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Health and Safety Executive

Evaluation into the success of occupational health and safety regulators and organisations use of expert systems

Prepared by **BOMEL Ltd**
for the Health and Safety Executive 2006

RR508
Research Report

HSE

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Evaluation into the success of occupational health and safety regulators and organisations use of expert systems

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This report describes a study into occupational health and safety (OH&S) Regulators and organisations use of expert systems to address work at height issues; workplace transport; slips and trips; and noise and vibration. An International literature review and consultation activity with 46 key OH&S organisations was conducted in order to identify expert systems and analyse their impact on health and safety. The feedback collected from both activities was organised into a matrix of expert systems on CD-Rom format which accompanies this report.

The report presents a definition of expert systems and discusses safety domains where expert systems have been used. Six health and safety related expert systems were explored further during consultations with key organisations and these are presented as case studies. The study concluded that limited information was available on health and safety related expert system application, and that no robust evaluation evidence existed. The recommendations suggest how HSE could continue to make steps to develop its own expert system.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

HSE Books

First published 2006

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INTRODUCTION

This report has been prepared by BOMEL Limited (BOMEL) for the Falls from Height Programme Team within the Health and Safety Executive (HSE) as Research Contract 6205. This project was commissioned by HSE to evaluate the success of occupational health and safety (OH&S) organisations (including Regulators) use of expert systems to address work at height issues; workplace transport; slips and trips; and noise and vibration.

The overall objectives of this project were:

- To carry out a thorough review of the expert systems that OH&S organisations (including Regulators) have used/adopted to address the workplace risks involving: work at height; workplace transport; slips and trips and noise and vibration.

  Following this review a decision was made that due to the limited information available on expert system application and evaluation (particularly in a health and safety context) it was not worthwhile continuing with the following objectives:

- To analyse how successful these expert systems have been in reducing incidents for each category.

- To evaluate the success of these expert systems and application of lessons learned to the GB context.

- To make recommendations as to how these expert systems could be applied to work within each of the areas identified.

- To reveal some preliminary thoughts about what expert systems may be appropriate to help HSE's Programmes in these areas better address risks concerned.

METHODOLOGY

The current study required a thorough review to be conducted of expert systems which OH&S organisations (and Regulators) used to address the workplace health and safety risks of interest. In conducting this work, two key activities were undertaken. Firstly, an International literature review was conducted on safety-related expert systems from a range of sources. Secondly, a series of consultations were conducted with key organisations in order to extend the traditional literature review.

International literature review methodology

- **Identification of expert systems** – A systematic review of International literature regarding safety-related expert systems was conducted. Systems used by International

regulators, health and safety organisations and private companies within industry were included in the review to ensure a thorough search. The review was not limited to expert systems designed specifically to address the workplace risks outlined by the HSE, rather systems relating to all aspects of health and safety were included as useful lessons can be learnt from them.

- **Structuring information on the key expert systems** – A detailed matrix was developed in order to organise the data collected during the information search. Key features of each expert system identified were presented in the matrix under specific headings such as the system's country of origin and the type of company / worker the system was designed for.

Interview methodology

- **Consultation with key International organisations -** Key organisations, International Regulators, non-Regulators and private companies that had been identified as part of the literature review were considered for further investigation.

- **Identification of key organisations for consultation –** To ensure the sample was representative a target list of key International organisations was drawn up to reflect a range of International Regulators, non-Regulators and private companies from around the world.

- **Question set development–** A comprehensive question set was developed based on the key variables highlighted in the matrix to provide a discussion framework for the consultation.

- **Consultation with key international organisations –** The consultation involved interviewing organisations about their knowledge and use of expert systems. The consultations were conducted through one-to-one telephone interviews and an email survey.

- **Updating the matrix** – The information collected during the consultation exercise was used to update the matrix.

RESEARCH FINDINGS

The following section provides a summary of the main findings from the International literature review and the consultations with key OH&S Regulators and organisations.

Expert systems definition

- An Expert System is a computer-based system designed to respond like a human expert in a given field (Encyclopaedia Britannica, Inc., 2006). An Expert System operates as a computer application that uses specialist domain knowledge to suggest solutions to problems in a particular discipline, for example, expert systems can help to diagnose human illnesses, make financial forecasts and identify workplace risks and hazards. These

types of tools may also be known as knowledge-based systems, decision-making tools and computer-aided learning.

Safety domains where expert systems have been used

Regulatory Advice

- Expert systems designed to support regulatory compliance provide detailed text of the regulations associated with user-selected topics. The purpose of expert systems for regulations is to allow the user to view only the relevant information from the large amounts of guidance and procedures. Examples of such systems include the OSHA Expert Advisors and the Dakota Decision Support Software.

Hazard analysis and avoidance

- The purpose of expert systems for hazard analysis and avoidance is to advise the user on the extent of particular health and safety risks. These systems are prescriptive and rely heavily on the accuracy of its recommendations as opposed to the text-based systems for regulatory advice. Examples of these systems include the Permit Control & Monitoring System (PCMS), the EASE system, the SPONCOM system and the SoundPLAN software.

Decision support

- Expert systems for decision support are designed to aid people who have to take decisions relating to hazardous environments. These types of systems can be developed as a stand-alone system or combined with a larger system. Examples of such systems include the CAPSULE system, the 'Action Checkpoints for Comfortable computer Work' and the DLI Engineering ExpertALRET expert automated diagnostic system.

Monitoring and diagnostic systems

- The purpose of monitoring and diagnostic expert systems is to alert the user of risks typically based on input from sensory data. This type of expert systems is often built into a monitoring loop, and it is possible to automate some of the corrective action required. Examples of these systems include the Multivariate State Estimation Technique (MSET); Manned Manoeuvring Unit (MMU), Fault detection, Isolation & Recovery (FDIR) NASA systems; and the Construction Safety and Health Monitoring System (CSHM).

Expert systems identified

Response to consultations

- A total of 46 organisations were approached for the consultation.

- The majority of organisations fell within the 'no further information to offer / no feedback received' category. Possible reasons for organisations responding in this way may be that many organisations do not see a need for expert systems or that organisations may be

worried about sensitive information entering the public domain that could be used by competitors.

- Three organisations participated (see 'participating organisations') in the consultation by providing further information about expert systems (e.g. OSHA provided further information regarding the OSHA Expert Advisors). A total of seven interviews were conducted with the three organisations who took part in the consultation.

- Three organisations fell into the 'direct refusal to take part' category in the consultation. For example, one organisation said that it was not their policy to participate in research.

Expert systems matrix

- The information collected on expert systems was structured and summarised under key expert system variables in a matrix format. It was developed based on the expert systems identified as part of the International literature review and the feedback gathered through engaging with key OH&S organisations.

- The final matrix accompanies this report in a CD-Rom format and presents clear and focused information about the expert systems that were identified. The matrix consists of two worksheets. The first worksheet highlights 43 'true' expert systems that were identified. The second worksheet highlights 37 'other' systems identified during the review; however, these were not true expert systems but rather static web pages or searchable databases.

Expert systems case studies

- Six expert systems were explored further during consultations with three key OH&S organisations, and these are presented in the form of case studies. OSHA provided information on four of its expert systems, NIOSH provided feedback on one of its systems and a UK company called aSAP provided information on its expert system.

- It is important to note that none of the systems identified in this review had any robust evaluation evidence to indicate their success in improving health and safety.

aSAP Permit Control & Monitoring System (PCMS)

- A UK company called aSAP provided further information about their PCMS Permit Control & Monitoring System. The system is designed to generate permits for workplaces that are considered as hazardous working environments. This system identifies workplace risks and hazards. The system's developer advised that an evaluation of the PCMS was not appropriate because all specific requirements are identified from the outset as part of the user's selection criteria. As such, any evaluation would be focussing on the effectiveness or the user's selection criteria rather than the effectiveness of the PCMS tool itself.

OSHA Expert Advisors

- US Regulator OSHA provided feedback about four of their Expert Advisors. The OSHA Asbestos Advisor produces guidance on how the Asbestos standard may apply to buildings and particular areas of work. The OSHA Confined Spaces Advisor was designed to provide users with interactive expert help to apply the OSHA Permit Required Confined Spaces Standard. OSHA's Fire Safety Advisor provides users with interactive expert help to apply OSHA's General Industry Standards for fire safety and emergency evacuation. The OSHA Hazard Awareness Advisor was designed to help user's determine which of the OSHA Standards for General Industry apply to the work performed at their organisation or site. The subjective feedback suggested that the Advisors were well received by users and that the systems were user-friendly.

NIOSH Spontaneous Combustion Expert System (SPONCOM)

- The National Institute for Occupational Safety and Health (NIOSH) in the US provided information on their SPONCOM system. The system was designed to allow mining companies to assess whether they would have a problem with spontaneous combustion of over-heating coals in mines. The subjective feedback from users suggests that the SPONCOM system is a successful aid to make changes to ventilation designs. Users also felt that the system was user-friendly as SPONCOM provides useful explanations rather than producing pages of output data.

CONCLUSIONS

In relation to the initial objective, the following conclusions can be drawn from the work undertaken in this project:

1. At present, there is limited information available in the public domain regarding expert systems designed to address health and safety issues. Furthermore, there is very limited information regarding any expert system that may address the specific health and safety issues of interest (e.g. work at height; workplace transport; slips and trips and noise and vibration).

2. Consulting with key organisations did not provide any further information. Most organisations did not use expert systems in relation to health and safety. However, when developing its own system HSE should consider general factors which (based on the anecdotal evidence from the consultations) are likely to naturally drive an increase in the use of expert systems. HSE should consider taking into account country specific social, economic and cultural factors that are likely to impact on the successful development of health and safety related expert system technology.

3. Of the 43 'true' expert systems that were identified, the information was limited and did not address the specific health and safety areas of interest to HSE. No robust evaluation evidence was available to assess their impact on health and safety. Reasons given why organisations had not conducted robust evaluations included: it is not in the interests of the

organisation; it is not applicable (e.g. aSAP's PCMS does not require evaluation because the system is designed to meet the client's selection criteria); and subjective opinion gathering of users was felt to suffice as evaluation work.

4. Six systems were focused on in more depth, but no robust evaluation evidence existed. Of these six expert systems, five out of the six were developed in the US.

5. It was agreed, following consultation with the HSE, that the lack of evaluation evidence meant that no further value would be gained from taking the analysis further.

RECOMMENDATIONS

The purpose of this study was to carry out a thorough review of expert systems other OH&S Regulators, non-Regulators and industry have used/adopted to address the workplace risks involving: work at height; workplace transport; slips and trips and noise and vibration. Based on the work undertaken, the following recommendations have emerged from this study:

1. Expert systems industry workshop

In order for HSE to develop expert systems that will be used successfully by industry, it is imperative to consult industry early on about what they would expect from a system of this nature in terms of content, format, maintenance and usability. Therefore, in order to provide HSE with further guidance on how to develop expert systems, an industry workshop is proposed to gather feedback from potential users on various issues regarding format, usability and content.

2. Keep abreast of expert systems research

The HSE should plan to review research and development in the area of health and safety related expert systems over the coming years, as it is likely that other organisations will follow suit of those based in the US. It is therefore recommended that the HSE revisit the research in the next three to five years to keep abreast of new developments regarding health and safety related expert systems.

3. Continue effort to develop HSE's own expert systems

The original objective of this study was to assist the HSE in making evidence-based decisions in order to develop its own expert systems for managing workplace risks. In light of the current findings, it is not possible to apply any lessons learnt due to the lack of evaluation evidence available. However, this lack of evidence should not necessarily discourage HSE from developing its own expert systems if a need for such systems has been identified. This will mean that HSE will have to take the lead in developing such expert systems rather than incorporating the lessons learnt by other regulators.

1 INTRODUCTION

1.1 INTRODUCTION

This report has been prepared by BOMEL Limited (BOMEL) for the Falls from Height Programme Team within the Health and Safety Executive (HSE) as Research Contract 6205. The overall objective of this project was to evaluate the success of occupational health and safety (OH&S) organisations (including Regulators) use of expert systems to address work at height issues; workplace transport; slips and trips; and noise and vibration.

1.2 CONTEXT OF THE STUDY

Over the last five years, an average of nearly 70 people have died and 4,000 have suffered a major injury annually as a result of a fall from height in the workplace. Falls from height are the most common cause of fatal injury and have traditionally been the second most common cause of major injury for workers. The HSE has included falls from height as one of its Strategic Programmes, chosen to help meet its targets for the reduction of injury rates in the workplace. Evaluating the success of OH&S organisations use of expert systems to manage risks at work in a number of areas (specifically work at height, workplace transport, slips and trips and noise and vibration) can provide important lessons (both positive and negative) to the Falls Programme about the way other organisations have used expert systems to manage the risks associated with work at height and other areas.

The findings of this study could be used in future years to help the Falls from Height Programme develop its own expert systems. Lessons learned on other work-related risks could be taken forward by other HSE programmes targeted on similar risks. BOMEL has therefore been commissioned to assist the HSE in making evidence-based decisions about the development of its own expert systems by evaluating the success of other OH&S organisation's use of expert systems to manage workplace risks.

1.3 OBJECTIVES

The objectives of the current study were:

1. To carry out a thorough review of the expert systems that OH&S organisations (including Regulators) have used/adopted to address the workplace risks involving: work at height; workplace transport; slips and trips and noise and vibration.

   Following this review a decision was made that due to the limited information available on expert system application and evaluation (particularly in a health and safety context) it was not worthwhile continuing with the following objectives:

2. To analyse how successful these expert systems have been in reducing incidents for each category.

3. To evaluate the success of these expert systems and application of lessons learned to the GB context.

4. To make recommendations as to how these expert systems could be applied to work within each of the areas identified.

5. To reveal some preliminary thoughts about what expert systems may be appropriate to help HSE's Programmes in these areas better address risks concerned.

1.4 SCOPE OF WORK

In order to address the study objectives as outlined in Section 1.3, a comprehensive programme of work was designed. The following five points outline the main phases of work activity:

1. Up-to-date applied and academic literature was reviewed in order to identify expert systems used by OH&S Regulators and organisations from around the world to ensure that potentially important information was reviewed, and to provide the HSE with a sound reference base for any future work in this area.

2. A consultation activity was conducted with OH&S Regulators and organisations from around the world using a comprehensive set of questions based on a series of key expert system features (or 'variables').

3. Using the feedback gathered from the literature review and consultation activity a matrix of expert system data was developed. Expert systems that were explored further during the consultations were also presented as case studies to provide the HSE with a better understanding of how these systems operate.

4. A meeting was held with the HSE to present the findings and to discuss any further activity in light of the lack of evaluation evidence for health and safety related expert systems. A decision (agreed by HSE and BOMEL) was taken at this meeting which reflected whether continuing with the research was perceived as worthwhile.

5. The findings were drafted into this report deliverable for the HSE project team.

1.5 SCOPE OF THIS REPORT

The project objectives and associated work activities have been addressed throughout this report as follows:

- Section 2 outlines the study methodology including the International literature review; the consultation with key OH&S Regulators and organisations; development of the question set for the consultation; conducting the interviews and completing the matrix.

- Section 3 presents the findings of the study.

- Section 4 presents the conclusions drawn from this study.

- Section 5 presents the study recommendations.

- Section 6 contains the references used in this study.
- Appendix A contains the list of organisations selected for consultation.
- Appendix B contains the question set developed for use when engaging with organisations.

2 METHODOLOGY

2.1 INTRODUCTION

The current study required a thorough review to be conducted of expert systems which OH&S Regulators, other health and safety organisations and companies have developed, used or adopted to address workplace health and safety risks such as work at height; workplace transport; slips and trips; and noise and vibration. In conducting this work, two key activities were undertaken. Firstly, an International literature review was conducted on safety-related expert systems from a range of sources. The review identified expert systems by examining OH&S Regulators, health and safety organisations and larger companies in the more hazardous industries and by assessing academic research. The data gathered represented the information regarding expert systems from around the world available in the public domain. Secondly, a series of consultations were conducted with key organisations in order to extend the traditional literature review. A comprehensive list of key organisations thought to have the potential for using expert systems was drawn up based on a set of criteria which reflected the relevance and value of engaging with them. These activities are described in more detail in the following sections.

2.2 INTERNATIONAL LITERATURE REVIEW METHODOLOGY

2.2.1 Overview

In conducting the International literature review, the following key activities were undertaken:

- **Identification of expert systems** – A systematic review of International literature regarding safety-related expert systems was conducted. Systems used by International regulators, health and safety organisations and private companies within industry were included in the review to ensure a thorough search. The review was not limited to expert systems designed specifically to address the workplace risks outlined by the HSE, rather systems relating to all aspects of health and safety were included as useful lessons can be learnt from them.

- **Structuring information on the key expert systems** – A detailed matrix was developed in order to organise the data collected during the information search. Key features of each expert system identified were presented in the matrix under specific headings such as the system's country of origin and the type of company / worker the system was designed for.

These activities are explored further in the following sections.

2.2.2 Identification of expert systems

2.2.2.1 ***Sources of information***

In order that the literature review provided a representative view of expert systems it was important to identify mechanisms by which to gather information (e.g. the internet). The two main mechanisms for searching for information were as follows:

- The internet (e.g. relevant websites such as www.hse.gov.uk and www.osha.gov)
- Academic literature (e.g. online academic databases such as Ingenta and Silver Platter and also resources at the British Library)

Information available on the internet was reviewed (through generic search engines and organisation's websites) and an information trawl of academic literature was also conducted. Online academic search databases such as Ingenta and Silver Platter were consulted for relevant information on expert systems. A BOMEL consultant also spent time at the British Library searching for information. The three 'reading rooms' that were deemed most relevant were 'Humanities'; 'Social Sciences'; and 'Business'. The library also has an electronic storage and retrieval system (ESTAR) which was used to search for relevant information. As each information source was explored new leads emerged indicating more specific areas where potential information may be found.

In order to apply a structure to the initial information gathering process BOMEL drew up a list of potential information sources accessible in the public domain that could be reviewed using the mechanisms highlighted above. The information sources identified were as follows:

- HSE specialists and contacts (e.g. the 'Falls from Height' programme team)
- BOMEL associated companies worldwide (e.g. Noble Denton)
- Industry / trade associations (e.g. British Safety Industry Federation (BSIF), Occupational Road Safety Alliance (ORSA))
- BOMEL contacts in 'best practice' organisations (e.g. British Gas (BG), British Petroleum (BP))

The information that was gathered was structured and organised into a matrix.

2.2.2.2 ***OH&S Regulators and non-Regulators***

The National and International Regulators and non-Regulatory bodies concerned with OH&S identified for the review are shown in Table 1. In order for the review to be representative BOMEL drew up a list of International Regulators and non-Regulators thought to have the potential for using expert systems and those with a reputation for best practice. Non-UK organisations are presented with the name of the country in brackets after the organisation's name and acronym.

Table 1 International OH&S Regulators, non-Regulators and organisations concerned with health and safety reviewed

STATUS	*NAME OF ORGANISATION*
REGULATORY	• Civil Aviation Authority (CAA) • Department for Environment, Food & Rural Affairs (DEFRA) • Department for Transport (DfT) • Federal Institute for Occupational Safety and Health (BAuA) (Germany) • Health and Safety at Work Inspectorate (HSWI) (Isle of Man) • Health and Safety Executive (HSE) • Health and Safety Executive for Northern Ireland (HSENI) • International Atomic Energy Agency (IAEA) • International Maritime Organisation (IMO) • Maritime and Coastguard Agency (MCA) • National Authority for Occupational Safety and Health (HSA) (Ireland) • Occupational Safety and Health Administration (OSHA) (US) • Occupational Safety and Health Service (OSH) (New Zealand) • Rail Safety and Standards Board (RSSB)
NON-REGULATORY	• Advanced Safety Applications and Procedures Ltd (aSap) • Advisory Committee on Roofwork (ARC) • Advisory Committee on Work at Height Training (ACWAHT) • Association for the Prevention of Accidents (APA) (Spain) • Association of Noise Consultants (ANC) • Birmingham Health, Safety and Environment Association (BHSEA) • British Automation and Robot Association (BARA) • British Constructional Steelwork Association Limited (BCSA) • British Industrial Truck Association (BITA) • British Safety Council (BSC) • British Safety Industry Federation (BSIF) • British Standards Institution (BSI) • British Standards Society (BSS) • Building Safety Group (BSG) • Canadian Centre for Occupational Health and Safety (CCOHS) (Canada) • Centre for the Improvement of Working Conditions and Environment (CIWCE) (Pakistan) • Construction Health and Safety Group (CHSG) • Department of Trade and Industry (DTI) • Federal Institute for Occupational Safety and Health (FIOSH) (Germany) • Finnish Institute of Occupational Health (FIOH) (Finland) • Food Standards Agency (FSA) • I'Institut National de Recherche et de Securite (INRS) (France) • Industrial Accident Prevention Association (IAPA) (Canada) • Industrial Injuries Advisory Council (IIAC) • Institution of Occupational Health and Safety (IOSH) • International Commission on Occupational Health (ICOH) (Italy) • International Institute of Risk and Safety Management (IIRSM) • International Labour Organisation (ILO) • International Society for Fall Protection (ISFP) (US) • Merseyside and Cheshire Construction Safety Group (MCCSG) • National Institute for Occupational Safety and Health (NIOSH) (US) • National Institute of Industrial Safety, Independent Administrative Institution (NIIS) (Japan) • National Institute of Occupational Health (NIOH-DK) (Denmark)

STATUS	*NAME OF ORGANISATION*
	• National Institute of Safety and Hygiene at Work (INSHT) (Spain) • National Occupational Health and Safety Commission (NOHSC) (Australia) • Occupational Road Safety Alliance (ORSA) • Occupational Safety Information and Education Centre (CIVOP) (Czech Republic) • Royal Society for the Prevention of Accidents (RoSPA) • The Environment Agency (EA) • United Kingdom Atomic Energy Agency (UKAEA) • World Health Organisation (WHO)

NB: Regulatory and non-Regulatory bodies are as defined by the HSE

It is important to note that organisations responsible for OH&S in countries around the world may serve two very similar, but fundamentally different purposes. Organisations such as OSHA and New Zealand's OSH are OH&S Regulators that have the power to enforce legislation in their countries, whereas NIOSH and Germany's FIOSH, although still concerned with OH&S, are not warranted to enforce and therefore cannot impose penalties or fines on organisations. Although this distinction was arbitrary in the early stages of the review for information gathering purposes, it became more pivotal later, especially when deciding which organisations should be contacted for further information (see Section 2.3.2). Non-Regulatory bodies were still included in the review because despite not having regulatory power, they would still be concerned with the same issues as Regulators and therefore could potentially provide useful information for this review.

Each organisation was reviewed by using the range information sources (as highlighted in Section 2.2.2.1). The majority of organisations' websites had their own search engines and relevant information could be generated by entering specific search terms. The information gathered was structured and organised into a matrix.

2.2.2.3 Organisations within industry

Following the systematic review of OH&S Regulators and non-Regulators, it was important to also review organisations within industry. This was to ensure that the review was representative of industry's use of expert systems as it is likely that this is where systems may have evolved, particularly within the safety critical industries such as oil and gas. Organisations were reviewed from the following industries:

- Oil
- Gas
- Nuclear
- Construction
- Manufacturing (includes chemical, machinery, timber and pharmaceuticals)

Industry organisations were reviewed by using the information sources highlighted in Section 2.2.2.1. Similarly to the review of OH&S Regulators, industry organisations were reviewed largely by searching for information on their websites. The information gathered was structured into the matrix.

2.2.2.4 'Expert system' search terms

In order to capture relevant information regarding expert systems from the vast amount of knowledge that exists, a range of relevant keywords was identified for use. It is highly likely that organisations from different countries and / or within different industries (although familiar with expert system type tools) may not all identify with the specific term 'expert system'. Therefore, to ensure that no critical information was overlooked during the information search, multiple search terms were used, as follows:

- Expert system/s
- Expert based systems
- Expert databases
- Knowledge-based systems
- Knowledge engineers
- E-tools
- Control systems
- Knowledge networks
- Decision making tools
- Computer-aided learning

In terms of the internet review, although every effort was made to search through the vast amounts of information generated, where hundreds of search results were displayed only the first two full pages of results were searched through. Search engines are by nature designed to search and display results of the most relevant information first, therefore it is unlikely that any vital pieces of information were missed during the search. These search terms were also used whilst searching for information at the British Library.

2.2.3 Structure and summary of information

In order to conduct a systematic and thorough review of literature concerning safety-related expert systems, the information collected was organised into a matrix format. Key expert system variables formed the basis of the matrix. This aided an efficient review process and also ensured that information could be presented in a focused and clear way. The final populated

matrix can be found in the CD-Rom accompanying this report. This matrix was a live document throughout the literature search activity, with data on expert systems being entered as they were identified.

2.3 INTERVIEW METHODOLOGY

2.3.1 Introduction

It was envisaged that the traditional literature review in isolation may not uncover the true extent of expert system usage because some information may not be available in the public domain. The review therefore required consultation with key International organisations thought to have the potential for using expert systems, in order to go beyond the traditional approach adopted for literature reviews. In conducting this work, the following key activities were undertaken:

- **Identification of key organisations for consultation –** To ensure the sample was representative a target list of key International organisations was drawn up to reflect a range of International Regulators, non-Regulators and private companies from around the world.

- **Development of question set –** A comprehensive question set was developed based on the key variables highlighted in the matrix to provide a discussion framework for the consultation.

- **Consultation with key international organisations –** The consultation involved interviewing organisations about their use and knowledge of expert systems. The consultations were conducted through one-to-one telephone interviews and an email survey.

- **Updating the matrix** – The information collected during the consultation exercise was used to update the matrix.

Each of these activities is described in more detail in the following sections.

2.3.2 Identification of key organisations for consultation

In order to conduct the consultations with key organisations, International Regulators, non-Regulators and private companies that had been identified as part of the literature review were considered for further investigation based on the following set of criteria:

- whether it was a Regulatory or non-Regulatory body (Regulatory taking precedence);

- whether any expert systems had been identified within that organisation from their website; and

- whether there was a ‘special interest’ in a particular organisation.

The National Institute of Industrial Safety (NIIS) in Japan was an example of a ‘special interest’ organisation because, although no expert systems were identified within this organisation, the country holds a reputation for good management of health and safety and use of technology. Only one private commercial company from each industry was included.

Based on the criteria outlined above, a total of 46 organisations were identified for consultation and ranked in order of priority.

2.3.3 Development of question set

2.3.3.1 Overview

The question set was designed to probe key expert system features as highlighted in the matrix. In designing the question set, the following specific issues were considered:

- The variables defined in the matrix.
- Evaluation studies conducted for the expert systems.
- Knowledge of other expert systems.

These issues are explored in the following sections, in relation to how they are represented in the question set.

2.3.3.2 Section 1: Key expert system variables

A series of key expert system features (variables) were transformed into questions to form the basis of Section 1 of the interview question set. These variables were as follows:

- Name of expert system
- Country of origin
- Organisation of origin (i.e. regulator or industry)
- System application (e.g. supporting regulatory compliance, identifying workplace risk and hazards, guiding accident analysis etc.)
- Safety domain / area (e.g. work at height, workplace transport, slips and trips, noise and vibration etc.)
- Type of company / worker the system is designed for
- Main components / functions within the system

- Aspects of the system unique to the originating country (i.e. are there any aspects which may not translate to a GB setting)
- Delivery of the system (e.g. Internet based, downloadable software etc.)
- System management (e.g. level of monitoring required, frequency of updates etc.)
- Costs, funding and sustainability (with case study examples where available to illustrate level of resource deployment and associated degree of impact)
- Length of time in existence
- Communications / marketing of the system
- Contact details / references providing more information about the system
- Regulatory framework under which the system operates

2.3.3.3 Section 2: Expert system evaluation studies

Section 2 of the question set explored whether or not any evaluations had been carried out on the expert systems and what the results had shown. The issues covered included:

- the usability of the system;
- the potential impact it has had on accident reduction;
- the evidence which exists to support any evaluation findings; and
- the value for money or cost benefits of the expert system.

2.3.3.4 Section 3: Other expert systems

Section 3 of the question set was designed to uncover any other potential expert systems that may exist which were not identified during the literature search. This was an opportunity to explore expert systems that may not have been available in the public domain as they were possibly being used as internal systems within organisations.

2.3.4 Consultation with key organisations

2.3.4.1 Introduction

The consultations with organisations consisted of one-to-one telephone interviews and an email survey. Survey good practice was adopted throughout. Initially, a total of 46 organisations were contacted to participate in the consultation. However, this number increased as the consultation activity spawned new contacts and information leads. The following sections describe this process in more detail.

2.3.4.2 Telephone interviews

One-to-one telephone interviews were used to conduct the majority of the consultation exercise as they allowed for probing and clarification of information that could only be accomplished as part of a two-way conversation. In addition, as many of the organisations selected for the consultation spanned the globe, telephone communication proved to be an efficient and inexpensive method to conduct the consultations.

The majority of the 46 organisations were contacted by 'cold calling' and asking for either the health and safety manager or the I.T. manager. BOMEL had existing relationships with some of the organisations in the consultation and, as such, it was possible to ask for named individuals. The purpose of the research was then explained and individuals were asked if they could help. It is important to note that with almost all of the organisations in the consultation, it took more than one phone call (in some cases up to ten) before the correct person was identified in the organisation. As some of the organisations in the consultation had been identified as using expert systems from the literature search, this information was used to further narrow the search for the best person to speak to regarding expert systems within particular organisations.

Individuals from organisations who were willing to help with the research arranged a convenient time and date for a BOMEL consultant to call them back to conduct the consultation. This allowed individuals from organisations to find relevant information and also allowed for the consultation to be conducted at the convenience of the interviewee.

2.3.4.3 Email questionnaires

Due to difficulties in identifying the most appropriate interviewee, some organisations requested background information about the study and also an electronic version of the questionnaire.

Emailing questionnaires proved to be an effective method to communicate with organisations around the world, especially Australia and New Zealand because of the time difference. Emailing questionnaires was also popular with some organisations due to language barriers.

2.3.5 Updating the matrix

Information that was collected during the consultation was used to update the matrix. The final expert systems matrix was therefore developed based on a review of International literature and also feedback through engaging with key organisations from around the world. The findings of both activities are presented in the following section (Section 3) as case studies and in the form of the matrix.

3 RESEARCH FINDINGS

3.1 INTRODUCTION

Expert systems were reviewed by conducting an International literature review supported by interviews with key OH&S Regulators and organisations (as detailed in Section 2). The following section outlines the findings from the literature review and consultation. This includes an in-depth study of a selection of the expert systems identified in the form of case studies. A definition of expert systems is also provided and research regarding safety domains where expert systems have been applied is presented.

3.2 EXPERT SYSTEMS DEFINITION

3.2.1 Introduction

The following section defines what an expert system is and highlights some of the ways expert systems can be used in a health and safety context.

3.2.2 Definition of expert systems

An Expert System is a computer-based system designed to respond like a human expert in a given field (Encyclopaedia Britannica, Inc., 2006). An Expert System operates as a computer application that uses specialist domain knowledge to suggest solutions to problems in a particular discipline. For example, expert systems can help to diagnose human illnesses, make financial forecasts and identify workplace risks and hazards. These types of tools may also be known as knowledge-based systems, decision-making tools and computer-aided learning.

A degree of debate surrounds the definition of expert systems, because the logic used to write such systems stems from artificial intelligence. The aim of artificial intelligence is ultimately to replace the human being by programming computers and other machines to perform activities that are typically thought to require human intelligence. A system that uses such logic networks is deemed a ‘true’ expert system.

Expert systems are distinguishable from other standard computer applications because a ‘true’ expert system is written using ‘expert system shell’ technology. Expert system shells have the capability of running complex logic tasks and are generally much more sophisticated than regular computer packages. Many information technology (I.T.) software developers have marketed their software under the guise of expert systems in the hope of attracting interest. However, in the majority of cases these expert systems are often simply web pages of information and, at most, searchable databases.

In order to keep the search broad so as not to miss any potential information, a range of expert system search terms was used during the review. This served to ensure that the review was thorough, and also helped organisations to understand the type of tools we were looking to identify (see Section 2.2.2.4).

3.2.3 Safety domains where expert systems have been used

Although much of the research into expert systems focuses on the construction of systems rather than its affect on health and safety (HSE, 2000), there are some useful examples of expert systems which have been developed in a range of safety domains which are highlighted in this section.

3.2.3.1 Regulatory advice

Expert systems designed to support regulatory compliance provide detailed text covering the regulations associated with selected topics. The purpose of expert systems for regulations are to allow the user to view only the relevant information from the large amounts of guidance and procedures. Examples of expert systems for regulatory advice include:

- The US Occupational Safety and Health Administration (OSHA) have developed a series of 'Expert Advisors' which provide users with advice and guidance (http://www.osha.gov/dts/osta/oshasoft/index.html). The OSHA Asbestos Advisor supports regulatory advice by providing guidance on how to apply the OSHA Asbestos Standard to buildings and types of work (see Section 3.4 for more detail on OSHA Expert Advisors).

- The Dakota Decision Support Software supports regulatory compliance by helping the user to determine what regulations apply to their facility so that they can focus on the relevant areas (HSE, 2000). The tool simplifies the process of regulatory compliance auditing.

3.2.3.2 Hazard analysis and mitigation

The purpose of expert systems for hazard analysis and avoidance is to advise the user on the extent of particular health and safety risks and the most effective forms of risk management. These systems are normally prescriptive and therefore rely heavily on the accuracy of their recommendations as opposed to the systems for regulatory advice. Some examples of hazard avoidance expert systems include:

- A British company called aSAP (Advanced Safety Applications & Procedures) have produced a Permit Control & Monitoring System (PCMS) (http://www.safetyapplication.com/products.htm). This system identifies workplace risks and hazards by enabling effective management of permits for hazardous work environments. It identifies the risks and hazards and ensures that the permits are all completed correctly and within a very user-friendly workflow set-up (see Section 3.4 for more detail on aSAP's PCMS).

- The Artificial Intelligence Applications Institute (AIAI) have developed an expert system for the HSE called the EASE system which was designed to guide risk assessment for workplace exposure to potentially hazardous new substances (HSE, 2000).

- The US National Institute for Occupational Safety and Health (NIOSH) have developed a system called SPONCOM to assess hazards in mines by predicting the spontaneous combustion potential of a coal mining operation (http://www.cdc.gov/niosh/mining/pubs/pubreference/tl441.htm). The tool gives mining companies an idea about whether they may have a problem with spontaneous combustion, as the result of over-heating coal causing a fire (see Section 3.4 for more detail on NIOSH's SPONCOM).

- The SoundPLAN software was developed by a company called Braunstein & Berndt in Germany to identify workplace risks and hazards by modelling noise and air pollution (http://www.soundplan.com/). SoundPLAN is a software system that models interior noise levels, sound transmission through building walls, sound propagation into the environment, and allows interactive optimisation of noise control measures.

3.2.3.3 Decision support

Expert systems for decision support are designed to aid people who have to take decisions relating to hazardous environments. These types of systems can be developed as a stand-alone system or combined with a larger system. Examples of decision support expert systems include:

- The CAPSULE expert system was developed by the Imperial Cancer Research Fund as a decision support system to help doctors prescribe certain types of drugs by ranking the prescription based on the arguments for and against each individual patient's symptoms (HSE, 2000).

- The 'Action Checkpoints for Comfortable Computer Work' was developed by the National Institute of Industrial Health (NIIH) in Japan to help users assess their office and find solutions to create a comfortable work environment (http://www.niih.go.jp/en/gyouseki/result/pc_check/index.html).

- A US company called the DLI Engineering Corporation have produced the DLI Engineering ExpertALERT. This expert automated diagnostic system helps users to successfully diagnose machine spindle bearing problems (http://www.dliengineering.com/section.asp?nID=25). The system requires the user to enter the internal mechanical details of the machine that they intend to use into the software system.

3.2.3.4 Monitoring and diagnostic systems

The purpose of monitoring and diagnostic expert systems is to alert the user to risks, typically based on input from sensory data. These types of expert systems are often built into the monitoring loop and it is possible to automate some of the corrective action required. Examples of monitoring and diagnostic expert systems include:

- The US Argonne National Laboratory have developed the Multivariate State Estimation Technique (MSET) Expert System which identifies risks and hazards by

functioning as an early warning system for performance of sensors, equipment and plant processes (HSE, 2000). This is an extremely sensitive system that detects the smallest developing faults at the earliest possible time and alerts plant workers in advance of warnings provided by conventional monitoring systems.

- McDonnell Douglas Astronautics developed the Manned Manoeuvring Unit (MMU); and Fault Detection, Isolation & Recovery (FDIR) systems for NASA (http://ksi.cpsc.ucalgary.ca/KAW/KAW98/preece/). The systems and their respective components diagnose faults on equipment used for space applications. The systems are designed to be representative of the types of equipment commonly needed for space applications.

- The City University of Hong Kong were involved in developing a Construction Safety and Health Monitoring System (CSHM) (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=15178234&dopt=Abstract). This expert system identifies workplace risks in the Chinese construction industry by monitoring and assessing construction safety and health performance. The tool can be used either as a detector of potential risks and hazards or as a warning sign to areas of construction activities that require immediate corrective action.

3.3 EXPERT SYSTEMS IDENTIFIED

3.3.1 Introduction

The following section highlights the expert systems that were identified as part of this review.

3.3.2 Response to consultations

In order to go beyond the 'passive' literature search typically adopted for reviews, key OH&S organisations were also contacted (see Section 2.3). A total of 46 organisations were approached for the consultation. Figure 1 highlights the overall response received.

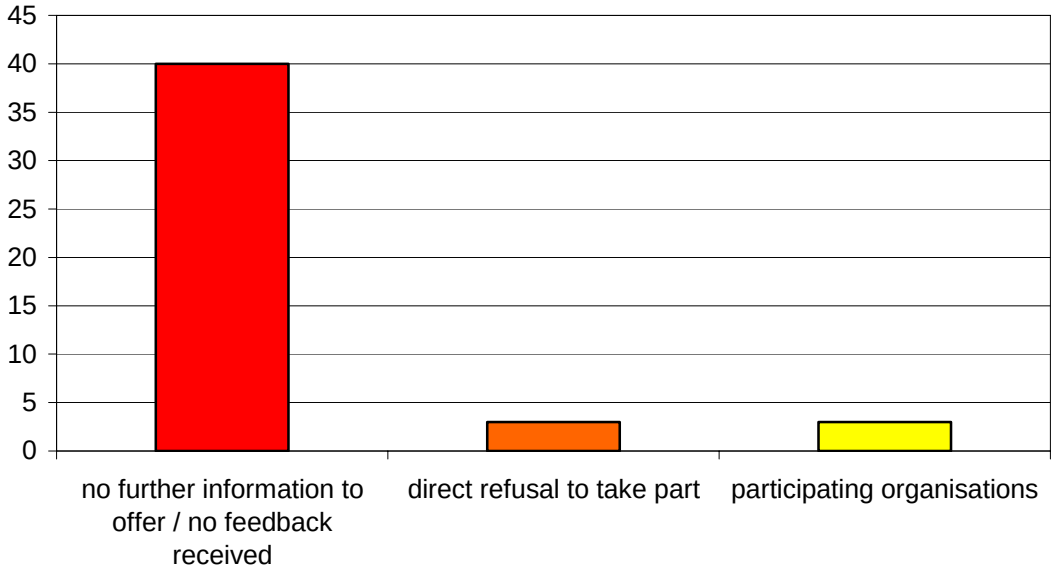

Figure 1 Response to consultations

Figure 1 highlights that of the organisations that were contacted for the consultation, the majority of organisations were within the 'no further information to offer / no feedback received' category. Possible reasons for organisations responding in this way may be that many organisations do not see a need for expert systems or that organisations may be worried about sensitive information entering the public domain that could be used by competitors. Three organisations participated (see 'participating organisations') in the consultation by providing further information about expert systems (e.g. OSHA provided further information regarding the OSHA Expert Advisors). A total of seven interviews were conducted with the three organisations who took part in the consultation.

Three organisations were in the 'direct refusal to take part' category in the consultation. For example, one organisation said that it was their policy not to participate in research.

3.3.3 Expert systems matrix

The information collected on expert systems was structured and summarised under key expert system variables in a matrix format (see Section 2.2.3). It was developed based on the expert

systems identified as part of the International literature review and the feedback gathered through engaging with key OH&S organisations. This systematic way of organising the information was employed in order to be able to compare and contrast different aspects of the systems.

The matrix itself consists of 18 expert system variable headings, as follows:

- Name of expert system
- Country of origin
- Organisation of origin (i.e. Regulator or industry)
- System application (e.g. supporting regulatory compliance, identifying workplace risk and hazards, guiding accident analysis etc.)
- Safety domain / area (e.g. work at height, workplace transport, slips and trips, noise and vibration etc.)
- Type of company / worker the system is designed for
- Main components / functions within the system
- Aspects of the system unique to the originating country
- Delivery of the system (e.g. Internet based, downloadable software etc.)
- System management (e.g. level of monitoring required, frequency of updates etc.)
- Costs, funding and sustainability
- Length of time in existence
- Communications / marketing of the system
- Contact details / references providing more information about the system
- Regulatory framework under which the system operates
- Existing system evaluation studies
- Reliability of existing literature and existing expert system evaluation studies
- Any identifiable health and safety (or other) changes that have occurred at the target organisation.

The final matrix accompanies this report in a CD-Rom format and presents clear and focused information about the expert systems that were identified. The original version of the matrix remains as an Excel document. The matrix consists of two worksheets. The first worksheet highlights 43 'true' expert systems (according to the definition in Section 3.2.2) that were identified. The second worksheet highlights 37 'other' systems identified during the review, however these were not true expert systems (according to the definition in Section 3.2.2) but rather static web pages or searchable databases.

The following expert systems were identified as 'true' expert systems:

A prototype system from Sheffield University for 'Optimal repair in reinforced concrete highway bridges'

A prototype system from which assistance can be obtained in the selection of optimal repair and maintenance solutions for highway bridge structures (http://www.dft.gov.uk/stellent/groups/dft_science/documents/page/dft_science_504480-13.hcsp).

Action Checkpoints for Comfortable Computer Work

This tool helps to identify workplace risks and hazards by helping to assess an office and find solutions to create a comfortable work environment (http://www.niih.go.jp/en/gyouseki/result/pc_check/index.html).

Adaptive Knowledge Base Builder

This system was developed as part of a series of educational systems for a University to use with their own students and for research (http://ui4all.ics.forth.gr/workshop2004/files/ui4all_proceedings/adjunct/evaluation/28.pdf).

AKBB (Granic 02)

This system was developed as part of a series of educational systems for a University to use with their own students and for research (http://ui4all.ics.forth.gr/workshop2004/files/ui4all_proceedings/adjunct/evaluation/28.pdf).

ANEMIA

This knowledge based consultation system addresses the clinical problem of managing anaemic patients (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=3048868&query_hl=1&itool=pubmed_docsum).

CAPSULE System

This tool is a decision support system to help users prescribe certain types of drugs by ranking the prescription based on the arguments for and against each individual patient symptoms (HSE, 2000).

COCTO

This is a static verification tool performing redundancy and conflict detection (http://ksi.cpsc.ucalgary.ca/KAW/KAW98/preece/).

CSHM (Construction Safety and Health Monitoring) System

This expert system identifies workplace risks in the Chinese construction industry by monitoring and assessing construction safety and health performance (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=15178234&dopt=Abstract).

Dakota Decision Support Software

This tool supports regulatory compliance by helping the user to determine what regulations apply to their facility so that they can focus on the relevant areas. The tool simplifies the process of regulatory compliance auditing (HSE, 2000).

Distributed Tutor-Expert System

This is a system developed as part of a series of educational systems for a University to use with their own students and for research (http://ui4all.ics.forth.gr/workshop2004/files/ui4all_proceedings/adjunct/evaluation/28.pdf).

DLI Engineering ExpertALERT expert automated diagnostic system

This system successfully diagnoses machine spindle bearing problems (http://www.dliengineering.com/section.asp?nID=25).

DMS1

This system is used for fault diagnosis or repair (http://ksi.cpsc.ucalgary.ca/KAW/KAW98/preece/).

Drug-free Workplace Advisor

This system provides information to businesses about how to establish and maintain an alcohol- and drug-free workplace (http://www.dol.gov/elaws/drugfree.htm).

DTEx-Sys (Rosic 00)

This is a web-oriented intelligent tutoring system (ITS) that has been developed whilst considering issues such as en masse user accessibility and learning and teaching in arbitrary domains
(http://ui4all.ics.forth.gr/workshop2004/files/ui4all_proceedings/adjunct/evaluation/28.pdf).

DUST-EXPERT

The system provides information on the safe design and operation of plants that are subject to dust explosions (HSE, 2000).

EASE System (for Windows)

This tool guides risk assessment by providing both authorities and manufacturers with computer based guidance from the Regulator (HSE, 2000).

EPICEA database

This is a system that has been designed to collect information from a survey of severe and fatal accidents (http://en.inrs.fr/ - enter ‘EPICEA’ into the search engine).

FLSA Child Labour Rules Advisor

This tool supports regulatory compliance by providing answers to questions about workers and businesses that are subject to Federal child labour rules (http://www.dol.gov/elaws/esa/flsa/cl/default.htm).

FLSA Hours Worked Advisor

This tool helps employees and employers to determine the hours that an employee spends in work-related activities in order to fulfil the US labour regulatory requirements (http://www.dol.gov/elaws/esa/flsa/hoursworked/default.asp).

Health Benefits Advisor

This tool is designed to help workers and their families better understand company provided group health benefits and the laws that govern them, especially when they experience changes in their life and work situations such as marriage, childbirth, job loss or retirement (http://www.dol.gov/elaws/ebsa/health/2.asp).

Manned Manoeuvring Unit (MMU); Fault Detection, Isolation & Recovery (FDIR)

This system diagnoses faults on equipment used for space applications (http://ksi.cpsc.ucalgary.ca/KAW/KAW98/preece/).

MSHA Fire Suppression & Fire Protector Advisor

The Mine Safety and Health Administration (MSHA) designed this Advisor as a quick reference for fire suppression and fire protection (http://www.dol.gov/elaws/fire_surp.htm).

MSHA Training Plan Advisor

The Advisor will determine the name and type of mine/company from a mine/contractor identification number (ID) (http://www.dol.gov/elaws/msha_train.htm).

Multivariate State Estimation Technique (MSET) Expert System

This tool identifies risks and hazards by functioning as an early warning system for performance of sensors, equipment and plant processes (HSE, 2000).

OSHA Confined Spaces Advisor 1.1

This tool supports regulatory compliance by providing guidance to help employers protect workers from the hazards of entry into permit-required confined spaces (http://www.dol.gov/elaws/confined.htm).

OSHA Fire Safety Advisor 1.0a

This system supports regulatory compliance by interviewing users about their building, work practices, and policies at their facility (http://www.dol.gov/elaws/fire.htm).

OSHA Hazard Awareness Advisor 1.0

This tool identifies and understands common occupational safety and health hazards by asking users about activities, practices, materials, equipment, and policies at their work-place (http://www.osha.gov/dts/osta/oshasoft/leadx_wb.html).

OSHA Lead in Construction Advisor 1.0

This tool supports regulatory compliance by helping users, especially small businesses, to understand OSHA's 'Lead in Construction' standard (http://www.osha.gov/dts/osta/oshasoft/leadx_wb.html).

OSHA The SafeCare Advisor

This system identifies occupational safety and health hazards in long-term care facilities (http://www.osha.gov/dts/osta/oshasoft/safecare.html).

Permit Control & Monitoring System (PCMS)

This system identifies workplace risk and hazards by enabling effective management of permits for hazardous work environments (http://www.safetyapplication.com/products.htm).

PLC (Programmable Logic Controller) Training Course

This expert system technology for air blast circuit breakers and air dryer systems was adopted for individual on-site training (http://www.electricity-today.com).

Preventing falls from slips and trips

This system is an online e-learning course on how to prevent injuries in the workplace that are a result of slips, trips or falls from the same level (http://www.ccohs.ca/products/courses/preventing_falls/#list).

SACCO

This is a static verification tool performing redundancy and conflict detection (http://ksi.cpsc.ucalgary.ca/KAW/KAW98/preece/).

SEPIA database

This system has been designed for chemical risk prevention (http://en.inrs.fr/ - enter 'SEPIA' into the search engine and then follow links to Technical Expertise and Consulting).

SoundPLAN

This tool identifies workplace risks and hazards by modelling noise and air pollution (http://www.soundplan.com/).

SPONCOM (Spontaneous combustion (i.e. fire) that occurs in mines as a result of the over-heating of coal)

The tool helps to assess hazards in mines by predicting the spontaneous combustion potential of coal mining operations (http://www.cdc.gov/niosh/mining/pubs/pubreference/tl441.htm).

SYCOJET

This system is a structure-based expert system shell testing tool, capable of generating test cases in order to evaluate the functionality of the shell (http://ksi.cpsc.ucalgary.ca/KAW/KAW98/preece/).

TAPES

This is an expert system that help-desk workers can use for product recommendation (http://ksi.cpsc.ucalgary.ca/KAW/KAW98/preece/).

Tex-Sys (Stankov 97) (an updated version is called xTEx-Sys)

This is a system developed as part of a series of educational systems for a University to use with their own students and for research (http://ui4all.ics.forth.gr/workshop2004/files/ui4all_proceedings/adjunct/evaluation/28.pdf).

The Asbestos Advisor 2.0

This system supports regulatory compliance by providing a detailed text of regulations and allows the user to view and print the full regulation texts associated with selected topics regarding Asbestos (http://www.osha.gov/dts/osta/oshasoft/asbestos/index.html).

Tutor-Expert System

This a system developed as part of a series of educational systems for a University to use with their own students and for research (http://ui4all.ics.forth.gr/workshop2004/files/ui4all_proceedings/adjunct/evaluation/28.pdf).

VITEK2

This is an expert system which aids interpretive reading of antimicrobial resistance tests (Journal of Antimicrobial Chemotherapy, 2002).

WHONET

This is software developed for the management of microbiology laboratory data and the analysis of antimicrobial susceptibility test results (http://www.who.int/drugresistance/whonetsoftware/en/index.html).

A full description and specific details regarding each system can be found in the matrix on the CD-Rom attached to this report.

3.4 EXPERT SYSTEM CASE STUDIES

3.4.1 Introduction

The following section highlights six expert systems that were explored further during consultations with three key OH&S organisations, presented in the form of case studies. OSHA provided information on four of its expert systems, NIOSH provided feedback on one of its systems and a UK company called aSAP provided information on its only expert system. The organisations and their respective systems are summarised in Table 2.

Table 2 Summary of organisations and systems

ORGANISATION	*EXPERT SYSTEMS*
aSAP	• Permit Control & Monitoring System (PCMS)
OSHA	• The Asbestos Advisor 2.0 • OSHA Confined Spaces Advisor 1.1 • OSHA Fire Safety Advisor 1.0a • OSHA Hazard Awareness Advisor 1.0
NIOSH	• SPONCOM 1.0 (Expert System for Spontaneous Combustion in Mines)

The expert system case studies presented in the following sections include information about what each system was designed to do, the main components within the system and the level of monitoring required. Any evaluation work that may have been conducted follows the description of the system. In the case of the OHSA Advisors, only one consolidated section is presented for evaluation work because the subjective information gathered was common to all the OSHA Advisors.

It is important to note that none of the systems identified in this review had any robust evaluation evidence to indicate their success in improving health and safety.

3.4.2 aSAP Permit Control & Monitoring System (PCMS)

3.4.2.1 Purpose of system

To effectively manage permits for hazardous working environments.

3.4.2.2 Safety domain

Safe work environments (any work environment that requires a permit)

3.4.2.3 Source

http://www.safetyapplication.com/products.htm

3.4.2.4 ***Overview***

- The Permit Control & Monitoring System (PCMS) was designed to generate permits for workplaces that are considered hazardous working environments. The permits are required at workplaces in order to promote having a "safe system of work".

- This system identifies workplace risks and hazards. It ensures that the permits are correctly completed in a user-friendly workflow set-up. It essentially allows for the real time monitoring of the status of all the permits within a particular organisation or site.

- The system covers a range of safety domains from working at height to confined spaces, and excavation to electrical work. The system was designed for use by a range of industries including Oil, Gas, Pharmaceuticals and Utilities. PCMS can be used in any area where there is a requirement to monitor or perform health and safety activities in accordance with the HSE requirements.

- The system has four key components: the permit control system (manages the life cycle of the permit); the permit monitoring system (provides a 'real-time' window in which the status of all permits in the system are reported online); the administration system (provides the user with maintenance functionality) and the mobile system (provides all desktop functionality through a PDA type device).

- Some of the key functions within the system include: web based deployment over the internet, intranet and extranet; a risk assessment that is performed as part of the generation of the permit and identification of conflicts that flags up warnings if other permits are active within the same area.

- There are no aspects of this system which are unique to GB as the system is a multi-tier application based on the latest Java technology, which is Platform independent. Any country specific settings are configured as part of an 'Internationalisation module'.

- PCMS can be purchased as a bespoke system with different levels of service depending on the specific contract. There are two options for licensing the system, either by the number of potential users or as an unlimited corporate licence. PCMS can be delivered as a client server application or a web based system. It can also be delivered as an ASP hosted module.

- The system can be managed remotely or via an administrator within organisations. Once the system is up and running, it requires very little intervention and is completely sustainable. The company recommend that a single point of contact should be assigned within organisations, as this person will be responsible for administration of the system and tasks such as adding and deleting users and equipment. The system is usually updated twice a year.

- The system has been operational for six years and has been advertised through marketing seminars, relevant articles and at specific conferences. The system operates under aSAP's in-house 'System Development Lifecycle' documentation and procedures.

3.4.2.5 Evaluation(s) of the aSAP PCMS expert system

The system's developer advised that an evaluation of the PCMS was not appropriate because all specific requirements are identified from the outset as part of the user's selection criteria. As such, any evaluation would be focussing on the effectiveness or the user's selection criteria rather than the effectiveness of the PCMS tool itself.

3.4.3 OSHA Asbestos Advisor 2.0

There has been some subjective evaluation work conducted for the OSHA Advisors. This is presented at the end of this section as the feedback is common to all of the Advisors.

3.4.3.1 Purpose of system

To provide information that supports regulatory compliance regarding Asbestos.

3.4.3.2 Safety domain

Hazardous substances (Asbestos)

3.4.3.3 Source

http://www.osha.gov/dts/osta/oshasoft/asbestos/index.html

3.4.3.4 Overview

- The OSHA Asbestos Advisor is an expert system that supports regulatory compliance by providing detailed information on regulations which the user can view and print on selected topics. The Asbestos Advisor interviews users about buildings, worksites and the type of tasks workers perform.

- The Advisor produces guidance on how the Asbestos standard may apply to those buildings and particular types of work. The guidance provided depends on answers given by the user. It can provide general guidance and can also provide guidance focussed on a particular project.

- The Advisor is intended for use by building owners and managers, and for contractors that might perform work on those structures. However the system is an aid for anyone who requires information on OSHA Asbestos Standards.

- The main sections of the Advisor are: general guidance; individual project guidance; a glossary; answers to frequently asked questions about asbestos; and detailed text of the regulations.

- Although this Advisor was originally designed in the US for use in the US, it is freely available for download from the internet. The Advisor has also been distributed on disk by trade associations to its members, and by large firms to their subsidiaries.

- The version 2.0 reflects updates for revisions, corrections and clarifications of the rules published by OSHA in Federal Register September 29, 1995 and August 23, 1996.

- The system was constructed in 1995 with contractor support costing approximately $85,000, excluding the cost of agency staff and legal fees. OSHA announced the launch of the Asbestos Advisor with press releases, information on the web and also marketed it to relevant trade associations and other organisations.

3.4.4 OSHA Confined Spaces Advisor 1.1

3.4.4.1 Purpose of system

To provide information that supports regulatory compliance on working in confined spaces.

3.4.4.2 Safety domain

Confined spaces

3.4.4.3 Source

http://www.osha.gov/dts/osta/oshasoft/csa.html

3.4.4.4 Overview

- The OSHA Confined Spaces Advisor was designed to provide users with interactive expert help to apply the OSHA 'Permit Required Confined Spaces Standard' (29 CFR 1910.146). The current version of this advisor is version 1.1, which replaces version 1.0 that was developed in March 1997.

- The Confined Spaces Advisor will interview the user about a workspace in order to determine whether, and how, it is subject to the Permit Required Confined Spaces Standard. It will advise the user about what aspects of the standard applies to them based on the answers they have provided.

- The system was specifically designed to be used for any work to be carried out in confined spaces that have hazardous conditions.

- This system helps all kinds of users in general industry apply the OSHA Permit Required Confined Spaces Standard. It determines whether a space is a 'confined space' and whether it is a 'permit required confined space' in order to provide appropriate guidance for safe work.

- This tool analyses facts to determine the applicability of US Department of Labour regulations.

- It is available for download from the internet and has been distributed on disk by trade associations to their members and large firms to their subsidiaries. This system is downloaded approximately 500 times per month from the Internet.

- The system was updated in December 1997 and has not changed since.

- The system was constructed with contractor support costing approximately $75,000, excluding the cost of agency staff and legal fees.

3.4.5 OSHA Fire Safety Advisor 1.0a

3.4.6 Purpose of system

To provide users with guidance on how to apply OSHA's 'General Industry Standards' for fire safety and emergency evacuation.

3.4.7 Safety domain

Fire safety

3.4.7.1 Source

http://www.osha.gov/dts/osta/oshasoft/softfirex.html

3.4.7.2 Overview

- OSHA's Fire Safety Advisor provides users with interactive expert help to apply OSHA's 'General Industry Standards' for fire safety and emergency evacuation (Subpart E, 29CFR1910.36, 37 and 38).

- The Advisor interviews the user about various issues such as the conditions of a building to assessing compliance with the relevant standards. It will tell the user what aspects of the standard apply to them, based on the answers provided by the user. The safety domain that this system addresses includes fire safety and emergency evacuation; fire fighting; fire suppression; fire detection systems and equipment; fire prevention plans; and emergency action plans. The system helps all kinds of users apply the OSHA fire safety standards in general industry. These rules apply to any site from a one-room building to a large factory.

- The main functions within the system include: functionality to write customised 'Emergency Action Plans' and 'Fire Prevention Plans'; the capability to analyse the user's answers with expert decision-logic; and allowing the user to conduct detailed compliance reviews.

- It is available for download from the internet in a software format and is downloaded approximately 600 times per month. It is important to note that this system has many rules that are interlinked. This means that decisions and / or actions under one area of the rules may trigger responsibilities under other sections. Standard programmes can often miss these interlinked rules; however this system was designed so that it does not miss interlinked rules.

- The system was revised in September 2000 and has not changed since. The system was developed with contractor support costing approximately $85,000 excluding the cost of agency staff and legal fees. The system has been operational for six years.

- The system was marketed with press releases and was featured on the OSHA website. The system was also marketed to relevant trade associations, and other organisations.

3.4.8 OSHA Hazard Awareness Advisor 1.0

3.4.8.1 Purpose of system

To provide information that supports Regulatory compliance on hazard awareness.

3.4.8.2 Safety domain

General health and safety in the workplace (hazard identification)

3.4.8.3 Source

http://www.osha.gov/dts/osta/oshasoft/hazexp.html

3.4.8.4 Overview

- This system was designed to help user's determine which of the OSHA 'Standards for General Industry' (29 CFR 1910) apply to the work performed at their organisation or site. This is a hazard identification tool, which advises on a range of areas such as slips and falls, noise, ventilation and radiation.

- The Hazard Awareness Advisor interviews users about the work to be performed, the chemicals used, any operational policies, and any other aspects of the workplace. It then determines and identifies the regulations that are most likely to apply. The system's main purpose is to identify common hazards and provide the user with very basic guidance about those hazards.

- The tool was designed to aid small and medium sized businesses. However, many large companies in the US and companies of varying sizes in other countries also use this tool.

- This expert system has over 500 logical rules built into it, which select from more than 300 blocks of guidance to produce unique customized reports. It analyses facts to determine the applicability of US Department of Labour regulations.

- Although this tool has a wide range of uses, the developers advise that it is not recommended for use within agricultural, maritime, or construction worksites as they involve specific hazardous situations not addressed by this tool.

- The system is available as downloadable software from the internet. It has also been distributed electronically and on CD-Rom by trade associations to their members and by large firms to their subsidiaries.

- The system was constructed with contractor support costing approximately $150,000 excluding the cost of agency staff and legal fees. This expert system has been in use for seven years.

- This system was initially announced with press releases. It was then marketed through the OSHA website and through relevant trade associations and other bodies. The OSHA Hazard Awareness Advisor has also been presented at safety conferences.

3.4.9 Evaluation(s) of the OSHA Expert Advisors

The OSHA Advisors have not been evaluated in the formal sense (i.e. an experimental design consisting of measures before and after use of the system). However the system developers have done some subjective opinion gathering. The feedback suggested that the Advisors were well received by users and were also user-friendly. In addition to this, several hundred websites (e.g. business, military and university websites) all point to the OSHA Advisors for further information and guidance. The developer of the Advisors highlighted that next time they developed an Advisor they would use the latest 'expert system shell' to write the logic rules.

3.4.10 NIOSH Spontaneous Combustion Expert System (SPONCOM)

3.4.10.1 Purpose of system

To help identify the risks and hazards of spontaneous combustions in mining operations.

3.4.10.2 Safety domain

Mining safety

3.4.10.3 Source

http://www.cdc.gov/niosh/mining/products/product97.htm

3.4.10.4 Overview

- Spontaneous combustion in mining operations is a risk emanating from the over-heating of coals, which can cause fire in mines. NIOSH identify five main causes of

spontaneous combustion: the properties of the coal; the geological conditions of the mine; the mining practices (methods of extracting coal); mining conditions (e.g. temperature and light levels); and the history of coal operations in the area. Accordingly, these factors represent the main components of the SPONCOM expert system.

- The system was designed to allow mining companies to assess whether they would have a problem with spontaneous combustion caused by the over-heating of coals in mines. This system was designed for use prior to the mining work commencing on site and should ideally be utilised at the planning and design stages of a mine operation by mining engineers.

- Mining follows a similar process regardless of geographical location, and although this tool was developed in the U.S. and operates under the U.S. Code of Federal Regulations, it serves a generic purpose for underground coal mining work.

- Mines are significantly larger work sites today than they were in the past, and therefore the system was updated to reflect this in 2004, by increasing the limits on the input levels. This modification occurred largely due to feedback from users.

- The system is written in DOS-based C++ programming language and is yet to be converted into a Windows based format.

- The SPONCOM expert system was developed under a research programme and does not cost NIOSH anything to run (apart from infrastructure costs).

- The system was developed in 1995 and has been available for use for 10 years. The system was available on floppy disk until 1996; at this time the system became freely downloadable from the NIOSH website. NIOSH records the number of times the system is downloaded from the website.

- The tool has been marketed by NIOSH at relevant conferences, through trade magazines and on its own webpage. SPONCOM is also advertised through a specific marketing tool called ‘Technology News’ which has 3,000 members on its mailing list.

3.4.10.5 Evaluation(s) of the SPONCOM expert system

The SPONCOM expert system has not been evaluated robustly by its developers in terms of its effect on health and safety. However, the developers state that it is considered the standard method for assessing the risk of spontaneous combustion because NIOSH has distributed approximately 800 copies of it.

NIOSH has subjective feedback about the system which they collected by talking to the users of the system. The feedback from users suggests that the SPONCOM system is a successful aid to making changes to ventilation designs. Users also felt that the system was user-friendly, because instead of producing pages of output data, SPONCOM provides useful explanations. In

addition, the US Regulatory Agency was reported to accept the use of the SPONCOM system and has confidence in its application.

The developers of SPONCOM believe that the tool does help to reduce the risk of spontaneous combustion as it makes users aware of the risks, although this is not supported by any robust evaluation evidence.

The system is free to use and was rated as ‘high’ for value for money by its developers. NIOSH state that they would produce SPONCOM in the same way again, because it has been based on decades of research. However, the developers agree that SPONCOM should now be transferred into a Windows format.

4 CONCLUSIONS

In relation to the initial objective, the following conclusions can be drawn from the work undertaken in this project:

Overall objective: **To carry out a thorough review of expert systems OH&S organisations (including Regulators) have used/adopted to address the following workplace risks: work at height; workplace transport; slips and trips and noise and vibration**

1. At present, there is limited information available in the public domain regarding expert systems designed to address health and safety issues. Furthermore, there is very limited information regarding any expert system that may address the specific health and safety issues of interest (e.g. work at height; workplace transport; slips and trips and noise and vibration).

2. Consulting with key organisations did not provide any further information. Most organisations did not use expert systems in relation to health and safety. However, when developing its own system HSE should consider general factors which (based on the anecdotal evidence from the consultations) are likely to naturally drive an increase in the use of expert systems. HSE should consider taking into account country specific social, economic and cultural factors that are likely to impact on the successful development of health and safety related expert system technology.

3. Of the 43 'true' expert systems that were identified, the information was limited and did not address the specific health and safety areas of interest to HSE. No robust evaluation evidence was available to assess their impact on health and safety. Reasons given why organisations had not conducted robust evaluations included: it is not in the interests of the organisation; it is not applicable (e.g. aSAP's PCMS does not require evaluation because the system is designed to meet the client's selection criteria); and subjective opinion gathering of users was felt to suffice as evaluation work.

4. Six systems were focused on in more depth, but no robust evaluation evidence existed. Of these six expert systems, five out of the six were developed in the US.

5. It was agreed, following consultation with the HSE, that the lack of evaluation evidence meant that no further value would be gained from taking the analysis further.

5 RECOMMENDATIONS

The purpose of this study was to carry out a thorough review of expert systems other OH&S Regulators, non-Regulators and industry have used/adopted to address the workplace risks involving: work at height; workplace transport; slips and trips and noise and vibration. Based on the work undertaken, the following recommendations have emerged from this study:

1. Expert systems industry workshop

In order for HSE to develop expert systems that will be used successfully by industry, it is imperative to consult industry early on about what they would expect from a system of this nature in terms of content, format, maintenance and usability. Therefore, in order to provide HSE with further guidance on how to develop expert systems, an industry workshop is proposed to gather feedback from potential users on various issues regarding format, usability and content.

2. Keep abreast of expert systems research

The HSE should plan to review research and development in the area of health and safety related expert systems over the coming years, as it is likely that other organisations will follow suit of those based in the US. It is therefore recommended that the HSE revisit the research in the next three to five years to keep abreast of new developments regarding health and safety related expert systems.

3. Continue effort to develop HSE's own expert systems

The original objective of this study was to assist the HSE in making evidence-based decisions in order to develop its own expert systems for managing workplace risks. In light of the current findings, it is not possible to apply any lessons learnt due to the lack of evaluation evidence available. However, this lack of evidence should not necessarily discourage HSE from developing its own expert systems if a need for such systems has been identified. This will mean that HSE will have to take the lead in developing such expert systems rather than incorporating the lessons learnt by other regulators.

6 REFERENCES

The main sources referenced in this report are presented below. The complete list of references for each of the expert systems identified can be found in Section 3.3.3 of this report.

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APPENDIX A

LIST OF ORGANISATIONS SELECTED FOR CONSULTATION

EVALUATION INTO THE SUCCESS OF OTHER REGULATORS USE OF EXPERT SYSTEMS

EXPERT SYSTEMS CONSULTATION WITH INTERNATIONAL REGULATORS AND PRIVATE COMPANIES

This document has been designed to further address the HSE objective:

- To carry out a thorough review of expert systems other OH&S Regulators have used/adopted to address the following workplace risks: work at height; workplace transport; slips and trips and noise and vibration.

This objective is to be achieved through Activity 2, which proposes:

- To conduct a series of interviews with key international OH&S regulators and organisations, to explore their use of expert systems.

This document presents a table which details a range of International regulators and private companies identified for the expert systems consultation. It is recognised that an initial ten organisations are to be contacted, however a total of 27 have been identified as relevant and these are highlighted in Table 1. Each organisation has been assigned a 'priority ranking' to reflect the relevance and potential value of consulting with each of them. Table 1 also specifies whether the organisation is a Regulator, if it addresses one or more of the HSE risk areas and if there is a special interest in consulting with that organisation. The criteria for identifying special interests in particular organisations includes: UK specialist non-regulatory bodies; national non-regulatory OH&S bodies; and organisations where expert systems have been identified. This serves to further compound the factors which have contributed to the ranking process.

International regulators identified for consultation originate from the more developed countries as they are more likely to be designing and developing expert systems. In addition, private companies from the high hazard industries, in particular the oil, gas, nuclear, construction and manufacturing industries were selected for consultation. A realistic indicator of the possible use of expert systems by private companies is likely to be their size (i.e. larger companies are more likely to use expert systems compared to smaller companies). The private companies highlighted in Table 1 are therefore the major companies within their industry.

It is suggested that HSE and BOMEL discuss the organisations that have been identified and the number of interviews to be conducted following receipt of this document to agree the way forward.

Table 1 highlights the 27 organisations (International Regulators and private companies) to be consulted with, in order of priority. Each organisation has been given a 'priority ranking' to represent its relevance and the perceived value of consultation based on whether the organisation is an OH&S Regulator, whether it addresses one or more of the HSE risk areas and whether or not there are any other special interests relating to the organisation (e.g. organisations where expert systems have been identified). This is further clarified by the reasoning given for consultation with these organisations.

Table 1 UK and International OH&S Regulators and industry organisations proposed for consultation

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
1	Health and Safety Executive (HSE) Rose Court 2 Southwark Bridge London SE1 9HS +44 (0) 8453450055	GB Occupational Health and Safety Regulator	• Slips Assessment Tool (SAT) • Noise Exposure Calculator • Hand-arm Vibration Calculator • Whole-body Vibration Calculator	HSE will be the first point of contact for this project. It will be necessary to speak to the relevant Programme teams to establish what other expert systems are in place (in addition to those identified) and the impact that these systems are having in the specific workplace risk areas. This consultation will enhance the knowledge gathered from the initial literature search.	X	X	X
2	Occupational Safety and Health Administration (OSHA) U.S. Department of	US Occupational Health and Safety Regulator	• OSHA e-law Advisors: Asbestos; Confined spaces; Mining Fire Suppression; Hazard	In comparison to all of the international regulators chosen for further investigation, OSHA has by far the largest selection of online expert systems. The majority fall under the banner of e-law advisors presented as a series of web pages. Although the majority of OSHA's expert systems are	X	X	X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Labor OSHA Coordinator for International Affairs Occupational Safety & Health Administration - Room N3641 200 Constitution Avenue Washington D.C. 20210 +1 800321-OSHA (6742)		Awareness; Lead in Construction; SafeCare • e-tools: Scaffolding; Fall Protection	not specific to the workplace risks of direct interest to the HSE project team, generic lessons learnt in developing and evaluating systems can be applied to other industries / job tasks. Therefore it is a priority to contact OSHA because they appear to be the most experienced in terms of designing and developing expert systems in general. Of particular interest are the e-tools for scaffolding and fall protection, because they address work at height issues and are considered as good case studies for this project. OSHA is also of special interest because it already has expert systems that are used by workers.			
3	Department for Transport (DfT) Great Minster House 76 Marsham Street London SW1P 4DR +44 (0) 20 7944	UK Transport Regulator	No systems identified	DfT is the UK's Transport Regulator and is therefore likely to be at the forefront of technology for different modes of on-road transport. Therefore any expert systems identified have the potential to be applied to workplace transport (driven on the road) making consultation with DfT important.	X	X	X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	8300						
4	Department for Environment, Food and Rural Affairs (DEFRA) Department for Environment, Food & Rural Affairs Nobel House 17 Smith Square London SW1P 3JR +44 (0) 207238 6951	UK Agriculture Regulator	No systems identified	DEFRA is the UK's Regulator for food and rural affairs. It is likely that they may have developed expert systems for agricultural workers to use, especially during the foot and mouth crisis. As agricultural workers are predominantly field-based, it is highly likely that expert systems identified are designed to prevent accidents such as falls through roofs and also that they are particularly user-friendly. Therefore HSE could potentially learn valuable lessons by including DEFRA in the consultation.	X	X	X
5	Civil Aviation Authority (CAA) 45-59 Kingsway London WC2B 6TE +44 (0) 2073797311	UK Specialist Aviation Regulator	No systems identified	It is regarded essential to consult the major UK regulators, namely those responsible for land (HSE), air (CAA) and sea (MCA) in order to gain an understanding of the extent of their expert systems use. It is envisaged that any systems identified within CAA (and also MCA) are likely to have applicability to HSE as they have been developed in a UK context. It is highly likely that the CAA use some of the more	X		X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
				'advanced' expert systems, compared to other regulators because of the nature of this organisation.			
6	Maritime and Coastguard Agency (MCA) Marine Office Central Court Knoll Rise Orpington Kent BR6 0JA +44 (0) 1689890400	UK Shipping and Maritime Regulator	No systems identified	The use of expert systems is generally more widespread in high hazard industries, in particular the maritime industries. Therefore as well as the CAA, it is important to consult the organisation concerned with shipping safety in the UK. It is likely that the MCA has expert systems in use and that they are fairly sophisticated, because they are responsible for the security of UK and international shipping.	X		X
7	Rail Safety and Standards Board (RSSB) Evergreen House 160 Euston Road London NW1 2DX +44 (0) 2079047518	GB Rail Regulator	No systems identified	It is important to include RSSB in the consultation because it is the UK's official Rail Regulator. It is likely that RSSB are using expert systems which are of special interest as they could be applied to the HSE risk areas, namely workplace transport.	X		X
8	International	International	No systems	Nuclear is a major hazards industry and the IAEA is the	X		X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Atomic Energy Agency (IAEA) International Atomic Energy Agency P.O. Box 100 Wagramer Strasse 5 A-1400 Vienna Austria +431 26000	Nuclear Regulator	identified	world's central intergovernmental forum for scientific and technical co-operation in the nuclear field. Therefore IAEA should be included in the consultation because it is likely that they themselves (or other industry members) have developed technology and indeed expert systems for major hazards and this thinking may be transferable to the HSE risk areas of interest which could be transferred into systems for minor hazards.			
9	Occupational Safety and Health Service (OSH New Zealand) 4th Floor, Unisys House 56 The Terrace Wellington New Zealand +64 (04) 915 4444	New Zealand Occupational Health and Safety Regulator	No systems identified	Despite no expert systems being identified from the literature search, it is important to consult with OSH in New Zealand because it is the official Regulator. This Pacific island shares the same reputation for industry and economy growth typical of countries in the west. Therefore important lessons can be learnt regarding expert systems by consulting with OSH in New Zealand.	X		X
10	The National Institute for	US Federal Agency for	• NIOSH Noise Meter	NIOSH is currently conducting a general evaluation of their hearing loss programme and it would be		X	X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Occupational Safety and Health (NIOSH) Nancy Stout Ed.D. Director Division of Safety Research (DSR) 1095 Willowdale Road Morgantown WV 26505-2888 Outside the U.S. +1 5135338328	Occupational Health and Safety Research	• 'SPONCOM' is a computer software system to help mining workers predict spontaneous combustion potential of a coal mining operation. • Hearing Loss Simulator (HLSim) Version 2.2.0.26 • The Coal Mine Roof Rating (CMRR) • Mine Emergency Response Interactive Training Simulation (MERITS) 1.0.15 • Vibrational Acceleration Statistical Analysis (VASA) Beta	informative to know what progress has been made as NIOSH may have already conducted evaluation studies for their various tools available online. There are some evaluation data available (possibly conducted in 2002) for the MERITS system; however its reliability is questionable because of lack of detail available in the public domain. NIOSH should be contacted as their evaluation programme is already underway and this could be an opportunity for the HSE to learn important lessons from them. Again NIOSH is of special interest because already have expert systems in use.			

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
			version				
11	National Occupational Health and Safety Commission (NOHSC) The Alan Woods Building Level 6 25 Constitution Avenue Canberra ACT 2601 Australia +61 0261216000	Australian Occupational Health and Safety Statutory Authority	• Hazardous Substances Information System (HSIS) (internet database) • OHS Practical Solutions database (a series of web pages)	The HSIS was identified as a good system to consider as a case study for the project. It may be the most applicable system to the UK because some of the criteria for legislation have been adopted from EC legislation.			X
12	I'Institut national de la recherche (INRS) Paris Centre 30 rue Olivier Noyer 75680 Paris	French Occupational Health and Safety Non-profit association	• SEPIA (definition unknown) • EPICEA (definition unknown)	Despite very limited information being generated from the literature search regarding expert systems in France, the French organisation concerned with OH&S has been included because two potentially interesting systems have been identified and it is important to learn more about these, and possibly others that may not be in the public domain.			X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Cedex 14 France +33 (0) 140443000						
13	Canadian Centre for Occupational Health and Safety (CCOHS) 135 Hunter St E Hamilton Ontario L8N 1M5 Canada +001 9055708094	National Canadian information resource in occupational health and safety	No systems identified	Although no expert systems were identified during the literature search, the Canadian OH&S organisation, CCOHS, has been included in the consultation. This information centre is renowned internationally for innovation and authoritative occupational health and safety resource. CCOHS collaborates with similar organisations around the world and aims to improve the scope and use of OH&S information in many different sectors of society. Therefore it is likely that the breadth and reliability of information from CCOHS will be of a high standard.			X
14	National Institute of Industrial Safety (NIIS) 1-4-6 Umezono Kiyose Tokyo 204-0024 Japan	Independent Administrative Institution under the Ministry of Health, Labour and Welfare	No systems identified	Japan is currently regarded as the fastest growing economy in the world and holds a reputation for innovation and advanced technology. It is therefore important to consult with Japan to see what lessons can be learnt.			X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	+0081 424914512						
15	International Labour Organisation (ILO) International Labour Office 4 route des Morillons CH-1211 Geneva 22 Switzerland +41 2279 6111	United Nations specialised agency	• Construction Safety and Health Monitoring (CSHM) System (includes work at height and slips and trips components) – has been studied in the Chinese construction industry.	The ILO does not have information on their website regarding systems that they use themselves, so consulting with them will reveal what systems they may use and also identify what other systems they have identified from around the world. An example of this is the study conducted in China with the Construction Safety and Health Monitoring System, which is also a relevant system considered for case study.		X	X
16	The World Health Organisation (WHO) Avenue Appia 20 1211 Geneva 27 Switzerland + 41 227912111	United Nations specialised agency	• Medicine e-tools • Food control systems	Although WHO only has e-tools for medicine and food available on its website, it is important to include in the consultation because it is an International organisation and may have access to literature which would otherwise be unavailable in the public domain.			X
17	International	Non-profit	No systems	The ISFP is an international organisation concerned		X	

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Society for Fall Protection (ISFP) 187 Parfitt Way SW Suite 200 Bainbridge Island Washington 98110 USA +001 8774728483	voluntary safety organisation	identified	with fall protection and heights safety. Although it is non-regulatory in nature and is primarily involved in the dissemination of fall protection information, this US based organisation would be highly likely to have come across expert systems in this field. Therefore because of its specific focus on fall protection and heights safety, it is important to consult with ISFP.			
18	The Environment Agency Net – Regs Project Team Environment Agency Block One, Government Buildings Burghill Road Westbury-on-Trym Bristol	UK Government Agency	• 'Netregs' is an internet based system that gives advice on how to comply with environmental law as well as advice on good environmental practice.	Netregs is a similar system to the OSHA e-laws, in terms of providing guidance. It may be that OSHA is more advanced than the Environment Agency is in developing expert systems. Therefore, although the Environment Agency is not as crucial to contact as OSHA is, it does need to be consulted because they are a UK regulator and obstacles they face may be relevant to the HSE.			X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	BS10 6BF +44 (0) 8708506506						
19	NHS Confederation 29 Bressenden Place London SW1E 5DD +44 (0) 2070743200	Confederation	• PHEONIX • VITEK • VITEK2 Medical expert systems for researchers – definitions for each are unknown	The NHS is highly likely to be using some form of expert systems due to the increasing workload pressures common in the UK health care industry. Furthermore, much of the expert system literature cites system examples derived from a medical context and it is therefore anticipated that NHS systems may be very advanced and therefore valuable lessons may be learnt. Therefore, the NHS is likely to be a key organisation to consult with as it is likely to be using sophisticated expert systems.			X
20	Occupational Road Safety Alliance (ORSA) c/o Royal Society for the Prevention of Accidents 353 Bristol Road Birmingham B5 7ST	Association	• 'Drivetronics' system	ORSA is a UK association aimed at raising awareness of occupational road risk. Of special interest is the expert system 'Drivetronics' which has been identified from the literature search and consulting with ORSA would serve to learn more about this system and any other systems that may be in use.			X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	+44 (0) 1212482095						
21	Food Standards Agency (FSA) Aviation House 125 Kingsway London WC2B 6NH +44 (0) 2072768000	Independent UK Government Department	No systems identified	The FSA has been included for consultation, despite its function being non-regulatory and the lack of systems identified. The FSA is a good example of where expert systems might be used because of the nature of their work and it is likely that they have come across expert systems which the HSE could learn lessons from. In addition, BOMEL has a contact at the FSA.			X
22	Taylor Woodrow 2 Princes Way Solihull B91 3ES United Kingdom +44 (0) 1216008000 (Taywood / Hemdean Consulting)	Construction Company	• Hemdean Consulting have produced a knowledge management system for Taylor Woodrow. • Also systems found on their website: e-COGNOS system, e-Construct system, ProdAeC (definitions	In order to have a mix of safety critical industries for consultation, construction companies should also be consulted. Taylor Woodrow is working on projects around the world and employs over 6,000 staff. Taylor Woodrow has a research and development division within it called 'Taywood' which will be the first point of contact. An independent consultancy developed an expert system for Taylor Woodrow, however information about the system is limited. It is unknown whether the other systems found on their website were developed by the same consultancy or in-house.			X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
			unknown)				
23	Advanced Safety Applications and Procedures Ltd (aSAP) Broadgate Court 199 Bishopsgate London EC2M 3TY +44 (0) 2078146618	Limited Company	• PCMS Permit Control & Monitoring System	A company called aSAP has been included for consultation because its principle function is to develop and sell expert systems for industry use. Therefore consulting with aSAP would not only highlight further expert systems developed or under construction, but also give HSE reliable information about the lessons that could be learnt.			X
24	Nirex Ltd Curie Avenue Harwell Oxfordshire OX11 0RH UK +44 (0)1235 825 500	Nuclear Waste Management Company	No systems identified	Although the International Regulator for the Nuclear industry has been included, it is important to involve the industry itself. Nirex has therefore been chosen for consultation because it is one of the UK's largest nuclear companies. It is likely that Nirex is using expert systems and it may be possible for HSE to transfer the technological lessons to its key risk areas.			X
25	BP 501 Westlake	Oil Company	No systems identified	BP is one of the major companies in the exploration and production of crude oil and has a workforce of over			X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Park Blvd Room 17.150 Houston TX 77079 USA (260 Balham High Rd London SW17 7AN +44 (0) 2086724511)			100,000. Although no expert systems were identified on their website, it is fairly likely that BP has expert systems of some kind in use for their employees. BOMEL also has a contact at BP.			
26	BG Thames Valley Park Reading Berkshire RG6 1PT United Kingdom +44 (0) 1189353222	Gas Company	No systems identified	BG is a leading player in the global energy market and has approximately 4,800 staff internationally. No expert systems were identified however it is likely that BG has expert systems in use for their workforce. In addition BOMEL has a contact at this organisation.			X
27	AstraZeneca 15 Stanhope Gate London W1K 1LN	Pharmaceuticals Manufacturing Company	No systems identified	In addition to including oil, gas and construction companies in the consultation, representative organisations from the manufacturing industry have also been included in order to get a cross section of companies. AstraZeneca is one of the major			X

Priority ranking (1- 27)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	+44 (0) 20 7304 5000			pharmaceuticals companies and employs over 64,000 staff worldwide. Although no expert systems were identified on their website, it is likely that with the size of their workforce, some form of expert systems may be in use.			

Table 2 highlights a further 19 organisations to be consulted with, subsequent to the original list of 27. This second list is Phase 2 of the consultation, in the event that organisations from the original list did not wish to participate, or could not provide further information. Note that none of these organisations were identified as using expert systems from the passive literature search.

Table 2 UK and International OH&S Regulators and industry organisations proposed for Phase 2 consultation

Priority ranking (28 - 46)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
28	Health and Safety Executive for Northern Ireland (HSENI) 83 Ladas Drive Belfast BT6 9FR +44 (0) 28 9024 3249	Northern Ireland Occupational Health and Safety Regulator	No systems identified	HSENI is the OH&S Regulator for Northern Ireland and has been included for consultation. Although no systems were identified during the literature search it is likely that this enforcing authority may have come across expert systems from which HSE could learn lessons from. HSENI has been given priority over HSA (Ireland) because Northern Ireland is within the UK.	X		
29	National Authority for Occupational Health and Safety (HSA) 10 Hogan Place Dublin 2 Ireland +00 353 1 614	Irish Occupational Health and Safety Regulator	No systems identified	The OH&S Regulator in Southern Ireland has also been included for consultation. One of the principal functions of this Regulator is to develop new laws and standards; therefore it is likely that HSA (with its added European Union backing) may be developing expert systems that could just as easily be adapted for use in the UK.	X		

Priority ranking (28 - 46)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	7000						
30	Health and Safety at Work Inspectorate (HSWI) Murray House Mount Havelock Douglas Isle of Man IM1 2SF +44 (0) 1624 685952	Isle of Man Occupational Health and Safety Regulator	No systems identified	HSWI has been identified as an organisation which should be consulted with because it may have also come across expert systems which they are using themselves and from which HSE could learn important lessons from.	X		
31	Federal Institute for Occupational Safety and Health (FIOSH) Friedrich-Henkel-Weg 1-25 D-44149 Dortmund P.O. Box 17 02 02 44061 Dortmund	Federal institute under public law	No systems identified	FIOSH is the German organisation concerned with OH&S; however no expert systems were identified during the literature search. As FIOSH is not a Regulator it is likely that much of their work involves research and information. Consultation with this organisation will not only serve to enhance the information gathered from the literature search, but also allow HSE to learn lessons from any systems they may have developed themselves.			X

Priority ranking (28 - 46)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Germany +00 4923190710						
32	National Institute of Occupational Health (NIOH-DK) Lersó Parkallé 105 DK-2100 Copenhagen Denmark +0045 39165200	Government research	No systems identified	Although the Danish organisation concerned with Occupational health is in a research role, it is likely that they may have come across expert systems for use in Denmark or other countries. Consultation with this organisation will not only serve to enhance the information gathered from the literature search, but also allow HSE to learn lessons from any systems they may have developed themselves.			X
33	Finnish Institute of Occupational Health (FIOH) Topeliuksenkatu 41aA FIN-00250 Helsinki Finland +00358 304741	Research and specialist institute	No systems identified	Consultation with FIOH will not only serve to enhance the information gathered from the literature search, but also allow HSE to learn lessons from any systems they may have developed themselves.			X
34	National Institute of	Scientific and professional	No systems identified	The INSHT operates primarily in a research role and therefore are likely to be researching how expert			X

Priority ranking (28 - 46)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Safety and Hygiene at Work (INSHT) c/Torrelaguna 73 28027 Madrid Spain +0034 913636100	specialised body		systems could be applied to industries in Spain. It is also likely to be in a similar stage as HSE in terms of developing expert systems. It is of benefit to consult with INSHT because they may have come across expert systems that would compliment the literature search, but also may be using systems that HSE could adapt for the UK context.			
35	International Commission on Occupational Health (ICOH) Via Fontana Candida 1 I-00040 Monteporzio Catone Italy +0039 0694181407 / 204	Non-governmental organisation	No systems identified	The Italian organisation concerned with Occupational health has been included for consultation, despite it being non-regulatory and the lack of systems identified from the literature search, because it is possible that they are using expert systems, or at least have come across systems. Consultation with this organisation will not only serve to enhance the information gathered from the literature search, but also allow HSE to learn lessons from any systems they may have developed themselves.			X
36	Occupational Safety	Non-governmental	No systems identified	The organisation concerned with OH&S in the Czech Republic is CIVOP and has been included for			X

Priority ranking (28 - 46)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Information and Education Centre (CIVOP) PodebradskÁ 56/186 198 00 Praha 9 Czech Republic +0042 2862045/0042 266107509	independent organisation		consultation because of the differential economic and social conditions compared to more western societies such as the US and UK. It is of special interest to learn more about how the Czech Republic is shaping its approach to expert systems and specifically whether they have developed any particular systems, and in what sector of industry they have been utilised.			
37	Centre for the Improvement of Working Conditions and Environment Lahore (CIWCE) CIWCE (Near Chandni Chowk) Township Lahore Pakistan +0092	Government body (Punjab)	No systems identified	In addition to Europe, New Zealand and the US, it is important to include Asia in the International review. The organisation concerned with OH&S in Pakistan has therefore been included. It is unlikely that advanced expert systems exist in Pakistan due to the low literacy levels amongst the workforce. However, it may be useful to learn about any basic systems that are in use.			X

Priority ranking (28 - 46)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	425123537 / 5150042						
38	Institution of Occupational Safety and Health (IOSH) The Grange Highfield Drive Wigston Leicestershire LE18 1NN +44 (0) 1162573100	UK Occupational Health and Safety independent organisation	No systems identified	Although IOSH is a UK organisation, no expert systems were identified and therefore it is not viewed as essential as the other UK organisations to be consulted with. However it is likely that IOSH may have come across expert systems which would complement the literature search.			
39	Advisory Committee on Work at Height (ACWAHT) Secretariat to the Advisory Committee on Work at Height Training c/o CDTU Health and	Industry committee set up by HSE	No systems identified	ACWAHT has been included for consultation because its principle activity is to develop guidance on training for work at height across different industries, therefore it may be that this organization has either developed some form of expert system or more likely has come across expert systems which HSE could learn lessons from.		X	

Priority ranking (28 - 46)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Safety Executive 5th Floor Grove House Skerton Road Manchester M16 0RB						
40	Association of Noise Consultants (ANC) 6 Trap Road Guilden Morden Near Royston Hertfordshire SG8 0JE +44 (0) 1763852958	Corporate organisation	No systems identified	ANC is a corporate organisation whose primary concern is to improve the standards and services for the protection of noise and vibration, therefore the ANC has been included for consultation as they address one of the HSE's key risk areas. It may be that ANC have come across systems specific to protection from noise and vibration that the HSE could adapt.		X	
41	United Kingdom Atomic Energy Agency (UKAEA) Harwell	Non-departmental public body	No systems identified	Although the International Regulator for the Nuclear industry has been included for consultation, it is still thought important to consult with the UK Nuclear organisation. UKAEA may already have expert systems in place and / or in use, which may have been			X

Priority ranking (28 - 46)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	International Business Centre Didcot Oxon OX11 ORA +44 (0) 1235820220			designed specifically for the UK context.			
42	British Industrial Truck Association (BITA) 5-7 High Street Sunninghill Ascot SL5 9NQ +44 (0) 1344623800	UK Trade Association for the Industrial Truck Industry	No systems identified	BITA is a trade association which represents all the major interests of the industrial truck industry and this is likely to include OH&S of drivers. Consultation with this organisation will not only serve to enhance the information gathered from the literature search, but also allow HSE to learn lessons from any systems they may have developed themselves.			
43	Federation of Master Builders (FMB) Gordon Fisher House 14-15	Trade Association	No systems identified	The FMB has been included for consultation because it is a represents the interests of employers and workers in the building industry and it is highly likely that have come across expert systems that cover at least one of the HSE risk areas.		X	

Priority ranking (28 - 46)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Great James Street London WC1N 3DP +44 (0) 2072427583						
44	British Safety Industry Federation (BSIF) Unit 3 Ffrodd Richard Davies St Asaph Business Park Glascoed Road St Asaph Clwyd LL17 7LJ +44 (0) 1745585600	Trade body	No systems identified	The BSIF has been included for consultation because it is concerned with cross industry safety and therefore is likely to have come across expert systems across different industries. Consultation with this organisation will not only serve to enhance the information gathered from the literature search, but also allow HSE to learn lessons from any systems they may have developed themselves.			
45	British Glass Manufacturer's Confederation 9 Churchill Way Chapeltown	Trade Association	No systems identified	Manufacturing is considered to be a high hazards industry and it is likely that this trade association would be representing the OH&S interests of its workers, through advocating use of expert systems. Although this organisation is unlikely to be developing systems			X

Priority ranking (28 - 46)	*Name of organisation*	*Status of organisation*	*Expert systems identified from literature search*	*Reasons for consulting*	*Regulator*	*HSE risk area*	*Special interest*
	Sheffield S35 2PY +44 (0) 1142901850			themselves, they may have come across systems specific to glass manufacturing that could be adapted to suit other industries.			
46	British Rubber Manufacturer's Association 6 Bath Place Rivington Street London EC2A 3JE +44(0) 2074575040	Trade Association	No systems identified	In addition to the glass manufacturing trade association, the British Rubber Manufacturer's Association has been included for consultation, in order for HSE to learn more about expert systems that may be in use in the manufacturing industry.			X

APPENDIX B

QUESTION SET DEVELOPED FOR USE WHEN ENGAGING WITH ORGANISATIONS

EVALUATION INTO THE SUCCESS OF OTHER OH&S REGULATORS USE OF EXPERT SYSTEMS

OVERVIEW

BOMEL is an independent research consultancy conducting research on behalf of the Health and Safety Executive (HSE) in Great Britain (GB) to understand more about how expert systems are being used by International OH&S Regulators and industry to manage workplace risks. The aim of the research is to help the HSE understand how it can learn important lessons from the success of other organisation's use of expert systems to manage workplace risks.

EXPERT SYSTEMS

An expert system can be described as a computer application that uses specialist domain knowledge to suggest solutions to problems in a particular discipline, for example, expert systems can help to diagnose human illnesses, make financial forecasts and identify and manage workplace risks and hazards. These types of tools may also be known as knowledge-based systems, decision-making tools and computer-aided learning.

YOUR INVOLVEMENT

We would welcome the opportunity to talk with you about any expert systems that you may use as an organisation and any others that you may have come across, at a time and date convenient with you. We are interested in hearing about issues including what the system was designed to do, the main components within it, how the system is managed and how successful the system has been (see the following pages for the full list of questions). We are primarily interested in expert systems designed to address safety at work, however we would like to know about any other systems that you use or have come across.

BENEFITS OF INVOLVEMENT

Taking part in the consultation will give you the opportunity to contribute to an international review of safety-related expert systems. Helping us with this research also has much wider implications. It will ultimately provide the HSE with an understanding of the true extent and type of systems that exist, and help the HSE to apply expert system best practice to the GB context.

PROPOSED DATE AND TIME

Interviews are being conducted in April and early May 2006. We would welcome the opportunity to talk with you about expert systems during this time period on a date and time convenient with you. The interview will last approximately 20 - 25 minutes. However, this may vary depending on the information that you are able to provide us with.

CONFIDENTIALITY

Everything that you say will be treated in the strictest of confidence. Your personal details will not be passed on to the HSE or made available to any other parties, however specialist knowledge gathered from industry professionals regarding their successful use of expert systems will be considered for documentation as case studies in an official report for the HSE. We would provide you with copies of such information that we intend to use.

SECTION 1. EXPERT SYSTEMS CURRENTLY IN USE			
1.	Do you have any expert systems in place in your organisation? *(If YES, continue with Section 1. If NO, go to Section 3)*	Yes	☐
		No	☐
		Not Applicable	☐
2.	What is the name of the expert system?		
3.	What is the system designed to do? *(e.g. support regulatory compliance, identify workplace risk and hazards, guide accident analysis etc.)*		
4.	Which safety domain / area does it cover? *(e.g. work at height, workplace transport, slips and trips, noise and vibration etc.)*		
5.	What type of company / worker is the system designed for?		
6.	What are the main components / functions within the system?		
7.	Are there any aspects of the system which are unique to the originating country? *(i.e. are there any aspects which may not translate to a GB setting)*		
8.	How is the system delivered? *(e.g. Internet based, downloadable software etc.)*		
9.	How is the system managed? *(e.g. level of monitoring required, frequency of updates etc.)*		

10.	What are the costs of the system and how is it funded? How sustainable is the system? *(give case study examples where available to illustrate level of resource deployment and associated degree of impact)*	
11.	How long has the system been in existence for?	
12.	How has the system been marketed / communicated?	
13.	What regulatory framework does the system operate under?	
14.	Is there anyone else we should speak to about the system? Or do you have any other references or documentation about the system that you can share with us?	

SECTION 2. EVALUATION(S) OF EXPERT SYSTEMS

15.	Have you evaluated this system(s)?	Yes	☐
		No	☐
		Not Applicable	☐

16.	How did you evaluate it?	
17.	What did you find? *(What do you consider to be the advantages and / disadvantages?* *What factors contributed to the success / failure?)*	

18.	Is it / are they user-friendly? How is it / are they user-friendly?	
19.	What evidence do you have to support this?	
20.	Do you know if the system has made any safety or health related improvements? *(e.g. reduction in accidents / incidents, improvement in reported health problems, less near misses, less confusion over implementation of legislation)*	
21.	What evidence do you have to support this?	
22.	How would you rate the value for money / cost-benefits? *(On a scale of 1 – 5, with 1 indicating 'low' value for money, up to 5 indicating 'high' value for money)*	
23.	Would you do it in the same way again?	

SECTION 3. OTHER EXPERT SYSTEMS		
24. Do you know of any other health and safety related expert systems? *(If YES, record in Section 1 on separate form)*	Yes	☐
	No	☐
	Not Applicable	☐

Thank you for your valuable assistance with this important research.

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APPENDIX C

EXPERT SYSTEMS MATRIX

The expert matrix system for this report can be viewed and downloaded at: www.hse.gov.uk/research/rrhtm/rr508.htm

Published by the Health and Safety Executive 11/06

HSE

Health and Safety Executive

Evaluation into the success of occupational health and safety regulators and organisations use of expert systems

This report describes a study into occupational health and safety (OH&S) Regulators and organisations use of expert systems to address work at height issues; workplace transport; slips and trips; and noise and vibration. An International literature review and consultation activity with 46 key OH&S organisations was conducted in order to identify expert systems and analyse their impact on health and safety. The feedback collected from both activities was organised into a matrix of expert systems on CD-Rom format which accompanies this report.

The report presents a definition of expert systems and discusses safety domains where expert systems have been used. Six health and safety related expert systems were explored further during consultations with key organisations and these are presented as case studies. The study concluded that limited information was available on health and safety related expert system application, and that no robust evaluation evidence existed. The recommendations suggest how HSE could continue to make steps to develop its own expert system.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

RR508

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