THE BEHAVIOURAL KEYWORDS
<table>
<thead>
<tr>
<th>GLOSSARY OF BEHAVIOURAL KEYWORDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uneven distribution</strong></td>
</tr>
<tr>
<td><strong>High crowd density</strong></td>
</tr>
<tr>
<td><strong>Disruption to a stationary crowd</strong></td>
</tr>
<tr>
<td><strong>Rapid crowd flow</strong></td>
</tr>
<tr>
<td><strong>Cross flows</strong></td>
</tr>
<tr>
<td><strong>Disruption or obstruction to a crowd flow</strong></td>
</tr>
<tr>
<td><strong>Non-compliance</strong></td>
</tr>
<tr>
<td><strong>Dangerous behaviour</strong></td>
</tr>
<tr>
<td><strong>Aggressive behaviour</strong></td>
</tr>
<tr>
<td><strong>People with special needs</strong></td>
</tr>
</tbody>
</table>
APPENDIX E

Second Draft of the Crowd Safety Risk Assessment Methodology Document
(Document reformatted for this thesis)
ASSESSING CROWD SAFETY

A Guide to Assessing the Risks to Crowds in Public Venues

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INTRODUCTION

BACKGROUND

1. Large crowds are a normal part of the operation of many public venues. From a commercial point of view large numbers of visitors may be desirable. But excessive crowding and poor safety provisions could lead at worst to injury or death and at the very least to frustration, dissatisfaction and reduced enjoyment.

2. The Health and Safety at Work, etc. Act 1974 (HSW Act) places a duty on the employer to ensure the health and safety of his employees and persons not in his employment who may be affected by his undertaking. When applied to a public venue where the work activity involves the attendance of crowds, the employer has a duty to safeguard the health and safety of such crowds and to ensure that the risk to which they are exposed is as low as is reasonably practicable.

3. Under Regulation 3 of the Management of Health and Safety at Work Regulations 1992 (MHSWR), the employer is also required to make a suitable and sufficient assessment of the risks to the health and safety of his employees and others who might be affected. In a public venue, this means the public venue owner should assess the risk his undertaking poses to employees and others, including the visiting crowds.

SCOPE

4. This guide is intended to help the public venue owner to assess the safety risks his venue poses to the visitors. It consists of two parts: Introduction and A Method for Assessing Crowd Safety Risks in Public Venues. The first part outlines the risk assessment principles and gives guidance on who should carry out the assessment. The second part suggests a method for assessing crowd safety risks and gives practical advice on how to carry it out. This guide is not prescriptive. With the large number of public venues involved, considerable variation in venue design, visitor types and work practices exists. The content of this document can only be used as guidance and the reader will need to use discretion where the guidance does not match the exact circumstances of the venue.

5. This guide is concerned with the assessment of risks to the safety of the visiting crowds only. In order to comply with Regulation 3 of the MHSWR, the public venue owner should also assess the health and safety risks to his employees and others who may be affected (e.g. contractors, tenants).
DEFINITIONS FOR THE PURPOSES OF THIS GUIDE

6. **Crowd safety** - the safety of members of the visiting crowds. It covers the safety of individual members as well as the crowd as a whole.

7. **Front line staff** - members of the employed and volunteer staff who have direct contact with the visiting crowds and whose work involves interacting with, managing and/or monitoring them (e.g. stewards, ticket collectors at turnstiles, etc.).

8. **Hazard** - anything which has the potential to cause harm to members of the visiting crowds. This could be (a dangerous property of) an item or a substance, a condition, a situation or an activity.

9. **Public venue** - a place which opens to members of the public and where they assemble. It could be purpose built or otherwise, permanent or temporary, fixed or transient and indoor or outdoor. Examples of public venues include airports, railway stations, stadia, shopping malls, exhibition halls, leisure parks, fairgrounds and sites that are used to hold one-off events (e.g. concerts, street festivals).

10. **Public venue owner** - a person or an organisation which owns the public venue and/or can legally seek to control the number of people entering the venue and the activities within it.

11. **Risk** - the likelihood that the harm from a hazard is realised and the extent of it (i.e. the number of people who might be exposed and the consequences for them). In the context of a risk assessment, risk should reflect both the likelihood that harm will occur and its severity. In this document, a qualitative measure of risk has been developed (see Figure 4).

WHAT IS A RISK ASSESSMENT?

12. Risk assessment is a systematic process that examines an undertaking and assesses the risks that could arise from it. In general, it involves identifying the hazards present and then evaluating the risks involved, taking into account whatever precautions are already being taken. The purpose of a risk assessment is to help the public venue owner to decide what additional actions need to be taken to eliminate the hazards or to reduce the risks. This will help him to comply with his duties under the HSW Act and other relevant health and safety law.

13. Many public venue owners already carry out some form of risk assessment on a day-to-day basis. During the course of their operations, they will monitor the situation, recognise
problems as they develop and introduce corrective measures by either taking immediate action there and then or by implementing longer term solutions. The MHSWR however requires that public venue owners should undertake a systematic general examination of their venues and that they should record significant findings from that risk assessment.

14. The *Management of Health and Safety at Work Regulations 1992: Approved Code of Practice* sets out the principles of a risk assessment. In particular, a suitable and sufficient risk assessment should:

(a) identify all relevant hazards and address all significant risks;
(b) enable the employer to identify and prioritise the measures that need to be taken;
(c) be appropriate to the nature of the work and remain valid for a reasonable period of time;
(d) address what actually happens rather than what is supposed to happen. Actual practice may differ from the procedures and this is frequently a route whereby risks creep in unnoticed;
(e) ensure that all groups of employees and others who might be affected are considered;
(f) identify those groups who might be particularly at risk;
(g) take account of existing preventive or precautionary measures.

15. Risk assessment is not a stand-alone process. Rather, it is an integral part of the planning process, undertaken to ensure the smooth running of the venue. Its findings could help the venue owner to create policies, to set performance standards and to allocate resources. It can also help the venue owner to decide what changes should be made to his venue, what crowd management measures to take, the appropriate staffing levels and the need for future development.

**WHO SHOULD CARRY OUT THE ASSESSMENT?**

16. It is the duty of the public venue owner to conduct a suitable and sufficient assessment of the health and safety risks his venue poses to the visiting crowds. He may appoint one or more of his own employees as assessors to assist him in carrying out this duty and/or may enlist help or support from outside the organisation (e.g. a consultant). However, this does not absolve him from this legal duty. Ultimately, the responsibility rests with him.

17. The public venue owner is also responsible for ensuring that a suitable and sufficient assessment has been carried out of the risks posed by other operations which take place in his venue. For example, in a multi-occupancy situation where the activities of different
occupants could affect each other and where there are safety issues which are of common concern, the risk assessment may need to cover the venue as a whole to be fully effective. This will require some degree of co-ordination and co-operation.

18. The assessor(s) appointed by the public venue owner should be competent. In general, the assessor(s) should have:

(a) a knowledge and understanding of the venue and its operation;
(b) a knowledge and understanding of the principles of risk assessment;
(c) the capacity to apply his knowledge to crowd safety risk assessment. This will include identifying crowd safety problems and assessing the need for action;
(d) an understanding of relevant current best practice in ensuring crowd safety;
(e) an awareness of the limitations of his own experience and knowledge; and
(f) a willingness and ability to supplement existing experience and knowledge.

19. The public venue owner is solely responsible for ensuring that those he has appointed are competent and given adequate information and support (e.g. training, time and resources) to carry out their tasks.

20. A crowd safety risk assessment may be carried out by individual assessors on their own or by a team of assessors. In the view of the Health and Safety Executive (HSE), however, a team approach is usually more desirable especially for large venues. The advantage of a team approach is that the assessment can draw on the range of knowledge and experience of the team members. It can also ensure that the risk assessment has taken different views and understanding into account.

21. The size of the assessment team could vary, depending on the complexity of the venue. As a rule of thumb, it should have enough people to answer the majority of the queries that could arise in the assessment without recourse to further expertise.

22. Therefore, for an existing public venue, the assessment team would normally consist of:

(a) the venue manager - he is responsible for the venue operation, understands the overall situation and is in the position to make most decisions; and
(b) appropriate members of the front line staff - they deal with the visiting crowds and therefore know what actually happens on the ground. They also have in-depth knowledge and experience of what problems could arise.

23. For a brand new public venue or a new extension to an existing venue, it is often useful to carry out a preliminary risk assessment at the design stage to examine the main features. A detailed assessment can be carried out later on when the venue is closer to its
completion. The assessment team would normally consist of representatives of the venue owner and the designer organisations. The former will be responsible for operating the venue and can contribute by identifying operational problems posed by the design. The latter has the technical expertise to suggest design solutions and to comment on their costs and feasibility.

24. In addition, at some points in the assessment, it may be necessary to involve others from both within and outside the organisation who could provide additional expertise or whose activities interact with the operation. It is up to the venue owner to decide how they should be involved (e.g. as a member of the assessment team, to participate in parts of the assessment or to co-ordinate and exchange information only when necessary). The following are examples of those who may be involved in the risk assessment:

(a) other departments within the organisation where some of the front line staff belong (e.g. catering);
(b) the emergency services;
(c) the promoter(s) or organiser(s) of the event to be held in the venue;
(d) major tenants (e.g. in a shopping centre or a transport venue);
(e) operators of the transport systems used by many visitors;
(f) the local authority planning or environmental health department;
(g) specialists who can provide the necessary technical input to the assessment (e.g. where fireworks, laser or other special effects are used).

25. There are no fixed rules about how the assessment team should work. But experience from other sectors (e.g. the high hazard industries) suggests a structured brainstorming (i.e. a group discussion which encourages uninhibited expression of views) could be useful. This provides an opportunity for team members to share their knowledge and experience and to discuss specific concerns. The venue owner needs to appoint a chairperson who is competent in risk assessment and in chairing such meetings. His role will be to control and guide the team through the assessment. A brainstorming can be done in half-day sessions. How many sessions are required would obviously depend on the size of the venue and the complexity of the operation. For most public venues, once the team is familiar with the method, it would be able to complete the bulk of the assessment between one and a few sessions.
A METHOD FOR ASSESSING CROWD SAFETY RISKS
IN PUBLIC VENUES

THE OVERALL RISK ASSESSMENT APPROACH

26. When carrying out a crowd safety risk assessment, you need to think about what hazards could arise and why, who might be harmed and how, whether the existing precautions are enough and, if not, what more should be done. The assessment would therefore consist of the following steps:

   Step 1: Identify hazards
   Step 2: Identify causes, consequences and who might be harmed
   Step 3: Decide whether existing precautions are adequate
   Step 4: Evaluate risks
   Step 5: Decide what further actions might be required
   Step 6: Record assessment findings
   Step 7: Review and revise assessment

   Figure 1 gives an overview of the assessment process for quick reference. You may find the assessment record form in Appendix A useful for recording what you have found throughout the assessment.

27. The rest of this guide takes you through each step of the assessment. Where specific advice is given in support of the guidance, they are included in an Inset. Examples are also provided to show how the guidance could be applied in practice.

28. If you are responsible for a number of similar venues (e.g. railway stations) or if your venue contains a number of similar features (e.g. rides in an amusement park), you might produce a basic "model" risk assessment reflecting the core hazards and risks associated with these venues or features. This may be applied by managers at each venue or by supervisors at each feature, but only if they:

   (a) are satisfied that the "model" assessment is broadly appropriate to their venues or features; and
   (b) adapt the model to the detail of the actual situations in their venues or features, including any extension necessary to cover hazards and risks not referred to in the model.
1. Break down the venue into more manageable areas
2. Look afresh at what hazards the venue itself could pose
3. Think about what the visitors do and how they may behave
4. Assess your safety management system
5. Identify hazards associated with the use of substances or items which could cause harm
6. Look for possible disruptions to the normal or intended operation
7. For each hazard, decide what causes the problem
8. Think about who might be harmed and how
9. Identify the precautions already in place and consider how effective they are
10. Decide whether the precautions are enough
11. For each remaining hazard, estimate its likelihood and the severity of its consequences
12. Estimate the risk level
13. Identify what more could be done to reduce the risk further
14. If there is more than one set of possible solutions, decide which is the best option

Figure 1: Crowd Safety Risk Assessment Process
STEP 1: IDENTIFY HAZARDS

29. The aim here is to systematically identify all significant hazards which could arise in your venue. You may already be aware of some hazards. But it is also important to identify hazards that are not immediately apparent - for example, a latent hazard or a new hazard which arises due to, say, the introduction of a new feature. Any hazards which are not identified here will not be addressed and thus leave a gap in the risk assessment.

30. Public safety hazards often arise from a combination of the following factors. You need to examine them, look for things that could go wrong and then decide what problems they could pose to public safety:

(a) the venue (e.g. a pinch point),
(b) the visitors (i.e. what they do and how they behave),
(c) poor safety management (e.g. insufficient staff training),
(d) the presence of hazardous substances or items (e.g. the use of a special effects),
(e) a disruption to the normal or intended operation (e.g. delays or cancellation of a service or a fire).

Guidance on how to examine these factors are given below.

31. Involve your front line staff. They might have noticed things which are not immediately obvious. Also, they might help to reveal what actually happens on the ground. At the very least, you should ask them what they think. However, it is much better to include them as part of the assessment team. For a major venue, you may need to carry out some form of brainstorming session (see paragraph 25). For a smaller venue, you can sit down with one or two experienced members of the front line staff and systematically go through each part of your venue.

32. In addition to a brainstorming session, it is often useful to carry out a venue inspection and to observe the crowds. This allows you to look afresh at what could cause harm. You could also find the information needed to identify hazards from sources such as past incident records, written comments from the front line staff, customer complains, safety audit reports, notes made in debriefing sessions and post-event reports.

Break down the venue into more manageable areas

33. It may be difficult to assess the whole venue at once especially if the venue is large. Therefore, it is worth breaking it down into a number of smaller and more manageable areas first and then examining each area in turn. You can do so based on the main
function for which each area is used (i.e. into functional areas) or in accordance with any system already in use to distinguish different parts of the venue.

**For example:** An airport terminal can be broken down into the following functional areas: access routes from a train station, from a bus station, from car park(s); forecourt; check-in area; concourse; passport control; departure lounge; gate rooms; etc.

A theme park can be broken down into the forecourt; the concourse and different attraction or ride areas.

In order to help the visitors to find their ways around, a large shopping complex may have already been divided into a number of smaller zones. They could also be used for the purpose of the risk assessment.

A street event can be broken down in terms of the streets it occupies.

**Look afresh at what hazards the venue itself could pose**

34. Examine the overall layout of the venue to identify:

   (a) if any popular areas, busy access routes, main attractions and popular facilities are situated too close together or intersect each other; and
   (b) if there is a convergence of several access routes into a single area or route.

35. Examine the features in each area and find out what hazards they could pose. One way of doing this is to apply suitable combinations of the following venue feature keywords and venue hazard keywords. The former lists the types of feature you might find in each area. The latter describes how they may lead to a hazard.

<table>
<thead>
<tr>
<th>VENUE FEATURE KEYWORDS</th>
<th>VENUE HAZARD KEYWORDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>Insufficient: capacity</td>
</tr>
<tr>
<td>Access route</td>
<td>Insufficient: quantity</td>
</tr>
<tr>
<td>Entry/exit point</td>
<td>Insufficient: quality</td>
</tr>
<tr>
<td>Flooring/underfoot condition</td>
<td>Obstruction: access</td>
</tr>
<tr>
<td>Slope, stairway, escalators, lifts, etc.</td>
<td>Obstruction: view</td>
</tr>
<tr>
<td>Step, kerb, ramp, etc.</td>
<td>Pinch point/funnelling effect</td>
</tr>
<tr>
<td>Bank and edge</td>
<td>Unguarded</td>
</tr>
<tr>
<td>Wall, pillar, post, bollard, fence, etc.</td>
<td></td>
</tr>
<tr>
<td>Furniture/street furniture</td>
<td></td>
</tr>
<tr>
<td>Facilities</td>
<td></td>
</tr>
<tr>
<td>Information source</td>
<td></td>
</tr>
<tr>
<td>Maintenance or construction work</td>
<td></td>
</tr>
</tbody>
</table>
Examples of the application of some of the venue feature keywords is shown in Appendix B. A glossary of the venue hazard keywords is given in Appendix C.

36. These keywords are here only to prompt you, the assessors, and to structure the hazard identification process so that it is systematic. They are not meant to be exhaustive. You can add your own keywords to the lists, remove those which you think are irrelevant and refine them to meet your needs. **Inset 1** advises on how to use these keywords.

**Inset 1:** A step-by-step guide to the use of the venue feature keywords and the hazard keywords

(a) Select a relevant venue feature keyword; say, **Place**
(b) Select the hazard keywords which are applicable to the selected venue feature keyword; say, **Insufficient: capacity**
(c) Combine the venue feature keyword with each of the hazard keywords selected to identify how that particular venue feature may lead to public safety hazards

*For example:* If you are assessing the forecourt of an amusement park, the keywords **Place** - **Insufficient: capacity** could mean that it is not big enough to cope with the number of people there (i.e. including those arriving, queuing to buy tickets, waiting to get through the entrance turnstiles, large groups waiting to get in, etc.). A hazard which could arise from this is that some of them may spill onto the adjacent road and mingle with the traffic.

(d) Some keywords may not be applicable to your venue. Therefore, do not be surprised if they do not generate an issue. Just ignore them and move on.
(e) Select the next relevant venue feature keyword and so on until all features in this area have been considered.

37. You do not have to apply the keywords rigidly and don’t let them restrict your thoughts. Write down whatever hazards you can think of from the keywords even though it does not seem the right place. You may have also identified the immediate cause of a hazard here. Write it down as well (see **Example 1**). The aim here is to identify as many hazards as possible. Exactly where and how they are identified is not important.

*Example 1 (using the suggested assessment form shown in Appendix A):*

**Record of Crowd Safety Risk Assessment**

<table>
<thead>
<tr>
<th>Area: Forecourt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazards</td>
</tr>
<tr>
<td>Part of the crowd may spill onto the adjacent road and mingle with moving vehicles.</td>
</tr>
</tbody>
</table>
Think about what the visitors do and how they may behave

38. The aim is to identify those activities and behaviours which could lead to a hazard. Think about what the area is used for, who your visitors are, the circumstances they may be in (e.g. in a hurry, in a lively mood) and so on. There is no need to account for all activities and behaviour, just look for those which could cause a problem. You can probably identify much of what the visitors do from experience and from past problems. But it can also be useful to observe the crowds and note down the things which concern you.

39. You may find the following venue feature keywords and behavioural keywords useful. The venue feature keywords are the same as those given in paragraph 35. The behaviour keywords describe the types of activity or behaviour which could cause harm. Appendix D gives a glossary of the behavioural keywords.

<table>
<thead>
<tr>
<th>VENUE FEATURE KEYWORDS</th>
<th>BEHAVIOURAL KEYWORDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>Uneven distribution</td>
</tr>
<tr>
<td>Access route</td>
<td>High crowd density</td>
</tr>
<tr>
<td>Entry/exit point</td>
<td>Disruption to a stationary crowd</td>
</tr>
<tr>
<td>Flooring/underfoot condition</td>
<td>Rapid crowd flow</td>
</tr>
<tr>
<td>Slope and stairway</td>
<td>Cross flows</td>
</tr>
<tr>
<td>Step, kerb, ramp, etc.</td>
<td>Disruption or obstruction to a crowd flow</td>
</tr>
<tr>
<td>Bank and edge</td>
<td>Non-compliance</td>
</tr>
<tr>
<td>Wall, pillar, post, bollard, fence, etc.</td>
<td>Dangerous behaviour</td>
</tr>
<tr>
<td>Furniture/street furniture</td>
<td>Aggressive behaviour</td>
</tr>
<tr>
<td>Facilities</td>
<td>People with special needs</td>
</tr>
<tr>
<td>Information source</td>
<td></td>
</tr>
<tr>
<td>Maintenance or construction work</td>
<td></td>
</tr>
</tbody>
</table>

40. Again, these keywords are here only to prompt you. They are not meant to be exhaustive, don’t let them restrict your thoughts. **Inset 2** advises on how to use these keywords.

**Inset 2:** A step-by-step guide to the use of the venue feature keywords and behavioural keywords

(a) Select a relevant venue feature keyword; say, Place
(b) Select the behavioural keywords to describe the type of activity or behaviour which could take place there; say, Uneven distribution
(c) Combine the venue feature keyword with each of the behavioural keywords selected to decide what problems such activity or behaviour may cause.
For example: Place - Uneven distribution could mean that too many people choose to stay in the same area in, say, a large hall. This could lead to overcrowding.

(d) Ignore those hazards which you have already identified earlier and move on. Also ignore keywords which do not apply to your situation.

For example: A path is obstructed by a stationary crowd in front of a nearby attraction. You may have already identified this earlier when examining the venue layout. You may have also thought of people entering a restricted area through a broken fence (i.e. Fence - Non-compliance) when you assessed this feature earlier.

(e) Select the next behavioural keyword and so on until all features in this area have been considered.

For example: From Place - Disruption to a stationary crowd, you could identify behaviour such as surging and people pushing their way through a packed crowd.

Facilities - Disruption or obstruction to a crowd flow could remind you of the situation where movement is blocked by people waiting for others nearby.

See Example 2

Example 2:

<table>
<thead>
<tr>
<th>RECORD OF CROWD SAFETY RISK ASSESSMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area:</strong> Forecourt</td>
</tr>
<tr>
<td><strong>Hazards</strong></td>
</tr>
<tr>
<td>Crowd movement is obstructed by people waiting for others nearby</td>
</tr>
<tr>
<td>People try to cut through the crowd to get to the toilets</td>
</tr>
</tbody>
</table>

Assess your safety management system

41. Look afresh at your safety management system. The following issues are particularly relevant to ensuring public safety. First, identify any shortcomings relating to each issue. Then consider how they could affect your operation in each area.
Inset 3 advises on how this can be done.

Inset 3: A step-by-step guide on how to assess your safety management system

(a) Select a relevant issue; say, command and communication.
(b) Decide what could go wrong; say, breakdown in communications. You may find a few shortcomings in each issue.
(c) For each shortcoming, ask yourself how it could affect your operation.

For example: As a result of a breakdown in communications, the arriving crowds are sent to the wrong entrance.

(d) Decide what hazards could arise.

For example: Severe congestion at that entrance and/or severe cross flows created by people turning back.

(e) Select the next issue and so on until all issues that are relevant to your operation in the area have been considered.

See Example 3

Example 3:

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Causes</th>
<th>Consequences</th>
<th>Existing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe congestion and/or cross flows at entrance A</td>
<td>Breakdown in communications results in arriving crowd being incorrectly sent to this entrance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Identify hazards associated with substances and items which could cause harm

42. Your operation may involve the use (and storage) of substances and/or items which have the potential to cause harm to members of the public. If this is the case, you need to identify the hazards and assess the risks created by them. First, identify what they are and where they are used and stored. The following are examples of the kinds of substances and items which could create hazards in a public venue:

(a) substances which are hazardous to health and are covered by the Control of Substances Hazardous to Health Regulations 1994 (COSHH) (e.g. substances that are toxic, corrosive or irritant; have maximum exposure limits or occupational exposure standards; have chronic or delayed effects; or biological agents)
(b) machinery (e.g. escalators, turnstiles, ticket machines, rides in a fairground or an amusement park, etc.)
(c) electric cables, generators, etc.
(d) fireworks, special effects in a place of entertainment or a show (e.g. laser), etc.
(e) open fire/naked flame (e.g. at a stall selling hot food)
(f) moving objects (e.g. vehicles, trolleys, etc.)

43. Then, decide what hazards each substance or item could pose to the visitors. Think about where and when it is used and how visitors may be exposed to it. Address what could actually happen rather than what is supposed to happen. Take into account any possibility for human errors by staff who handle the substance or operate and maintain the item. Also think about the visitors’ behaviour (see Example 4). Manufacturers’ instructions or datasheets and accident records can also help you to spot hazards and to put risks in perspective.

Example 4:

<table>
<thead>
<tr>
<th>Area: Forecourt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazards</td>
</tr>
<tr>
<td>People pushed against unguarded mobile electric generators</td>
</tr>
<tr>
<td>People knock over hot food equipment</td>
</tr>
</tbody>
</table>
Look for potential disruption to the normal or intended operation

44. The aim is to consider how your venue operation could be disrupted and what new hazards could arise as a result. A major disruption such as a major fire would call for a complete change of the mode of operation (e.g. from normal operation to an evacuation) thus introducing new hazards. Even a relatively minor disruption such as a train delay or cancellation could exacerbate a problem or turn the trivial into a significant hazard.

45. First, identify the scenarios which could disrupt your operation. The following are some examples:

(a) accident (e.g. traffic accident outside or within the venue)
(b) closure of a part of the venue
(c) closure of a nearby or related venue (e.g. the closure of an adjacent train station)
(d) delay or cancellation (e.g. flight delay, late kick-off in a football match)
(e) disruption to the arrival/departure profile (e.g. severe traffic congestion on a main approach road)
(f) emergency situation (e.g. a fire, bomb threat, structural collapse, toxic release, etc.)
(g) loss of utility (e.g. power cut)
(h) public disorder
(i) system or equipment failure (e.g. escalator stops, a jammed door or gate, etc.)
(j) weather (e.g. a sudden change of weather and adverse weather condition such as too hot/cold, heavy rainfall/snowfall, high wind, etc.)

46. For a minor disruption which causes a slight deviation in parts of the venue, hazard identification could be relatively straightforward to do. Simply think about what effects each relevant scenario could have on the venue operation, on crowd movement, on people’s behaviour and on the substances and items used. Then identify the problems which could arise as a result (see Example 5).

Example 5:

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences</th>
<th>Existing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion on access route to the escalators.</td>
<td>Escalator(s) fail.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last minute rush.</td>
<td>A severe traffic problem due to roadworks on one of the main approach roads to the venue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
47. A detailed assessment would be necessary in the case of a major disruption where the operation required to ensure safety is very different from the normal operation. The assessment would involve examining the venue itself, the visitors, the safety management system and the substances and items in the vicinity. Again, the venue feature keywords (see paragraph 35), the venue hazard keywords (paragraph 35), the behavioural keywords (paragraph 39), and the safety management issues (paragraph 41), could help you to assess the first three of the above. Hazardous substances and items can be assessed by considering how they could react in that situation and what hazards this could introduce.

48. Write down what you have identified. You need to indicate on the assessment record form the scenario you are considering (see Example 6).

**Example 6:**

**RECORD OF CROWD SAFETY RISK ASSESSMENT**

**Scenario:** A major fire at the store room behind Entrance A

**Area:** Forecourt

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences</th>
<th>Exist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assess route X and Entrance A are blocked by the fire <em>(i.e. from the keywords Access route - Obstruction: access)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrance B at the other end of the forecourt could become a pinch point in an evacuation <em>(i.e. from the keywords Entry/exit point - Insufficient: capacity)</em></td>
<td>This remains the only main exit point and people tends to leave through here rather than to use other emergency exits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>People still arriving at Entrance A.</td>
<td>Staff at a nearby train station are not informed about the fire until much later. Hence, they still direct the arriving crowd to this entrance <em>(i.e. lack of coordination)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A certain chemical in the store room could release fumes</td>
<td>The heat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric cable could be damaged</td>
<td>The fire or the heat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
STEP 2: IDENTIFY CAUSES, CONSEQUENCES AND WHO MIGHT BE HARMED

49. The aim is to find out what causes the hazards or hazardous situations identified in STEP 1, what danger they could pose and who might be affected. Identifying the cause(s) could help you to decide later in the assessment process what actions are needed to get rid of the hazards. The identification of consequences and who might be harmed could help you to decide how to protect people against the harm and to estimate risks (see Example 7).

Example 7:

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences</th>
<th>Existing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part of the crowd spills onto the adjacent road and mingles with moving vehicles.</td>
<td>During peak hours, the number of people arriving exceeds the capacity of the forecourt.</td>
<td>People, especially young children, could get knocked down by vehicles.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• not enough ticket counters</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• only a minority of the visitors buy tickets in advance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• tickets are not processed quickly enough at the entrance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crowd movement is obstructed by people waiting for others nearby.</td>
<td>People waiting for friends, etc.</td>
<td>Exacerbate the crowd congestion problem in the area</td>
<td></td>
</tr>
<tr>
<td>People try to cut through the crowd to get to the toilets.</td>
<td>Entrances to the toilets are often blocked by the main crowd flow</td>
<td>Severe cross flows especially when persons in wheelchairs try to make their way to the disabled persons toilet</td>
<td></td>
</tr>
<tr>
<td>People pushed against unguarded mobile electric generators</td>
<td>• crowding and cross flows in the area</td>
<td>Burns. Toddlers and young children are particularly vulnerable due to their height</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• some generators protrude slightly onto the access route</td>
<td></td>
<td></td>
</tr>
<tr>
<td>People knock over hot food equipment</td>
<td>• crowding and cross flows in the area</td>
<td>Severe burns to those in the immediate vicinity. Teenagers and young persons are particularly likely to be involved as they are more “lively” and tend to push each other around</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• people being pushed against the grills</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• people try to push their way through the crowd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congestion on access route to the escalators.</td>
<td>• Escalator(s) fail</td>
<td>Crowding problem which could affect the immediate area and possibly beyond</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• No alternative access routes or people not aware of their existence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last minute rush.</td>
<td>• A severe traffic problem due to roadworks on one of the main approach roads to the venue</td>
<td>Crushing at the entrance/turnstiles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• No alternative routes or people not aware of their existence</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


For each hazard, decide what causes the problem

50. Find out what causes a hazard. You may have already found the immediate causes earlier on in STEP 1. But don't stop there - there could well be other (underlying) causes that are equally important. It is worth bearing in mind that a hazard often arises due to a combination of reasons. Some of them may not be obvious. It could, for example, arise from the overall layout of the venue rather than the features you were assessing. It could be because of another problem elsewhere in the venue or what happens in another place (e.g. crowds leaving a nearby football match). It is also possible that the problem is caused by a part of your operation which seems not directly linked to crowd management (e.g. how tickets are sold).

For example: Crowd congestion in a forecourt could be caused by one or more of the following reasons: the forecourt is simply too small, the venue becomes more popular than originally designed for, not enough ticket counters, only a minority of the visitors buy tickets in advance, tickets are not processed quickly enough at the entrance and so on.

51. If the hazard is caused by people's behaviour, it is important to consider what makes them behave in such a way. You will not be able to find a satisfactory solution to the problem if you simply dismiss this as the fault of the individuals concerned!

52. If a hazard is due to a poor safety management system, you may have to look beyond the immediate issues listed in paragraph 41. Think about the more "global" safety management issues (e.g. policy, safety culture, etc.) and ask yourself whether you have done enough. You can find out more about safety management systems in the HSE publication entitled Successful Health and Safety Management and the HSE leaflet Five Steps to Successful Health and Safety Management (see Appendix E).

Think about who may be harmed and how

53. When identifying the consequences and who might be harmed, also think about how many people may be affected (i.e. whether a hazard would harm a few individuals or most people in the vicinity) and whether any visitor groups are particularly vulnerable. Vulnerable groups may include disabled persons, young children and elderly people. They are often more likely to be harmed or are likely to suffer more when harmed.
STEP 3: DECIDE WHETHER EXISTING PRECAUTIONS ARE ADEQUATE

Identify the precautions already in place and consider how effective they are

54. Some hazards may already be controlled in some way, whether by deliberate measures (e.g. by venue design, safety devices (such as barriers), crowd management measures or operational procedures) or by the circumstances in which they are found. The aim is therefore to identify the precautions and decide whether they are adequate or whether more should be done.

55. Think about how effective the existing precautions are. Again, you need to look at how they actually work, not how they are supposed to work. Also consider how your precautions may fail or become less effective. You could get caught out if you automatically assume that they would always work as intended!

For example: The circumstances could change as a result of an incident elsewhere. Venue features and engineered devices could suffer from vandalism, wear and tear, component failures, etc.

Crowd management measures and procedures could be hindered by equipment failures, human errors, breakdown in communications, confusion in roles and responsibilities and so on.

Decide whether the precautions are enough

56. In order to decide whether the existing precautions are enough, you will need to carry out a preliminary risk evaluation. As a general guide, if taking into account the existing precautions the risk is trivial or if is no greater than exists in a similar everyday situation, you can say that it is adequately controlled and no further action will be needed. You can therefore ignore the hazard and exclude it from the rest of the risk assessment. Otherwise, the hazard is still significant and you need to evaluate it in detail (see STEP 4). A trivial risk is one which is extremely remote (i.e. it has never happened before and there are no reasons whatsoever to suggest that it will ever happen) or one which does not cause any real harm (i.e. no more than inconvenience to the visitors, discomfort, frustration and so on). When deciding how the risk compares with that in an everyday situation, you should compare like with like. You cannot ignore a hazard on the grounds that its risk compares favourably with that involved in, say, a dangerous sport!

For example: In a street event, the pavement kerb could pose a tripping hazard. But, you could ignore it on the grounds that the risk is no more than that arising from walking along the high street on a normal Saturday afternoon.

If the crowd density is much higher than that on the normal high street, so will be the risk. One reason for this is that people may not see the kerb.
Therefore, the above argument is no longer valid and this hazard should be evaluated further.
STEP 4: EVALUATE RISKS

For each remaining hazard, estimate its likelihood and the severity of its consequences

57. The aim is to decide for each significant hazard how much risk is involved after the existing precautions have been taken. The findings will enable you to establish how significant the hazards are and thus to prioritise any remedial actions required to control them. The evaluation of risk usually involves the following steps:

(a) decide how likely the hazard is to be realised (i.e. estimate the likelihood);
(b) decide how serious the harm is should the hazard be realised (i.e. estimate the severity); and
(c) establish the level of risk based on the above.

58. When estimating likelihood, it is important that you consider both how likely the hazard is to occur and to cause harm, not just how likely it is to occur. This is because not all hazards cause harm all the time; the potential for a hazard to cause harm is realised only under some circumstances. In a risk assessment, we are only interested in the likelihood of someone being harmed.

For example: Cross flows and obstructions do not normally give rise to a significant problem unless they take place in a busy area.

59. When estimating severity, you need to take into account the circumstances under which the hazard takes place.

For example: If people climb up to a height, the seriousness of the injury, should they fall, will depend on how high they manage to climb. Also, more people would be injured if this behaviour takes place where there is a packed crowd underneath.

The severity (and the likelihood of an injury) of people mingling with moving vehicles will depend on whether it takes place on a busy main road with fast moving traffic or on a quiet side road where the vehicles move slowly.

Establish the risk level

60. You can find out the risk level of a hazard based on its estimated likelihood and severity. Inset 4 gives a step-by-step description on how to evaluate risk.
**Inset 4: A step-by-step guide to risk evaluation**

(a) To estimate likelihood, select a Likelihood Category (LC) from Figure 2 which can best describe how likely the hazard is to be realised.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likely (L)</td>
<td>A similar problem has happened before (either here or elsewhere) AND there are no reasons to think that it will not happen in the foreseeable future.</td>
</tr>
<tr>
<td>Possible (P)</td>
<td>Never happened before BUT there are reasons to suggest that it could happen.</td>
</tr>
<tr>
<td>Unlikely (U)</td>
<td>Never happened before BUT could occur under exceptional circumstances.</td>
</tr>
<tr>
<td>Very Unlikely (UL)</td>
<td>Never happened before AND there are no reasons to suggest that it will.</td>
</tr>
</tbody>
</table>

**Figure 2: Likelihood Categories**

(b) To estimate severity, select a Severity Category (SC) from Figure 3 which can best describe how serious the consequence will be should the hazard be realised.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic (Ca)</td>
<td>Multiple deaths/life threatening injuries.</td>
</tr>
<tr>
<td>Major (Ma)</td>
<td>A single death/life threatening injury OR injuries to a number of people who require hospitalisation.</td>
</tr>
<tr>
<td>Significant (Si)</td>
<td>A single injury which requires hospitalisation OR injuries to a number of people who require first-aid treatment.</td>
</tr>
<tr>
<td>Minor (Mi)</td>
<td>A single injury which may require some first-aid treatment; visitors feel anxious and are concerned about their safety.</td>
</tr>
<tr>
<td>Negligible (Ne)</td>
<td>No real harm; no more than inconvenience, discomfort, frustration, etc..</td>
</tr>
</tbody>
</table>

**Figure 3: Severity Categories**
Inset 4: A step-by-step guide to risk evaluation (cont.)

(c) From the selected likelihood category and severity category, you can establish the risk level of the hazard from the matrix given in Figure 4.

<table>
<thead>
<tr>
<th></th>
<th>Likely</th>
<th>Possible</th>
<th>Unlikely</th>
<th>Very Unlikely</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Catastrophic</strong></td>
<td>A</td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td><strong>Major</strong></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td><strong>Significant</strong></td>
<td>B</td>
<td>C</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td><strong>Minor</strong></td>
<td>C</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Negligible</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4: A Risk Classification Matrix

(d) The interpretation of the risk levels is laid down in Figure 5.

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Intolerable risk. Immediate action(s) must be taken to eliminate the hazard or to eliminate its source, regardless of the cost.</td>
</tr>
<tr>
<td>B</td>
<td>Should not be tolerated unless risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained.</td>
</tr>
<tr>
<td>C</td>
<td>Should not be tolerated unless the cost of risk reduction exceeds the improvement gained.</td>
</tr>
<tr>
<td>D</td>
<td>Broadly acceptable risk. But risk reduction should still be made if an inexpensive measure can be found.</td>
</tr>
<tr>
<td>-</td>
<td>Trivial risk. No further actions required.</td>
</tr>
</tbody>
</table>

Figure 5: Interpretation of Risk Levels

There are no hard and fast rules for deciding whether the risk reduction cost is grossly disproportionate to or exceeds the improvement gained. You need to use your own judgement. To put things in perspective, it is often useful to think about the costs of failing to take the necessary precautions. Apart from personal suffering, the costs may also include compensation payments, insurance costs, adverse publicity, loss of revenue, possible prosecution and other effects on your company’s viability.

61. *Inset 4* is given as guidance only. You can modify the likelihood categories, the severity categories and the number of risk levels to meet your specific needs. However, at the
very least, you need to be able to decide whether the risks are intolerable, should be kept as low as reasonably practicable or are broadly acceptable.

**Example 8:**

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Existing Precautions</th>
<th>LC</th>
<th>SC</th>
<th>Risk</th>
<th>Action</th>
</tr>
</thead>
</table>
| Part of the crowd spills onto the adjacent road and mingles with moving vehicles | • the road is normally quiet with only a few vehicles at any one time  
• vehicles are slow moving | P  | Si | C    |        |
| Crowd movement is obstructed by people waiting for others nearby        |                                                                                     | U  | Mi |      |        |
| People try to cut through the crowd to get to the toilet               |                                                                                     | P  | Si | C    |        |
| People try to cut through the crowd to get to the toilet               |                                                                                     | L  | Si | B    |        |
| People try to cut through the crowd to get to the toilet               |                                                                                     | L  | Ma | A    |        |
| People try to cut through the crowd to get to the toilet               | Procedures to divert crowd flows have been tried and tested many times in the past. | U  | Mi |      |        |
| People try to cut through the crowd to get to the toilet               | • arrangements with the police and a motoring organisation to receive information on any major roadworks well in advance  
• well established procedures to warn coach parties of the roadworks | P  | Ma | B    |        |
STEP 5: DECIDE WHAT FURTHER ACTIONS MIGHT BE REQUIRED

Decide what more should be done to reduce the risk further

62. Identify what more should be done to eliminate each remaining hazard or to reduce the risk. Ask yourself:

(a) whether you have done all the things that the law says you have got to do; and
(b) whether generally accepted standards are in place.

The law also says that you must do what is reasonably practicable to keep the venue safe. Therefore, your real aim is to make the risks as small as possible by adding to your precautions if necessary. Figure 5 suggests the appropriate courses of action for each risk level. Priority should be given to hazards which pose the higher risks.

63. First, consider whether it is possible to get rid of the hazard altogether. This can usually be achieved by removing the source of the hazard or by tackling its causes. If this is not "reasonably practicable" to do (see Figure 5), then think about how to control the risk (i.e. to make it less likely to occur or to cause harm, to reduce its severity and/or to protect people against harm). Guidance and good practices by other venues could help you to identify the remedial actions required.

If there is more than one set of possible solutions, decide which is the best option

64. If there are several possible actions, you may have to examine them in more detail to decide which of them to take. In general, you need to think about the level of risk posed, how effective the actions would be in controlling the risk, whether they could give rise to a problem elsewhere, how soon they can be put in place and whether the hazard needs to be addressed urgently or whether it is better to wait for a more permanent solution. You can of course also take into consideration related cost-benefit factors such as the costs of taking those actions and how they may affect things like visitors’ enjoyment and the attractiveness of the venue.

65. Keep a record of what you have decided. If you believe that no actions are needed, it is useful to write down the reasons. It is also good practice to write down who is to carry out each action (see Example 9) and to have in place a way of monitoring its progress.
### Example 9

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Precautions</th>
<th>LC</th>
<th>SC</th>
<th>Risk</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part of the crowd spills onto the adjacent road and mingle with moving vehicles.</td>
<td>People try to cut through the crowd to get to the toilets</td>
<td>P</td>
<td>Si</td>
<td>C</td>
<td>• open more ticket counters during peak periods&lt;br&gt;• find ways to encourage advance purchase&lt;br&gt;• review procedures on processing tickets&lt;br&gt;<strong>Actions on:</strong> Sales Manager&lt;br&gt;<strong>Precautions:</strong> Normally quite a few vehicles at time they are slow moving&lt;br&gt;<strong>Risk:</strong> C&lt;br&gt;<strong>Actions:</strong> The above actions should help to reduce this problem. Therefore no further actions.</td>
</tr>
<tr>
<td>Crowd movement is obstructed by people waiting for others nearby</td>
<td>People pushed against unguarded mobile electric generators</td>
<td>U</td>
<td>Mi</td>
<td>-</td>
<td>The above actions should help to reduce this problem. Therefore no further actions.</td>
</tr>
<tr>
<td>People try to cut through the crowd to get to the toilets</td>
<td>People pushed against unguarded mobile electric generators</td>
<td>P</td>
<td>Si</td>
<td>C</td>
<td>Could relocate the toilets but the cost of doing so outweighs the improvement gained. No actions.</td>
</tr>
<tr>
<td>People pushed against unguarded mobile electric generators</td>
<td>People knock over hot food equipment</td>
<td>L</td>
<td>Si</td>
<td>B</td>
<td>• the generators should be guarded&lt;br&gt;• ensure that generators are in line&lt;br&gt;• closely monitor crowd flows and control access into this area when necessary&lt;br&gt;<strong>Actions on:</strong> Operation Manager and Duty Supervisors&lt;br&gt;<strong>Precautions:</strong> People knock over hot food equipment&lt;br&gt;<strong>Risk:</strong> B&lt;br&gt;<strong>Actions:</strong> No inexpensive action identified to reduce risk.</td>
</tr>
<tr>
<td>People knock over hot food equipment</td>
<td></td>
<td>L</td>
<td>Ma</td>
<td>A</td>
<td>• carry out inspection to ensure that all such grills are adequately guarded&lt;br&gt;• relocate traders to another part of the venue&lt;br&gt;• closely monitor crowd flows and control access into this area when necessary&lt;br&gt;• stewards should discourage such &quot;lively&quot; behaviour in this area&lt;br&gt;<strong>Actions on:</strong> Operation Manager and Duty Supervisors&lt;br&gt;<strong>Precautions:</strong> People knock over hot food equipment&lt;br&gt;<strong>Risk:</strong> A&lt;br&gt;<strong>Actions:</strong> People knock over hot food equipment.</td>
</tr>
<tr>
<td>Congestion on access route to the escalators</td>
<td></td>
<td>U</td>
<td>Mi</td>
<td>-</td>
<td>No inexpensive action identified to reduce risk.</td>
</tr>
<tr>
<td>Last minute rush</td>
<td></td>
<td>P</td>
<td>Ma</td>
<td>B</td>
<td>• publicise and advise visitors to set off early&lt;br&gt;• increase staff level and put in extra crowd control measures&lt;br&gt;• consider delaying the start of the event if the situation significantly deteriorates&lt;br&gt;<strong>Actions on:</strong> Operation Manager and Duty Supervisors&lt;br&gt;<strong>Precautions:</strong> Last minute rush&lt;br&gt;<strong>Risk:</strong> B&lt;br&gt;<strong>Actions:</strong> Last minute rush.</td>
</tr>
</tbody>
</table>
STEP 6: RECORD ASSESSMENT FINDINGS

66. If your undertaking has five or more employees, you are required by the MHSWR to record the significant findings of your assessment. You should be able to show, through the record, that you have undertaken a suitable and sufficient assessment and that you have done what is reasonably practicable to reduce the risks. Significant findings usually include:

(a) the significant hazards identified in the assessment;
(b) the existing precautions in place;
(c) the remaining risks, including any groups of visitors who are especially at risk;
(d) the conclusions of the assessment, including the actions you have identified to further reduce the risks.

The record could be documented in writing or by other means (e.g. electronically) so long as it is retrievable for use by management or for examination (e.g. by enforcing authority inspectors).

67. Some hazards may have already been addressed elsewhere. For example, if hazardous substances are used, your COSHH assessment should have addressed the risks. Also, some of the existing precautions may have already been described in other documents (e.g. procedures). There is no need to repeat this information in the record, you can simply refer to where it can be found.

68. Keep the record for future reference or use. It helps to show that you have done what the law requires and can therefore help you if an inspector questions your precautions or if you become involved in any legal action (e.g. for civil liability). It can also remind you to keep an eye on particular concerns. Appendix A shows the crowd safety risk assessment record form used throughout this guide. You may find it useful. Alternatively, you can develop your own form or record your assessment in another format if that suits you better.
STEP 7: REVIEW AND REVISE ASSESSMENT

69. Risk assessment is not a once-and-for-all activity. You are required under the MHSWR to review your assessment and, if necessary, revise it if there are developments which suggest that your assessment may no longer be valid, such as:

(a) a significant change to your operation, to your venue, in visitor composition or in the circumstances (e.g. the introduction of new hazards due to activities elsewhere, renewed terrorist threats);
(b) the detection of a significant problem; or
(c) the occurrence of a major incident or a potentially serious near miss.

In any case, it is good practice to review your assessment at regular intervals (e.g. annually) and record any amendments you have made. Even if there are no changes, it is useful to record that fact to show that you have carried out the review.

70. If your operation concerns the staging of a regular event, ideally you need to start your review shortly after the event has finished. This is so that any problems and incidents which took place in the event are still fresh in people’s minds. In any case, the timing of the review should be such that you have enough time before the next event to implement the new actions identified in the assessment.
# RECORD OF CROWD SAFETY RISK ASSESSMENT

Area: ________________________________

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences</th>
<th>Existing Precautions</th>
<th>LC</th>
<th>SC</th>
<th>Risk</th>
<th>Actions</th>
</tr>
</thead>
</table>

*LC = Likelihood Category  SC = Severity Category*
### APPENDIX B: EXAMPLES OF THE APPLICATION OF SOME VENUE FEATURE KEYWORDS

<table>
<thead>
<tr>
<th>KEYWORDS</th>
<th>EXAMPLES OF APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>viewing areas, a hall, rooms, an open space where people gather</td>
</tr>
<tr>
<td>Access route</td>
<td>designated/undesignated paths, corridors, junctions, turnings</td>
</tr>
<tr>
<td>Entry/exit point</td>
<td>including doors, gates, turnstiles</td>
</tr>
<tr>
<td>Bank and edge</td>
<td>River bank, dockside, the edge of a platform, etc.</td>
</tr>
<tr>
<td>Furniture/street furniture</td>
<td>lamp posts, benches, plants/trees, decor, fountains, monuments</td>
</tr>
<tr>
<td>Facilities</td>
<td>toilets, food and drink outlets, stalls, litter bins, check-in desk, ticket machines</td>
</tr>
<tr>
<td>Information source</td>
<td>information display boards/monitor screens, public address systems, enquiry desks, signs, notices</td>
</tr>
</tbody>
</table>
### APPENDIX C: GLOSSARY OF THE VENUE HAZARD KEYWORDS

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insufficient: capacity</strong></td>
<td>insufficient space to cater for the crowds, crowd movement and other needs such as emergency access (e.g. area too small, access route too narrow, not enough space in front for people to queue)</td>
</tr>
<tr>
<td><strong>Insufficient: quantity</strong></td>
<td>the quantity of the feature in the venue is not enough to meet the demand (e.g. no or not enough access paths, lack of toilet facilities, too few signs)</td>
</tr>
<tr>
<td><strong>Insufficient: quality</strong></td>
<td>the feature is or becomes unusable or unsafe to use (e.g. uneven/slippery flooring, steep slope, broken fences, insecure structure, feature consists of protruding objects which could give rise to a cut or a tripping hazard, ambiguous signs)</td>
</tr>
<tr>
<td><strong>Obstruction: access</strong></td>
<td>access to and from an area is blocked or significantly restricted (e.g. by an object or by other people)</td>
</tr>
<tr>
<td><strong>Obstruction: view</strong></td>
<td>the feature is blocked and cannot be seen from a distance (e.g. people are unable to see a turning, a staircase or a ramp beforehand, an information display board is hidden behind an object or a gathering crowd or its text is too small to read from a distance) OR the view of spectators is blocked by an object or by other people (e.g. by a pillar)</td>
</tr>
<tr>
<td><strong>Pinch point/funnelling effect</strong></td>
<td>a narrow stretch or point which could hold up access or cause the crowd flows to taper</td>
</tr>
<tr>
<td><strong>Unguarded</strong></td>
<td>no or insufficient prevention of access to dangerous parts of an object or an area (e.g. exposed sharp edges, an unprotected pot-hole or where members of the public can wander into a dangerous part of a work site)</td>
</tr>
</tbody>
</table>
## APPENDIX D: GLOSSARY OF THE BEHAVIOURAL KEYWORDS

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uneven distribution</td>
<td>Higher concentrations of people in some part(s) of the venue or on some access route(s).</td>
</tr>
<tr>
<td>High crowd density</td>
<td>The density of the crowd is such that it has the potential to cause problems, such as overcrowding and crushing.</td>
</tr>
<tr>
<td>Disruption to a stationary crowd</td>
<td>Actions which have the potential to upset the stability/order of a stationary crowd (e.g. people cut through a crowd, pushing, surging, lateral movement etc.).</td>
</tr>
<tr>
<td>Rapid crowd flow</td>
<td>The speed of the crowd movement is such that it has the potential to cause problems, such as crushing, pile-up and trampling.</td>
</tr>
<tr>
<td>Cross flows</td>
<td>The direction(s) of the crowd movement could cause a safety problem (e.g. significant amount of cross flows, a contraflow, a whirlpool effect, etc.).</td>
</tr>
<tr>
<td>Disruption or obstruction to a crowd flow</td>
<td>Actions that could disrupt the smooth flow of the crowd or obstruct crowd flow (e.g. people suddenly stop or slow down or change direction, people try to cut in or to cut through, individuals or a queue blocking an access route, etc.).</td>
</tr>
<tr>
<td>Non-compliance</td>
<td>Disregarding the &quot;house-rules&quot; or not following instructions or directions (e.g. entering a restricted or a closed-off area, smoking in a no smoking area, illegal parking, moving in the wrong direction up a one-way system, refusing to move away from the gangway when asked, etc.).</td>
</tr>
<tr>
<td>Dangerous behaviour</td>
<td>Actions which in themselves could cause harm to oneself and others (e.g. climb up/down/over, jump over, slide or run down a steep slope, etc.).</td>
</tr>
<tr>
<td>Aggressive behaviour</td>
<td>Including antagonistic behaviour, fighting, missile throwing, etc..</td>
</tr>
<tr>
<td>People with special needs</td>
<td>People such as disabled persons, parents with young children, old people, people carrying large items, etc. may act and behave differently.</td>
</tr>
</tbody>
</table>
APPENDIX E: FURTHER READING

The following list of HSE publications is only a small selection of those available. A comprehensive list is available from HSE Books. Free leaflets are available from both HSE Books and the HSE Area Offices.


*Five Steps to Risk Assessment*, IND(G)163L (free leaflet)

*Successful Health and Safety Management*, HS(G)65, ISBN 0 7176 0425 X


*Five Steps to Successful Health and Safety Management: Special help for directors and managers*, IND(G)132L (free leaflet)

*Control of Substances Hazardous to Health and Control of Carcinogenic Substances. Control of Substances Hazardous to Health Regulations 1994: Approved Codes of Practice*, L5, ISBN 0 7176 0819 0

APPENDIX F

Briefing Notes and Questionnaires used in the User Trails and the Questionnaire Survey in the Combined Validity and Usability Test
About the Guide:

Regulation 3 of the Management of Health and Safety at Work Regulations 1992 requires all employers to assess the risks their undertaking poses to employees and others who may be affected, including the public. Such a requirement also applies to public venue owners. The Health and Safety Executive has commissioned RM Consultants Ltd (RMC) to develop a guide to the assessment of crowd safety risks in public venues. The aim of the guide is to provide the assessors with the necessary support and assistance so that they can conduct a suitable and sufficient risk assessment on crowd safety. It is intended for public venue managers and others whose duties include assessing crowd safety.

About the User Trial:

The guide consists of a suggested risk assessment method and associated guidance. The aim of the user trial is to evaluate the method and how it is presented. This will enable us to identify ways of improving the guide so that it adequately addresses your assessment needs. Enclosed is a copy of the guide. The instructions for the trial are as follows:

- You are advised to read the guide before the trial. This will help to reduce the time required to complete the trial.
- Prior to the trial, select a part of your venue (or an event) which you wish to assess. It would be beneficial if the selected part is as typical as possible of the venue (i.e. in terms of the types of crowd safety problems that could arise).
- Where possible, bring with you a plan of the selected part and other materials which you may need for the trial assessment.
- On the day of the trial, you will be asked to apply the method suggested in the guide to assess crowd safety in the selected part of your venue/event.
- Zachary Au from RMC will be present to observe the assessment. This will give him an opportunity to identify any problems posed by the guide. It is worth noting that it is the guide, not the evaluator, which is being tested in this trial!
• After the trial, you will be invited to give your comments by filling in a short questionnaire.
THE EVALUATION OF THE CROWD SAFETY RISK ASSESSMENT GUIDE

USER TRIAL QUESTIONNAIRE

This questionnaire aims to identify any deficiencies and weaknesses in the current version of the above guide. You are invited to comment on all aspects of the guide, such as the risk assessment method suggested here and how useful the guidance is. Please record your comments by completing this questionnaire. Based on your comments, RMC will modify the guide so that it becomes more appropriate to your risk assessment needs.

The Risk Assessment Method:

1. Do you find any parts of the assessment method difficult to apply in practice or do you think they might cause problems to other assessors in a similar situation? Please record your comments in terms of the following risk assessment steps:

   (i) identify public safety hazards
   (ii) identify the causes and consequences of the hazards
   (iii) decide whether the hazards are already sufficiently controlled
   (iv) estimate the risks
   (v) decide what further actions are needed and their priorities
   (vi) record your assessment findings
   (vii) review and revise your assessment

   Please explain what the problems are and comment on how the guide might be improved.

2. Apart from those problems you have already mentioned above, is there anything else which you particularly like or dislike?

3. Do you have any comments about the assessment method as a whole and how it could be improved? (e.g. Is it easy to use? Is it sufficient? Does it address the kind of public safety issues that concern you? Is it too time consuming or resource intensive to do? etc.)
The Guidance:

4. Did you find any parts of the risk assessment guide difficult to understand or did you feel unsure about what they meant (please specify)?

5. Do you think the guidance and the information given in the guide is appropriate to your needs?

6. Do you think the guidance and the information given is comprehensive enough or do you require more information (please specify)?

7. Do you have any other comments about the guide? (e.g. document length; ease of use; “way finding”; clarity of new phases, terms and concepts; layout; illustrative materials; etc.)

Thank you for taking part in the user trial.
THE EVALUATION OF THE HSE CROWD SAFETY RISK ASSESSMENT GUIDE

QUESTIONNAIRE FOR EVALUATORS

This questionnaire aims to identify any deficiencies or weaknesses in the current version of the above guide. You are invited to review all aspects of the guide, such as the risk assessment method suggested here and how useful the guidance is. Please record your comments by completing this questionnaire. You may need to write them down on a separate sheet of paper. Based on your comments, RMC will modify the guide so that it becomes more appropriate to your risk assessment needs.

The Risk Assessment Method:

1. Do you find any parts of the risk assessment method difficult to apply in practice or do you think they might cause problems to other assessors in a similar situation? Please record your comments in terms of the following risk assessment steps:

   (i) identify public safety hazards
   (ii) identify the causes and consequences of the hazards
   (iii) decide whether the hazards are already sufficiently controlled
   (iv) estimate the risks
   (v) decide what further actions are needed and their priorities
   (vi) record your assessment findings

   Please explain what the problems are and comment on how the guide might be improved.

2. Apart from those problems you have already identified above, is there anything else which you particularly like or dislike?

3. Do you have any comments about the assessment method as a whole and how it could be improved? (e.g. Is it easy to use? Is it sufficient? Does it address the kind of crowd safety issues that concern you? Is it too time consuming or resource intensive to do? etc.)
The Guidance:

4. Did you have difficulty in understanding any part of the guide or did you feel unsure about what it meant (please specify)?

5. Do you think the guidance and the information given in the guide is appropriate to your needs and the needs of other assessors in a similar situation? If not, please suggest how the guide could be improved.

6. Do you think the guidance and the information given is comprehensive enough or do you require more information (please specify)?

7. Do you have any other comments about the guide? (e.g. document length; ease of use; “way finding”; clarity of new phases, terms and concepts; layout; illustrative materials; etc.)

Thank you for taking part in our evaluation. Please use the enclosed stamped addressed envelope to return your comments.
APPENDIX G

Third Draft of the Crowd Safety Risk Assessment Methodology Document
(Document reformatted for this thesis)
ASSESSING CROWD SAFETY

A Prototype Methodology For The Assessment Of Risks To Crowds In Public Venues

S.Y.Z. AU
RM Consultants Ltd.
Genesis Centre
Birchwood Science Park
Warrington
Cheshire
WA3 7BH
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<td>41</td>
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<td>Hazardous substances or items</td>
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<td>Look for potential disruption to the normal operation and identify hazards in those situations</td>
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<td>Step 2: Identify causes, consequences and who might be harmed</td>
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<td>Identify causes</td>
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<td>Step 3: Decide whether existing precautions are adequate</td>
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<td>Step 5: Decide what further actions might be required</td>
</tr>
<tr>
<td>69</td>
<td>Decide what more should be done</td>
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Select the best course of action  
Follow up your actions

Step 6: Record assessment findings

Step 7: Review and revise

FURTHER READING

APPENDICES

Appendix A: Crowd safety risk assessment record form
Appendix B: Glossary of the hazard keywords
Appendix C: Crowd safety risk assessment follow-up form
**INTRODUCTION**

1. Large crowds are a normal part of the operation of many public venues. From a commercial point of view large numbers of visitors may be desirable. But excessive crowding and poor safety provisions could lead at worst to injury or death and at the very least to frustration, dissatisfaction and reduced enjoyment.

**The legal requirements**

2. Under the Health and Safety at Work, etc. Act 1974 (HSW Act), employers have general duties to ensure that risks to the health and safety of their employees and others who may be affected, including members of the public in a public venue, are properly controlled.

3. As a way of managing the health and safety law, Regulation 3 of the Management of Health and Safety at Work Regulations 1992 (MHSWR) states explicitly that employers are required to make a suitable and sufficient assessment of the risks. This requirement applies to almost everyone who runs a public venue.

**Scope**

4. This methodology is developed to help public venue owners, managers and others whose duties include looking after the public to assess the crowd safety risks in their venues. It is intended for all places where members of the public assemble, including:

   (a) train stations, bus stations, airports, ferry terminals and passenger terminals of other land, air and sea transport facilities;
   (b) stadia, race grounds and all other sports venues;
   (c) markets, shopping malls, museums and galleries, exhibition halls and leisure complexes;
   (d) fairgrounds, leisure parks and show grounds;
(e) cinemas, theatres, concerts and other venues for shows and entertainment; and
(f) sites that are used to hold outdoor or street events.

5. The methodology sets out an assessment approach for public venues in general. However, it is not prescriptive. There are considerable variations between different venues in their design, visitor types and work practices. Therefore, readers will need to use discretion where the content of this document does not match the exact circumstances of their venues. There are more specific documents for particular venue types (see FURTHER READING at the back of this document). They will need to be read in conjunction for specific cases.

6. This methodology is for the assessment of the safety risks to the visiting crowds only. In order to comply with Regulation 3 of the MHSWR, public venue owners should also assess the risks to their employees and others who may be affected (e.g. contractors, tenants).

Definitions for the purposes of this methodology

7. The following explains the meanings of some of the terms used in this document:

**Crowd safety** - the safety of members of the visiting crowds. It covers the safety of individual members as well as the crowd as a whole.

**Front line staff** - members of the employed and volunteer staff who have direct contact with the crowds and whose work involves interacting with, managing and/or monitoring them (e.g. stewards, ticket collectors at turnstiles).

**Hazard** - anything which has the potential to cause harm to members of the visiting crowds. This could be (a dangerous property of) an item or a substance, a condition, a situation or an activity.
| **Public venue** | a place which opens to members of the public and where people assemble. It could be indoor or outdoor, purpose built or adapted, permanent or temporary, fixed or transient. |
| **Public venue owner** | a person or an organisation which owns the public venue and/or can legally seek to control the number of people entering it and the activities within it. |
| **Risk** | the likelihood that the harm from a hazard is realised and the extent of it. In a risk assessment, risk should reflect both the likelihood that harm will occur and its severity. |
8. Risk assessment is a process which helps employers to systematically identify the problems present, estimate the size of the problems and decide what actions need to be taken. Many public venue owners already carry out some form of risk assessment during the course of their operations. They will monitor the situation, recognise the problems and introduce corrective measures. The MHSWR however requires that they should undertake a systematic examination of their venues and record all significant findings.

9. The HSE booklet *Five steps to risk assessment* sets out what an employer needs to do to assess risks:

(a) identify the hazards;
(b) decide who might be harmed and how;
(c) evaluate the risks arising from the hazards and decide whether existing precautions are enough;
(d) record all significant findings; and
(e) review and revise the assessment from time to time.

10. Risk assessment is not a stand-alone process. Rather, it is an integral part of planning to ensure the smooth running of the venue. Its findings could help venue owners to create policies, to decide what to do, to set performance standards and to allocate resources.
WHO SHOULD CARRY OUT RISK ASSESSMENT?

11. The public venue owners are legally responsible for ensuring that a suitable and sufficient risk assessment has been carried out. They are also responsible for ensuring that risks posed by other operations which take place in their venue are properly assessed.

12. The venue owners may appoint one or more of their employees as assessors to assist in carrying out this duty and to co-ordinate all safety matters. They may also enlist help from elsewhere. However, this does not absolve them from their legal duty. Ultimately, the responsibility rests with the venue owners.

Appoint competent assessors

13. The assessors appointed by the venue owners should be competent. In general, they should:

(a) understand the venue and the operation;
(b) have sufficient experience and knowledge on the crowd safety issues involved;
(c) understand the principles of risk assessment and be able to apply this knowledge to assess crowd safety risks; and
(d) have a willingness and ability to supplement existing experience and knowledge.

14. In order to carry out a proper assessment, the assessors will require adequate training, time and resources from the venue owners.

Team effort

15. A crowd safety risk assessment may be carried out by individual assessors on their own or by a team of assessors. In the view of the HSE, however, a team approach
is usually more desirable. The advantage of a team approach is that the assessment can draw on the range of knowledge, experience and viewpoints of the team members.

16. There are no fixed rules about how the assessment team should work but experience suggests a structured brainstorming (i.e. a group discussion which encourages uninhibited expression of views) could be useful.

17. The appointment of a competent person to chair the meeting is vital to the success of the team approach. The role of the chairperson is to control and guide the team through the assessment.

18. The size of the assessment team could vary from venue to venue. As a rule of thumb, it should have enough people to answer the majority of the queries that could arise in the assessment.

19. Therefore, for an existing public venue, the assessment team would normally consist of:

(a) the person(s) who is responsible for venue operation and safety, understands the overall situation and is in a position to make most decisions; and
(b) appropriate members of the front line staff - they deal with the visiting crowds and therefore know what actually happens on the ground. They also have in-depth knowledge and first hand experience of what problems could arise.

20. For a brand new venue or one which is going through significant changes, it is often useful to carry out a preliminary assessment at the initial design stage to examine the main features. A detailed assessment can be carried out later on when the venue is closer to its completion. The assessment team would normally consist of:
(a) representatives of the venue owner who will be responsible for operating the venue and can contribute by identifying operational problems posed by the design; and
(b) representatives of the designer organisations who have the technical expertise to suggest design solutions and to comment on their costs and feasibility.

Who else should be involved?

21. At some points in the assessment, it may be necessary to involve others from both within and outside the organisation. It is up to the venue owner to decide how they should be involved (e.g. as a member of the assessment team, to participate in parts of the assessment or to co-ordinate and exchange information only when necessary). The following are examples of those who may be involved in the risk assessment:

(a) other departments within the organisation where some of the front line staff belong (e.g. catering);
(b) the emergency services;
(c) the promoter(s) or organiser(s) of the event to be held in the venue;
(d) major tenants (e.g. in a shopping centre or a transport venue);
(e) operators of the transport systems used by many visitors;
(f) the local authority planning or environmental health department;
(g) specialists who can provide the necessary technical input to the assessment (e.g. where fireworks, lasers or other special effects are used).
A PROTOTYPE METHODOLOGY FOR ASSESSING CROWD SAFETY RISKS IN PUBLIC VENUES

AN OVERVIEW OF THE CROWD SAFETY RISK ASSESSMENT METHODOLOGY

22. The methodology presented here is designed specifically for the assessment of crowd safety risks in public venues. It shares the same principles as general health and safety risk assessment - i.e. you need to think about what problems could arise in your venue, what causes them, who might be harmed and how, whether the existing precautions are enough and, if not, what more should be done.

23. Figure 1 gives an overview of the assessment methodology which consists of seven steps. They are essentially the same as the five assessment steps set out in the HSE booklet *Five steps to risk assessment* (see paragraph 9). The only difference is that the third step in the booklet (i.e. “evaluate the risks arising from the hazards and decide whether existing precautions are enough”) has been broken down into Steps 3 to 5 in this document.

24. **Step 1: Identify hazards** - For each part of your venue, look for any problems that could arise from the venue design, the behaviour of the visitors, your crowd management arrangements and things that are hazardous in nature. Also think about what could happen should your normal operation be disrupted or in case of an emergency. There are some keywords later on in Table 1 of this document to help you to identify potential problems.

25. **Step 2: Identify causes, consequences and who might be harmed** - Find out what causes the problems. Decide how people might be harmed and whether anyone is particularly vulnerable.
26. **Step 3: Decide whether existing precautions are adequate** - Look at what precautions you already have in place and ask yourself whether they are enough or more should be done.

27. **Step 4: Evaluate risks** - It is likely that you have identified problems that are still not properly controlled. But before deciding what to do, you need to first of all find out how serious these problems are. For each problem, think about how likely it is that people will be harmed and how severe the harm is. There is a complete risk rating scheme in this document to help you to estimate the likelihood, the severity and, eventually, the risk posed by a problem.

28. **Step 5: Decide what further actions might be required** - Decide what you need to do to get rid of the problems or, at least, reduce their risks. Think about how serious the problems are. Your course of action needs to be appropriate to the risks of the problem it is intended to tackle.

29. **Step 6: Record assessment findings** - If you have five or more employees, you are required by law to record all significant findings of your assessment. There is a risk assessment record form in Appendix A, which you can use to write down what you have found in each assessment step.

30. **Step 7: Review and revise assessment** - The law also requires you to review and, if necessary, revise your assessment. Usually, you will need to do this once a year or if there is a significant change in venue design, management procedures or the circumstances.

31. You can carry out Steps 1 to 5 on each hazard in turn or identify all the hazards first (Step 1) and then do Step 2 then Step 3 and so on. Both approaches are equally valid. The rest of this document takes you through each assessment step in detail. Where specific advice is given in support of the methodology, it is included in an Inset. **Examples** are also provided to show how the methodology could be applied in practice.
Owners of similar venues or features

32. If you are responsible for a number of similar venues (e.g. railway stations) or if your venue contains a number of similar features (e.g. rides in an amusement park), you might produce a basic “model” risk assessment reflecting the core hazards and risks. This can then be applied by managers at each venue or by supervisors at each feature, but only if they:

(a) are satisfied that the “model” assessment is broadly appropriate to their venues or features; and

(b) adapt the model to the detail of the actual situations in their venues or features, including any extension necessary to cover hazards and risks not referred to in the model.
Figure 1: An Overview of the Crowd Safety Risk Assessment Methodology

<table>
<thead>
<tr>
<th>ASSESSMENT STAGES</th>
<th>ASSESSMENT PROCESS</th>
<th>PARAGRAPHS IN THIS GUIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect information for your assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break down the venue into more manageable areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify crowd safety hazards in normal operation conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Look for possible disruptions to the normal operation and identify hazards in those situations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify causes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify consequences and who might be harmed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify the precautions already in place and consider how effective they are</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decide whether the precautions are enough</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimate likelihood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimate severity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Establish the risk level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decide what more could be done to reduce the risk further</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If there is more than one set of possible solutions, decide which is the best option</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow up your actions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEP 6: Record Assessment Findings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEP 7: Review and Revise Assessment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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STEP 1: IDENTIFY HAZARDS

33. The aim here is to identify systematically all significant hazards that could arise in your venue. You may already be aware of some hazards. But it is also important to identify hazards that are not immediately apparent - for example, a latent hazard or a new hazard which arises due to, say, the introduction of a new feature. Any hazards that are not identified here will not be addressed and thus leave a gap in the risk assessment.

Collect information for your assessment

34. Involve your front line staff. They might have noticed things that are not immediately obvious to you. Also, they might help to reveal what actually happens on the ground. At the very least, you should ask them what they think. However, it is much better to include them as part of the assessment team. For a major venue, you may need to carry out some form of brainstorming session (see paragraphs 15 - 21). For a smaller venue, sit down with one or two experienced members of the front line staff and systematically go through each part of your venue.

35. It is also useful to carry out a venue inspection and to observe the crowds. This allows you to look afresh at what could cause harm. You could also find useful information from sources such as past incident records, video recordings, written comments from the front line staff, customer complaints, safety audit reports, notes made in debriefing sessions and post-event reports.

Break down the venue into more manageable areas

36. It may be difficult to assess the whole venue at once especially if the venue is large. Therefore, it is worth breaking it down into a number of smaller areas first and then examining each area in turn. You can do so based on the main function for which each area is used (i.e. into functional areas) or in accordance with any system already in use to distinguish different parts of the venue.
For example: An airport terminal can be broken down into the following functional areas: access routes to and from public transport facilities and car park(s); forecourt; check-in area; concourse; passport control; departure lounge; gate rooms; etc.

A shopping complex may have already been divided into several zones. They could also be used for the purpose of the risk assessment.

Identify crowd safety hazards in normal operation conditions

37. Crowd safety hazards often arise from the following factors: the design of your venue, visitors’ behaviour, your crowd management arrangements and the presence of hazardous substances or items. You need to think about them carefully and look for things that could go wrong.

38. Table 1 gives a set of “hazard keywords” to help your hazard identification. It summarises the types of hazards that could occur due to the above factors. Appendix B explains the meanings of the keywords - you can pull it out from this document for use.

39. To identify hazards systematically, you need to go through each area of your venue and examine every part of it (i.e. the layout, places where people gather, the access routes and other features such as entry/exit points, stairs and escalators, barriers and railings, furniture, facilities and so on). Ask yourself the following five questions:

(a) What hazards could each venue feature pose?
(b) Who are the visitors and what might they do that could cause a problem?
(c) Are there any shortcomings in your crowd safety management arrangements and what hazards could arise a the result? (e.g. unclear roles and responsibility; breakdown in command and communication; lack of co-operation and co-ordination with other relevant bodies; insufficient
monitoring of crowds; low staffing levels and inadequate selection and training.)

(d) Are there any **hazardous substances or items** in or near the area (see paragraphs 45 and 46)?

(e) What are the **interactions between different areas**? (e.g. a problem in an adjacent area could have a knock-on effect here or vice versa.)

40. Use the keywords as prompters to find out what hazards could take place there. Then, describe in your own words what you have identified and write them down in the assessment record form in Appendix A. Inset 1 gives a step-by-step example of how this can be done.

### Table 1: Keywords for Hazard Identification

<table>
<thead>
<tr>
<th>HAZARD KEYWORDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>crowding/congestion</td>
</tr>
<tr>
<td>obstruction to crowd movement</td>
</tr>
<tr>
<td>cross flows</td>
</tr>
<tr>
<td>rapid crowd movement or rushing</td>
</tr>
<tr>
<td>pushing/surging</td>
</tr>
<tr>
<td>vigorous movement in a stationary crowd</td>
</tr>
<tr>
<td>trip, slip or stumble</td>
</tr>
<tr>
<td>fall</td>
</tr>
<tr>
<td>walk into/pushed against an object</td>
</tr>
<tr>
<td>hit/struck by an object</td>
</tr>
<tr>
<td>people get trapped or stuck</td>
</tr>
<tr>
<td>topple</td>
</tr>
<tr>
<td>non-compliance</td>
</tr>
<tr>
<td>dangerous behaviour</td>
</tr>
<tr>
<td>aggressive behaviour or disorder</td>
</tr>
<tr>
<td>hazardous substance or item</td>
</tr>
</tbody>
</table>
Inset 1: A step-by-step example of a systematic hazard identification

(a) Divide the venue into smaller areas and assess each one in turn. For the purposes of this example, the area being assessed is the forecourt of a fictitious venue (see diagram below).

(b) Look at each part of the area. In this example, we have:
- the northern pedestrian access route with a flight of stairs and a taxi rank alongside
- the southern pedestrian access route with a ramp for disabled access
- the forecourt itself which has two large plant pots and bollards at the front, toilets, stalls and the ticket counters with tape barriers in front.
- the entry/exit point with barriers and a gate for disabled and emergency access.

(c) Examine each of the above features. Apply the hazard keywords in Table 1 and see what hazards could arise there. Don’t forget a safety hazard could arise from the venue itself, the visitors, the ways you manage the arriving/leaving crowds and substances or items which are hazardous in nature.

For example: Starting from the far end of the northern pedestrian access, the first feature is a flight of stairs. Go through the keywords and decide which of them is applicable. The following hazards could be identified:
- Congestion as people slow down at the top of the stairs.
- People could trip on the stairs.

Further along the access route, there is a taxi rank and then a large plant pot. Apply the keywords again and you might think of the following:
Inset 1: A step-by-step example of a systematic hazard identification (cont.)

- In the afternoon/evening, people stopping for a taxi could obstruct crowd flows.
- The plant pots obstruct movement and cause congestion during busy periods. Part of the crowd spill onto the adjacent road and could be hit by moving vehicles.

Move on to the next part and do the same until you have examined the whole forecourt.

(d) Describe in your own words what the hazards are and write them down on the assessment record form (see Example 1). In here, only the northern access route and the forecourt itself have been examined.

A few notes about the use of the “hazard keywords”

41. The keywords are here only to prompt you and to structure the hazard identification process so that it is systematic. They are not meant to be exhaustive. You can add your own keywords to the lists, remove those which you think are irrelevant and refine them to meet your needs.

42. The keywords are designed to account for hazards in all kinds of public venues. Therefore, some may not be applicable to your venue. Don’t be surprised if you can’t think of anything from a keyword. Just ignore it and move on to the next one.

43. On the other hand, you may identify the same hazard from different keywords. You only need to record it once. The main thing is to identify the hazards - which keyword you use to do so is unimportant.

For example: The fourth entry in Example 1 above could be identified from the keyword "congestion", "obstruction" or "hit". The fifth entry could be identified from either "fall" or "dangerous behaviour".

44. Do not apply the keywords rigidly and do not let them restrict your thoughts. Just write down whatever hazards you can think of from the keywords even though it does not seem the right place. You may have also identified the immediate cause...
of a hazard here. Write it down as well (see Example 1). The aim here is to identify all significant hazards and causes. Again, where or how they are identified is not important.

**Example 1 (using the suggested assessment form shown in Appendix A):**

**CROWD SAFETY RISK ASSESSMENT RECORD FORM**

<table>
<thead>
<tr>
<th>Area: Forecourt</th>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences &amp; Who Might Be Harmed</th>
<th>Existi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion at the top of the stairs</td>
<td>People slow down at the top of the stairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People could trip on the stairs</td>
<td>In the afternoon/evening, people stopping for a taxi could obstruct crowd flows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part of the crowd on the northern access spill onto the adjacent road and could be hit by moving vehicles</td>
<td>The plant pots obstruct movement and create congestion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People could fall down from the bollard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crowd movement obstructed by people waiting outside the toilets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross flows near the toilets.</td>
<td>People cut through the crowd to get to the toilets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queues in front of the ticket counters sometimes extend beyond the tape barrier and obstruct movement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People pushed against unguarded hot food equipment at one of the stalls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hazardous substances or items**

45. Your operation may involve the use and storage of substances or items which are hazardous in nature. A keyword “hazardous substance or item” has already been included in Table 1. But first of all, you need to identify what they are and where they are used and stored. The following are examples of the kinds of substances and items which could create hazards in a public venue:
(a) substances which are hazardous to health and are covered by the Control of Substances Hazardous to Health Regulations 1994 (COSHH) (e.g. substances that are toxic, corrosive or irritant; have maximum exposure limits or occupational exposure standards; have chronic or delayed effects; and biological agents)

(b) machinery (e.g. escalators, turnstiles, ticket machines, rides in a fairground, etc.)

(c) electrical equipment, electric cables, generators, etc.

(d) fireworks, special effects in a place of entertainment or a show (e.g. laser), etc.

(e) open fire/naked flame (e.g. at a stall selling hot food), hot spots, etc.

(f) moving objects (e.g. vehicles, trolleys, etc.)

46. When deciding what hazards the substance or item could pose, think about where, when and how it is used. Take into account any possible human errors by staff who handle and maintain the substance or item. Also think about visitors' behaviour (see the last entry in Example 1). Manufacturers’ instructions or data sheets and accident records can also help you to spot hazards and to put risks in perspective.

Look for potential disruption to the normal operation and identify hazards in those situations

47. The aim is to consider how your venue operation could be disrupted and what new hazards could arise as a result. A major disruption such as a major fire would call for a complete change of the mode of operation (e.g. from normal operation to an evacuation) thus introducing new hazards. Even a relatively minor disruption such as a train delay or cancellation could exacerbate a problem or turn the trivial into a significant hazard.

48. First, identify the scenarios which could disrupt your operation. The following are some examples:
(a) accident (e.g. traffic accident outside or within the venue)
(b) closure of a part of the venue
(c) closure of a nearby or related venue (e.g. the closure of an adjacent train station)
(d) delay or cancellation (e.g. flight delay, late kick-off in a football match)
(e) disruption to the arrival/departure profile (e.g. severe traffic congestion on a main approach road)
(f) emergency situation (e.g. a fire, bomb threat, structural collapse, toxic release, etc.)
(g) loss of utility (e.g. power cut)
(h) public disorder
(i) system or equipment failure (e.g. escalator stops, a jammed door or gate, etc.)
(j) weather (e.g. a sudden change of weather and adverse weather condition such as too hot/cold, heavy rainfall/snowfall, high wind, etc.)

49. For a minor disruption which causes a slight deviation in parts of the venue, hazard identification could be relatively straightforward to do. Simply think about what effects each relevant scenario could have on the venue operation, on crowd movement, on people’s behaviour and on the substances and items used. Then identify the problems which could arise as a result (see Example 2).

Example 2:

CROWD SAFETY RISK ASSESSMENT
RECORD FORM

Area: Forecourt

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences &amp; Who Might Be Harmed</th>
<th>Exist...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion on access route to the escalators.</td>
<td>Escalator(s) fail.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A last minute rush.</td>
<td>A severe traffic problem due to roadworks on one of the main approach roads to the venue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
50. A detailed assessment would be necessary in the case of a major disruption where the operation required to ensure safety is very different from the normal operation. The assessment would involve repeating the hazard identification process described in paragraphs 33 - 40 and Inset 1 for each emergency scenario.

51. Write down what you have identified. You need to indicate on the assessment record form the scenario you are considering (see Example 3).

Example 3:

CROWD SAFETY RISK ASSESSMENT
RECORD FORM

Scenario: A fire at the store room behind the Entrance
Area: Forecourt

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences &amp; Who Might Be Harmed</th>
<th>Exist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assess route and the entrance are blocked by the fire</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>People still arriving at the entrance and walk into the affected area.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Certain chemical in the store room could release fumes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trip or stumble, people walk into things, etc.</td>
<td>Electric cable could be damaged and lighting could be affected</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Venue: A fictitious venue
Assessment Date: January
Assessor: J Smith
Signed:
STEP 2: IDENTIFY CAUSES, CONSEQUENCES AND WHO MIGHT BE HARMED

52. The aim of this step is to find out what causes the hazards identified in STEP 1. what danger they could pose and who might be affected. Knowing the cause(s) could help you to decide later in the assessment process what actions are needed to get rid of the hazards. The identification of consequences and who might be harmed could help you to decide how to protect people against the harm and to estimate risks. (see Example 4)

Identify causes

53. You may have already found the immediate causes earlier on in STEP 1. But don’t stop there - there could well be other (underlying) causes that are equally important.

54. It is worth emphasising again that a hazard could arise from a combination of reasons: the venue design, the visitors and their behaviour, the crowd management arrangements and the presence of hazardous substances or items. Some causes may not be obvious. Congestion, for example, could be the result of an object obstructing crowd flows, insufficient capacity or the existence of a pinch point (i.e. venue design), too many people waiting or hanging around in the area (i.e. behaviour) and most people being directed to use this area (i.e. crowd management). Also, it could be because of a problem elsewhere in the venue or what happens in another place (e.g. crowds leaving a nearby football match).

55. If the hazard is caused by visitors’ behaviour, you also need to know why people behave in such a way. The chance is you will not find a satisfactory solution if you simply dismiss this as the fault of the visitors!

56. If a hazard is due to poor crowd management, you may have to look beyond the immediate issues listed in paragraph 39 (c). Think about the more “global” safety management issues (e.g. policy, safety culture, etc.) and ask yourself whether you
have done enough. You can find out more about safety management systems in the HSE publication *Successful Health and Safety Management* and the HSE booklet *Five Steps to Successful Health and Safety Management* (see FURTHER READING).

### Example 4:

**Area:** Forecourt

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences &amp; Who Might Be Harmed</th>
<th>Existing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion at the top of the stairs</td>
<td>• People slow down at the top of the stairs.</td>
<td>People being pushed/fall down the stairs. Could be trampled. Young children and the old are particularly vulnerable.</td>
<td></td>
</tr>
<tr>
<td>People could trip on the stairs</td>
<td>• Some young people try to push their way through the crowds.</td>
<td>People being pushed/fall down the stairs. Could be trampled.</td>
<td></td>
</tr>
<tr>
<td>In the afternoon/evening, people stopping for a taxi could obstruct</td>
<td>• Inadequate lighting.</td>
<td>Overcrowding in the area and some minor crushing.</td>
<td></td>
</tr>
<tr>
<td>crowd flows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part of the crowd on the northern access spill onto the adjacent road</td>
<td>• The plant pots obstruct movement.</td>
<td>People get knocked down by vehicles.</td>
<td></td>
</tr>
<tr>
<td>and could be hit by moving vehicles</td>
<td>• During peak hours, the number of people using the access route exceed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Almost everyone uses this route because of the locations of the</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>car parks, coach park and bus stop. Car park 4 is used as an over-spill</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>car park only.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>People could fall down from the bollard</td>
<td>• People, especially children and teenagers tend to climb and stand on</td>
<td>Falling injuries. Usually a twisted ankle, etc. but could be much worse. Mainly children and teenagers.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the bollard.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crowd movement obstructed by people waiting outside the toilets</td>
<td>• People waiting for others.</td>
<td>Exacerbates the congestion in this area.</td>
<td></td>
</tr>
<tr>
<td>Cross flows near the toilets.</td>
<td>• The position of the toilets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queues in front of the ticket counters sometimes extend beyond the</td>
<td>• People cut through the crowd to get to the toilets.</td>
<td>Severe congestion, pushing and even some minor crushing; especially when wheelchair users, prams or people carrying</td>
<td></td>
</tr>
<tr>
<td>tape barrier and obstruct movement</td>
<td>• Many people do not see the toilets at first. They go past them and</td>
<td>large items are involved.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>then turn around.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>People pushed against unguarded hot food equipment at one of the stalls</td>
<td>• Not enough counters.</td>
<td>Severe congestion and some pushing.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Only a small number of visitors buy tickets in advance.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Queues are not properly managed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Crowding and cross flows in the area.</td>
<td>Severe burns. Toddlers and young children are particularly vulnerable due to their height.</td>
<td></td>
</tr>
</tbody>
</table>
Identify consequences and who might be harmed

57. Think about how people might be harmed, how many may be affected (i.e. whether the hazard would harm the individuals directly involved or many more in the vicinity) and whether any visitor groups are particularly vulnerable. Vulnerable groups may include disabled persons, young children and elderly people. They are often more likely to be harmed or are likely to suffer more when harmed.
STEP 3: DECIDE WHETHER EXISTING PRECAUTIONS ARE ADEQUATE

Identify the precautions already in place

58. Some hazards may already be controlled in some way, whether by deliberate measures (e.g. by venue design, safety devices (such as barriers), crowd management measures or operational procedures) or by the circumstances in which they are found. The aim is therefore to identify the precautions and decide whether they are adequate or whether more should be done.

59. Think about how effective the existing precautions are. Again, you need to look at how they actually work, not how they are supposed to work. Also consider how your precautions may fail or become less effective. You could get caught out if you automatically assume that they would always work as intended!

For example: The circumstances could change as a result of an incident elsewhere. Venue features and engineered devices could suffer from vandalism, wear and tear, component failures, etc.

Crowd management measures and procedures could be hindered by equipment failures, human errors, breakdown in communications, confusion in roles and responsibilities and so on.

Decide whether the precautions are enough

60. In order to decide whether the existing precautions are enough, you will need to do a preliminary risk evaluation. For example, if after the existing precautions the risk is trivial or if it is no greater than exists in a similar everyday situation, you can say that it is adequately controlled and no further action will be needed. You can then ignore this hazard and exclude it from the rest of the risk assessment. Otherwise, the hazard is still significant and you need to evaluate it in detail (see STEP 4).
61. A trivial risk is one which is extremely remote (i.e. it has never happened before and there are no reasons whatsoever to suggest that it will ever happen) or does not cause any real harm (i.e. no more than inconvenience, discomfort, frustration and so on).

62. When deciding how the risk compares with that in an everyday situation, you should compare like with like. You cannot ignore a hazard on the grounds that its risk compares favourably with that involved in, say, a dangerous sport!

For example: In a street event, the pavement kerb could pose a tripping hazard. But, you could ignore it on the grounds that the risk is no more than that arising from walking along the high street on a normal Saturday afternoon.

If the crowd density is much higher than that on the normal high street, so will be the risk. One reason for this is that people may not see the kerb. Therefore, the above argument is no longer valid and this hazard should be evaluated further.
STEP 4: EVALUATE RISKS

63. The aim is to decide for each significant hazard how much risk still remains after the existing precautions have been taken. The findings will enable you to establish how significant the hazards are and thus to prioritise any remedial actions required to control them. The evaluation of risk usually involves the following steps:

   (a) decide how likely the hazard is to be realised (i.e. estimate the likelihood);
   (b) decide how serious the harm is should the hazard be realised (i.e. estimate the severity); and
   (c) establish the level of risk based on the above.

Estimate likelihood

64. When estimating likelihood, it is important that you consider how likely the hazard is to occur and to cause harm, not just how likely it is to occur. This is because not all hazards cause harm all the time; the potential for a hazard to cause harm is realised only under some circumstances. In a risk assessment, we are only interested in the likelihood of someone being harmed.

For example: Cross flows and obstructions do not normally give rise to a significant problem unless they take place in a busy area.

65. In many cases, whether people have been harmed by a similar hazard in the past could give you some idea as to how likely it is to occur and to cause harm. For example, if a similar hazard had occurred several times before despite the existing precautions, the chance is it is “likely” (see definitions in Table 2) to happen again. If it occurred only once or twice before, it is probably still “possible” to happen in the future. However, you must remember that a hazard which has never happened before does not mean it will never happen. How likely something is to happen does not necessarily relate to its past history. For instance, a new hazard could be introduced following a change in venue design, visitor profile, operational procedures or the circumstances.
Estimate severity

66. When estimating severity, you need to take into account the circumstances under which the hazard takes place.

For example: If people climb up to a height, the seriousness of the injury should they fall, will depend on how high they manage to climb. Also, more people would be injured if this behaviour takes place where there is a packed crowd underneath.

The severity (and the likelihood of an injury) of people mingling with moving vehicles will depend on whether it takes place on a busy main road with fast moving traffic or on a quiet side road where the vehicles move slowly.

Establish the risk level

67. You can find out the risk level of a hazard based on its estimated likelihood and severity. Inset 2 gives a step-by-step description on how to evaluate risk.

68. Please note that Inset 2 is given as one possible approach only. You can modify the likelihood categories, the severity categories and the number of risk levels to meet your specific needs. However, at the very least, you need to be able to decide whether the risks are intolerable, should be kept as low as reasonably practicable or are broadly acceptable.
Inset 2: A step-by-step approach to risk evaluation

(a) To estimate likelihood, select a Likelihood Category (LC) from Table 2 which can best describe how likely the hazard is to be realised. Bear in mind the history of a similar hazard.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likely (L)</td>
<td>It could reasonably be expected to happen in the foreseeable future.</td>
</tr>
<tr>
<td>Possible (P)</td>
<td>There are reasons to suggest that it could happen.</td>
</tr>
<tr>
<td>Unlikely (U)</td>
<td>Could occur under exceptional circumstances.</td>
</tr>
<tr>
<td>Very Unlikely (VU)</td>
<td>There are no reasons to suggest that it will happen.</td>
</tr>
</tbody>
</table>

(b) To estimate severity, select a Severity Category (SC) from Table 3 which can best describe how serious the consequence will be should the hazard be realised.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic (Ca)</td>
<td>Multiple deaths/life threatening injuries.</td>
</tr>
<tr>
<td>Major (Ma)</td>
<td>A single death/life threatening injury OR injuries to a number of people who require hospitalisation.</td>
</tr>
<tr>
<td>Significant (Si)</td>
<td>A single injury which requires hospitalisation OR injuries to a number of people who require first-aid treatment.</td>
</tr>
<tr>
<td>Minor (Mi)</td>
<td>A single injury which may require some first-aid treatment; visitors feel anxious and are concerned about their safety.</td>
</tr>
<tr>
<td>Negligible (Ne)</td>
<td>No real harm; no more than inconvenience, discomfort, frustration, etc..</td>
</tr>
</tbody>
</table>

(c) From the selected likelihood category and severity category, you can establish the risk level of the hazard from the matrix given in Table 4.

<table>
<thead>
<tr>
<th></th>
<th>Likely</th>
<th>Possible</th>
<th>Unlikely</th>
<th>Very Unlikely</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Catastrophic</strong></td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>-</td>
</tr>
<tr>
<td><strong>Major</strong></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>-</td>
</tr>
<tr>
<td><strong>Significant</strong></td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>-</td>
</tr>
<tr>
<td><strong>Minor</strong></td>
<td>C</td>
<td>D</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Negligible</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

See Example 5
**Example 5:**

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Existing Precautions</th>
<th>LC</th>
<th>SC</th>
<th>Risk</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion at the top of the stairs</td>
<td></td>
<td>P</td>
<td>Si</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>People could trip on the stairs</td>
<td></td>
<td>P</td>
<td>Si</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>In the afternoon/evening, people stopping for a taxi could obstruct crowd flows</td>
<td></td>
<td>P</td>
<td>Si</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Part of the crowd on the northern access spill onto the adjacent road and could be hit by moving vehicles</td>
<td></td>
<td>P</td>
<td>Ma</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>People could fall down from the bollard</td>
<td></td>
<td>P</td>
<td>Si</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Crowd movement obstructed by people waiting outside the toilets</td>
<td></td>
<td>U</td>
<td>Si</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Cross flows near the toilets.</td>
<td></td>
<td>U</td>
<td>Si</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Queues in front of the ticket counters sometimes extend beyond the tape barrier and obstruct movement</td>
<td></td>
<td>VU</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>People pushed against unguarded hot food equipment at one of the stalls</td>
<td></td>
<td>L</td>
<td>Ma</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>
STEP 5: DECIDE WHAT FURTHER ACTIONS MIGHT BE REQUIRED

Decide what more should be done

69. First of all, ask yourself:

(a) whether you have done all the things that the law says you have got to do; and
(b) whether generally accepted standards are in place.

The law also says that you must do what is reasonably practicable to keep the venue safe. Therefore, your real aim is to make the risks as small as possible by adding to your precautions if necessary.

70. The actions you identify here should be realistic, i.e. there is a good chance that the actions can be implemented, not a wish list. Table 5 suggests the appropriate courses of action for each risk level. Priority should be given to hazards which pose the higher risks.

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Intolerable risk. Immediate action(s) must be taken to eliminate the hazard or to eliminate its source, regardless of the cost.</td>
</tr>
<tr>
<td>B</td>
<td>Should not be tolerated unless risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained.</td>
</tr>
<tr>
<td>C</td>
<td>Should not be tolerated unless the cost of risk reduction exceeds the improvement gained.</td>
</tr>
<tr>
<td>D</td>
<td>Broadly acceptable risk. But risk reduction should still be made if an inexpensive measure can be found.</td>
</tr>
<tr>
<td>-</td>
<td>Trivial risk. No further actions required.</td>
</tr>
</tbody>
</table>

71. There are no hard and fast rules for deciding whether the risk reduction cost is grossly disproportionate to or exceeds the improvement gained. You need to use your own judgement. To put things in perspective, it is often useful to think about
the costs of failing to take the necessary precautions. Apart from personal suffering, the costs may also include compensation payments, insurance costs, adverse publicity, loss of revenue, possible prosecution and other effects on your company’s viability.

72. Secondly, consider whether it is possible to get rid of the hazard altogether. This can usually be achieved by removing the source of the hazard or by tackling its causes. If this is not “reasonably practicable” to do, then think about how to control the risk (i.e. to make it less likely to occur or to cause harm, to reduce its severity and/or to protect people against the harm). Guidance on specific areas (e.g. COSHH) and good practices by other venues could help you to identify the remedial actions required.

Select the best course of action

73. If there are several possible actions, you may have to examine them in more detail to decide which of them to take. In general, you need to think about the level of risk posed, how effective the actions would be in controlling the risk, whether they could give rise to a problem elsewhere, how soon they can be put in place and whether the hazard needs to be addressed urgently or whether it is better to wait for a more permanent solution. You can of course also take into consideration related cost-benefit factors such as the costs of taking those actions and how they may affect things like visitors’ enjoyment and the attractiveness of the venue.

74. Keep a record of what you have decided. If you believe that no actions are needed, write down the reasons. (see Example 6)

Follow up your actions

75. Once you have decided what to do, you need to make sure that the actions are implemented and are done properly. For instance, you need to decide who should be responsible for carrying out each action. You may also need to set a deadline
and to keep a record of the progress. You can pull out the "Follow-up Form" in Appendix C and use it to monitor the progress of the actions.

**Example 6:**

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Precautions</th>
<th>LC</th>
<th>SC</th>
<th>Risk</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion at the top of the stairs</td>
<td>P</td>
<td>Si</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>People could trip on the stairs</td>
<td>P</td>
<td>Si</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In the afternoon/evening, people stopping for a taxi could obstruct crowd flows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part of the crowd on the northern access spill onto the adjacent road and could be hit by moving vehicles</td>
<td>P</td>
<td>Ma</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>People could fall down from the bollard</td>
<td>P</td>
<td>Si</td>
<td>C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crowd movement obstructed by people waiting outside the toilets</td>
<td>U</td>
<td>Si</td>
<td>D</td>
<td></td>
<td>no inexpensive action identified to reduce risk</td>
</tr>
<tr>
<td>Cross flows near the toilets.</td>
<td>U</td>
<td>Si</td>
<td>D</td>
<td></td>
<td>could relocate the toilets but the cost of doing so outweighs the improvement gained. Therefore, put up signs at the front of the forecourt.</td>
</tr>
<tr>
<td>Queues in front of the ticket counters sometimes extend beyond the tape barrier and obstruct movement</td>
<td>manage queues</td>
<td>VU</td>
<td>-</td>
<td>-</td>
<td>no action required</td>
</tr>
<tr>
<td>People pushed against unguarded hot food equipment at one of the stalls</td>
<td>L</td>
<td>Ma</td>
<td>A</td>
<td></td>
<td>carry out inspection to ensure that all such equipment is adequately guarded. relocate traders to another part of the venue closely monitor crowd flows and control access into this area when necessary. stewards should discourage such &quot;lively&quot; behaviour in this area.</td>
</tr>
</tbody>
</table>
STEP 6: RECORD ASSESSMENT FINDINGS

76. If your undertaking has five or more employees, you are required by the MHSWR to record the significant findings of your assessment. You should be able to show, through the record, that you have undertaken a suitable and sufficient assessment and that you have done what is reasonably practicable to reduce the risks. Significant findings usually include:

(a) the significant hazards identified in the assessment;
(b) the existing precautions in place;
(c) the remaining risks, including any groups of visitors who are especially at risk;
(d) the conclusions of the assessment, including the actions you have identified to further reduce the risks.

The record could be documented in writing or by other means (e.g. electronically) so long as it is retrievable for use by management or for examination (e.g. by enforcing authority inspectors).

77. Some hazards may have already been addressed elsewhere. For example, if hazardous substances are used, your COSHH assessment should have addressed the risks. Also, some of the existing precautions may have already been described in other documents (e.g. procedures). There is no need to repeat this information in the record - you can simply refer to where it can be found.

78. Keep the record for future reference or use. It helps to show that you have done what the law requires and can therefore help you if an inspector questions your precautions or if you become involved in any legal action (e.g. for civil liability). It can also remind you to keep an eye on particular concerns. Appendix A shows the crowd safety risk assessment record form used throughout this guide. You may find it useful. Alternatively, you can develop your own form or record your assessment in another format if that suits you better.
STEP 7: REVIEW AND REVISE ASSESSMENT

79. Risk assessment is not a once-and-for-all activity. You are required under the MHSWR to review your assessment and, if necessary, revise it if there are developments which suggest that your assessment may no longer be valid, such as:

(a) a significant change to your venue, in visitor composition, in management procedures, or outside influences (e.g. new activities nearby, renewed terrorist threats);
(b) the detection of a significant problem; or
(c) the occurrence of a major incident or a potentially serious near miss.

In any case, it is good practice to review your assessment at regular intervals (e.g. annually) and record any amendments you have made. Even if there are no changes, it is useful to record that fact to show that you have carried out the review.

80. If your operation concerns the staging of a regular event, ideally you need to start your review shortly after the event has finished. This is so that any problems and incidents which took place in the event are still fresh in people’s minds. In any case, the timing of the review should be such that you have enough time before the next event to implement the new actions identified in the assessment.
FURTHER READING

HSE publications

The following list of publications is only a small selection of those available. A comprehensive list is available from HSE Books. Free leaflets are available from both HSE Books and the HSE Area Offices.


_Five Steps to Risk Assessment_, IND(G)163L (free leaflet)

_Successful Health and Safety Management_, HS(G)65, ISBN 0 7176 0425 X


_Five Steps to Successful Health and Safety Management: Special help for directors and managers_, IND(G)132L (free leaflet)

_Control of Substances Hazardous to Health and Control of Carcinogenic Substances_.

_Control of Substances Hazardous to Health Regulations 1994: Approved Codes of Practice_, L5, ISBN 0 7176 0819 0


_Managing Crowds Safely_, HS(G)154, ISBN 0 7176 1180 9

Publications specific to particular venue types


# CROWD SAFETY RISK ASSESSMENT RECORD FORM

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Causes</th>
<th>Consequences &amp; Who Might Be Harmed</th>
<th>Existing Precautions</th>
<th>Risk Levels</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examine each part/features of your venue and see what hazards could arise. Use the Hazard Keywords in Appendix B (or Table 1).</td>
<td>Find out what causes the hazard. It could be the venue design, the visitors, your crowd management and/or some outside influences.</td>
<td>Ask yourself how people might be harmed, whether it will affect individuals or many people and if any visitor groups are especially at risk.</td>
<td>List existing controls here or note where information may be found. Think about how effective they might be.</td>
<td>Decide how likely the hazard is to occur and to cause harm and its severity. Select a Likelihood Category (LC) from Table 2 and a Severity Category (SC) from Table 3. Then work out the risk level from Table 4.</td>
<td>Decide what you can do to minimize the risks. You will need to give priority to those which have a higher risk level. See Table 5.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LC</th>
<th>SC</th>
<th>Risk</th>
</tr>
</thead>
</table>

**Venue:**
**Assessment Date:**
**Assessor:**
**Page No:**
**Signed:**
**Dated:**
### APPENDIX B: GLOSSARY OF THE HAZARD KEYWORDS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>crowding/congestion</td>
<td>the density of the stationary or moving crowd is such that it has the potential to cause harm, such as crushing and trampling.</td>
</tr>
<tr>
<td>obstruction to crowd movement</td>
<td>the movement of the crowd is completely or partially blocked by an object or by other people.</td>
</tr>
<tr>
<td>cross flows</td>
<td>people heading in different directions through the same area.</td>
</tr>
<tr>
<td>rapid crowd movement or rushing</td>
<td>the speed of the crowd movement is such that it has the potential to cause harm, such as crushing, pile-up and trampling.</td>
</tr>
<tr>
<td>pushing/surging</td>
<td>people push their way through a stationary crowd/a crowd flow or a strong rush within a stationary crowd.</td>
</tr>
<tr>
<td>vigorous movement in a stationary crowd</td>
<td>a strong and massive movement within a stationary crowd, such as swaying or lateral movement, jumping up and down, etc.</td>
</tr>
<tr>
<td>trip, slip or stumble</td>
<td>people catch their feet, lose balance or make a false step on an uneven or slippery surface, a protruding object, a step, etc.</td>
</tr>
<tr>
<td>fall</td>
<td>people fall from a height, off a bank or edge, down a slope or stairs, etc.</td>
</tr>
<tr>
<td>walk into/pushed against an object</td>
<td>people strike themselves against e.g. a protruding object, a sharp object, a pillar or post, a bollard, a doorway, street furniture, etc.</td>
</tr>
<tr>
<td>hit/struck by an object</td>
<td>people receive a blow due to impact with a moving object (e.g. a vehicle), a missile, falling debris, etc.</td>
</tr>
<tr>
<td>people get trapped or stuck</td>
<td>people get caught and are unable to free themselves. For example, children trapped in between railings, wheelchair users are stuck on an uneven surface or in a packed crowd, people get trapped by machinery.</td>
</tr>
<tr>
<td>topple</td>
<td>A structure such as wall or fence, pillar or post, barriers, maintenance or construction work, etc. collapses and falls onto people.</td>
</tr>
<tr>
<td>non-compliance</td>
<td>disregarding the “house-rules” or not following instructions or directions (e.g. entering a restricted or a closed-off area, smoking in a no smoking area, illegal parking, moving in the wrong direction up a one-way system, refusing to move away from the gangway when asked, etc.).</td>
</tr>
<tr>
<td>dangerous behaviour</td>
<td>actions which in themselves could cause harm to oneself and others (e.g. climb up/down/over, jump over, slide or run down a steep slope, etc.).</td>
</tr>
<tr>
<td>aggressive behaviour or disorder</td>
<td>including antagonistic behaviour, fighting, missile throwing, etc.</td>
</tr>
<tr>
<td>hazardous substance or item</td>
<td>any substances or items that are hazardous in nature and could cause harm to people’s health and safety. See paragraphs 45 and 46 for details.</td>
</tr>
</tbody>
</table>
**CROWD SAFETY RISK ASSESSMENT FOLLOW-UP FORM**

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Actions</th>
<th>Who By</th>
<th>Target Dates</th>
<th>Status of the Actions</th>
<th>Completed Dates</th>
</tr>
</thead>
</table>

**Venue:**  
Assessment Date:  
Assessor:  
Reviewed by:  
Signed:  
Review Date:  
Dated:
APPENDIX H

Questionnaire used in the Verification Test
THE DEVELOPMENT OF A METHODOLOGY FOR THE ASSESSMENT OF RISKS TO CROWD SAFETY IN PUBLIC VENUES

VERIFICATION TEST QUESTIONNAIRE

This questionnaire invites your comments on different parts of the “Crowd Safety Risk Assessment Method” and your opinion on how useful and appropriate they are to you. We believe that the new method should be designed to fit the users, not the other way round. Your opinion on the method and your experience in applying it would therefore be a useful indicator of its adequacy.

**Step 1: Identify hazards**

1. Do you have any comments on the new hazard identification method? For example, did you encounter any problems when applying it? Is there anything which you particularly like or dislike? Are the “Hazard Keywords” helpful and are they appropriate to your assessment?

2. In your opinion, how useful is the new hazard identification method? (please tick)

   - Very Useful
   - Useful
   - Fairly useful
   - Not very useful
   - Useless

3. Compared with the method already in use by you/your organisation to identify hazards, do you think the new hazard identification method is

   - Much better
   - Better
   - About the same
   - Worse
   - Much Worse
Step 2: Identify causes, consequences and who might be harmed

4. Do you have any comments on the advice given in this part of the assessment method?

5. In your opinion, how useful is the advice?

   Very Useful  Useful  Fairly useful  Not very useful  Useless

6. Compared with the guidance or advice you/your organisation already has in relation to this step, do you think the advice given in the new method is

   Much better  Better  About the same  Worse  Much Worse

Step 3: Decide whether existing precautions are adequate

7. Do you have any comments on the advice given in this part of the assessment method?

8. In your opinion, how useful is the advice?
9. Compared with the guidance or advice you/your organisation already has in relation to this step, do you think the advice given in the new method is

<table>
<thead>
<tr>
<th>Much better</th>
<th>Better</th>
<th>About the same</th>
<th>Worse</th>
<th>Much Worse</th>
</tr>
</thead>
</table>

Step 4: Evaluate risks

10. Do you have any comments on the new risk evaluation method? For example, did you have any problems when applying it? Is there anything which you particularly like or dislike? Are the likelihood/severity categories and the risk classification scheme given in Inset 2 helpful and are they appropriate to your assessment?

11. In your opinion, how useful is the new risk evaluation method?

<table>
<thead>
<tr>
<th>Very Useful</th>
<th>Useful</th>
<th>Fairly useful</th>
<th>Not very useful</th>
<th>Useless</th>
</tr>
</thead>
</table>

12. Compared with the method already in use by you/your organisation to evaluate risks, do you think the new risk evaluation method is

<table>
<thead>
<tr>
<th>Much better</th>
<th>Better</th>
<th>About the same</th>
<th>Worse</th>
<th>Much Worse</th>
</tr>
</thead>
</table>
Step 5: Decide what further actions might be required

13. Do you have any comments on the advice given in this part of the assessment method? For example, what do you think about the interpretation of different risk levels given in Table 5?

14. In your opinion, how useful is the advice (including Table 5)?

<table>
<thead>
<tr>
<th>Very Useful</th>
<th>Useful</th>
<th>Fairly useful</th>
<th>Not very useful</th>
<th>Useless</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15. Compared with the guidance or advice you/your organisation already has in relation to this step, do you think the advice given in the new method is

<table>
<thead>
<tr>
<th>Much better</th>
<th>Better</th>
<th>About the same</th>
<th>Worse</th>
<th>Much Worse</th>
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</thead>
<tbody>
<tr>
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</tbody>
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Step 6: Record Assessment Findings

16. Do you have any comments on the advice given in this part of the assessment method? For example, what do you think about the sample assessment record form and follow-up form?
17. In your opinion, how useful are the advice and the sample forms?

- Very Useful
- Useful
- Fairly useful
- Not very useful
- Useless

18. Compared with the guidance and any forms you/your organisation already has for recording assessment, do you think the advice and the forms given in the new method is

- Much better
- Better
- About the same
- Worse
- Much Worse

**Step 7: Review and Revise Assessment**

19. Do you have any comments on the advice given in this part of the assessment method?

20. In your opinion, how useful is the advice?

- Very Useful
- Useful
- Fairly useful
- Not very useful
- Useless

21. Compared with the guidance or advice you/your organisation already has in relation to this step, do you think the advice given in the new method is

- Much better
- Better
- About the same
- Worse
- Much Worse
Overall

22. In your opinion, how useful is the “Crowd Safety Risk Assessment Method” as a whole?

Very Useful  Useful  Fairly useful  Not very useful  Useless

23. Compared with the assessment method already in use by you/your organisation, do you think the new “Crowd Safety Risk Assessment Method” is

Much better  Better  About the same  Worse  Much Worse

Thank you for taking part in the verification test.
APPENDIX I

Analysis of Results in Experiment 2
APPENDIX I-1

Analysis of Results in Group B
Experiment 2 - Summary of Results - Group B

Part 1:
The risk levels of 15 given hazards estimated by subjects using the following rating system: High (H), Medium (M), Low (L)

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Subjects</th>
<th>B-21</th>
<th>B-22</th>
<th>B-23</th>
<th>B-24</th>
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Convert rating into ranking:

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Part 2:
The risk levels estimated by the same subjects weeks later using the same rating system.

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Convert scores (in rating) into ranking:

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<td>8</td>
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<td>14</td>
<td>8</td>
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<tr>
<td>15</td>
<td>8</td>
</tr>
</tbody>
</table>
Consistency within Group B

**Kendall Coefficient of Concordance, \( W \)**

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<tr>
<th>Hazards</th>
<th>Subjects</th>
</tr>
</thead>
<tbody>
<tr>
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<td>B-22</td>
</tr>
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<td>R(_j)</td>
<td>(R_j - R_{\text{mean}})</td>
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</tr>
<tr>
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<td>14</td>
<td>10</td>
</tr>
<tr>
<td>15</td>
<td>3.5</td>
</tr>
</tbody>
</table>

\( R_{\text{mean}} = 45 \)

\( S = \varepsilon (R_j - R_{\text{mean}})^2 = 2347.5 \)

\[
\begin{array}{cccccc}
T_{21} & T_{22} & T_{23} & T_{24} & T_{25} & T_{26} \\
45.5 & 35 & 45.5 & 35 & 46 & 29.5 \\
\end{array}
\]

\[
W = s/[(1/12)k^2(N^3 - N) - k\varepsilon T] \\
k = 6 \\
N = 14 \\
\text{Coefficient of Concordance, } W = 0.347
\]

**Significance of W**

\[
\text{Chi-Square} = k(N-1)W = 27.04 \\
df = 13 \\
\text{Chi-Square} >= 27.04 \\
\text{Probability of Occurrence under } H_0 \text{ of } p = 0.012
\]

Group B-3
Consistency Over Time - Group B

Entire Group:

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<th>R_h</th>
<th>Rank</th>
<th>d_1</th>
<th>d_2</th>
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\[ \varepsilon d_i^2 = 84 \]

\[ T = \varepsilon(t^3-t)/12 \]

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<th>T_x</th>
<th>T_y</th>
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<tbody>
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</table>

\[ N = 14 \]

\[ \varepsilon x^2 = [(N^3-N)/12] - T_x = 225.5 \]

\[ \varepsilon y^2 = [(N^3-N)/12] - T_y = 227.5 \]

\[ r_s = (\varepsilon x^2 + \varepsilon y^2 - \varepsilon d^2)/[2(\varepsilon x^2\varepsilon y^2)^{1/2}] = 0.815 \]

Significance of \( r_s \)

Student's \( t = r_s [(N-2)/(1 - r_s^2)]^{1/2} = 4.865 \)

From "Table of Critical Values of t", for \( df = N - 2 = 13 \) (one-tailed test)

\[ t = 4.8647 \text{ is significant at } p<0.0005 \]
APPENDIX I-2

Analysis of Results in Group C
Part 2:
The risk levels estimated by the same subjects weeks later using the same rating system.

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<td>D</td>
<td>C</td>
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Convert scores (in rating) into ranking:

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Group C-2
Consistency Within Group C

Kendall Coefficient of Concordance, W

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\[
R_{\text{mean}} = 45 \\
S = \varepsilon(R_j-R_{\text{mean}})^2 = 2801.5
\]

\[
T = \frac{\varepsilon(t^3-t)}{12}
\]

\[
W = s/[(1/12)k^2(N^2 - N) - k\varepsilon T]
\]

\[
k = 6 \\
N = 14
\]

Coefficient of Concordance, W = 0.386

Significance of W

\[
\text{Chi-Square} = k(N-1)W = 30.11
\]

\[
df = 13 \\
\text{Chi-Square} >= 30.11
\]

Probability of Occurrence under H_0 of \( p = 0.005 \)
Consistency Over Time - Group C

Entire Group:

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\[ \sum d_i^2 = 215.5 \]

\[ T = \sum (t^3 - t)/12 \]

\[
\begin{array}{cc}
T_x & T_y \\
0.5 & 0.5 \\
\end{array}
\]

\[ N = 14 \]

\[ \varepsilon x^2 = \frac{(N^2 - N)}{12} - T_x = 227 \]

\[ \varepsilon y^2 = \frac{(N^2 - N)}{12} - T_y = 227 \]

\[ r_s = \frac{\varepsilon x^2 + \varepsilon y^2 - \varepsilon d^2}{2(\varepsilon x^2 \varepsilon y^2)^{1/2}} = 0.525 \]

Significance of \( r_s \):

Student's \( t = r_s \left( \frac{(N-2)}{(1 - r_s^2)} \right)^{1/2} = 2.139 \)

From "Table of Critical Values of \( t \),"

For df = N - 2 = 12 (one-tailed test)

\( t = 2.1387 \) is significant at \( p < 0.05 \)
APPENDIX I-3

Analysis of Results in Group D
Experiment 2 - Summary of Results - Group D

Part 1:
The risk levels of 15 given hazards estimated by teams of 3 subjects using the following rating system: A (highest risk), B, C, D & "-" (trivial risk)

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Convert scores (in rating) into ranking:

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Part 2:
The risk levels estimated by the same subjects weeks later using the same rating system.

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Consistency Within Group D

Kendall Coefficient of Concordance, $W$

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<td>13.5</td>
<td>7.5</td>
<td>4</td>
<td>11.5</td>
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</tbody>
</table>

$R_{\text{mean}} = 45$

$S = \varepsilon (R_1 - R_{\text{mean}})^2 = 3596$

$T = \varepsilon (t^3 - t)/12$

<table>
<thead>
<tr>
<th>T_{21}</th>
<th>T_{22}</th>
<th>T_{23}</th>
<th>T_{24}</th>
<th>T_{25}</th>
<th>T_{26}</th>
<th>$\varepsilon T$</th>
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<td>21</td>
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<td>62</td>
<td>24.5</td>
<td>22</td>
<td>35</td>
<td>188</td>
</tr>
</tbody>
</table>

$W = s/[(1/12)k^2(N^3 - N) - k\varepsilon T]$

$k = 6$

$N = 14$

Coefficient of Concordance, $W = 0.509$

Significance of $W$

Chi-Square $= k(N - 1)W = 39.72$

$df = 13$

Chi-Square $\geq 39.72$

Probability of Occurrence under $H_0$ of $p = ######$
Consistency Over Time - Group D

Entire Group:

<table>
<thead>
<tr>
<th>Hazards</th>
<th>R_i</th>
<th>Rank</th>
<th>Pt 1 (x) Pt 2 (y)</th>
<th>d_i</th>
<th>d_i^2</th>
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</thead>
<tbody>
<tr>
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<tr>
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<td>47</td>
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<tr>
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<td>1</td>
</tr>
</tbody>
</table>

\[ \varepsilon d_i^2 = 142.5 \]

\[ T = \varepsilon(t^2-t)/12 \]

\[ \begin{array}{cc} 
T_x & T_y \\
0 & 0.5 
\end{array} \]

\[ N = 14 \]
\[ \varepsilon x^2 = [(N^2 - N)/12] - T_x = 227.5 \]
\[ \varepsilon y^2 = [(N^2 - N)/12] - T_y = 227.0 \]
\[ r_s = (\varepsilon x^2 + \varepsilon y^2 - \varepsilon d^2)/[2(\varepsilon x^2\varepsilon y^2)^{1/2}] \]
\[ = 0.686 \]

**Significance of \( r_s \)**

Student’s \( t = r_s \sqrt{[(N-2)/(1 - r^2)]^{1/2}} \)
\[ = 3.27 \]

From "Table of Critical Values of \( t \)".

For \( df = N - 2 = 12 \) (one-tailed test)
\( t = 3.2703 \) is significant at \( p < 0.05 \)